The definition, selection and implementation of a new Hospital Information System to prepare the hospital for the electronic future: An example of project based education

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Abstract

The software supplier of a large hospital has been taken over. The hospital gets notice that the central hospital information system (HIS) will no longer be maintained, starting next year. This problem, not uncommon in business today, is used as a real-life case in a project-based course for first year students Business Information Technology (BIT).

Hospitals are changing, not only in the Netherlands but all over the world. Many hospitals grow by mergers, the patients become more aware and the relations between care providers, insurers and medical professionals become more intense. Therefore we can see a demand pull of information technology in the healthcare organizations. On the other side we notice that information technology is transforming the way healthcare is delivered. Innovations such as computer-based patient records, hospital information systems, decision support tools are beginning to affect the cost, quality, and accessibility of healthcare (US Congress, 1995).

The students get all basic material that the hospital had at the start of the project but not more than that. They have to construct the case themselves and make a strategic decision: "do we buy a new system from the same supplier or do we choose something completely new?" Subsequently they have to dig into the hospital information system. When a new central HIS is to be installed, it is not necessary to replace all of the peripheral systems in the hospital. How should the overall system be decomposed into subsystems, and how should the communication between new and remaining subsystems be organized?

After several weeks of intensive labor, at least the students have learned one thing: "the hospital information system does not have to bother with the millennium problem!" But have they learned more? While highlighting how this hospital is getting ready for the next century, we describe the added value of project-based education, in particular for the integration project of Business Information Technology.

1. Introduction

From the eleventh century until now University education is dominated by lectures (Bradford, 1993). Although many researchers (Bligh, 1971, Newble & Cannon, 1989, Mink, 1991) have shown deficiencies in this form of teaching, universities still hold on to this form of education. In project-based education, the initiative in the learning activities lies with the student. Tasks have to be split up between the members of a group such that all of the members can proceed with their tasks in an effective and efficient way (Spil & Coonjers, 1997). The gains in such projects are threefold: students get to know a real-life IT project (as opposed to textbook examples); students learn to integrate knowledge gained at other courses with the context of such a project; last but not least: students acquire the skills needed to work in project teams. In this paper, we look at such a project in considerable detail. A large regional hospital is needs a new Hospital Information System (HIS). It must be operational before the service contract of the old system runs out, which leaves only a limited amount of time for a rather complex conversion project.

The trend in Hospital Information Systems in the Netherlands is to change from big, centralized systems to kernel systems linked to different kinds of external subsystems. Typically, patient administration and financial administration are within the kernel HIS, whereas external systems could include Electronic Medical Dossiers, Picture Archiving and Communication Systems (PACS) and laboratory systems (Harmsen, 1997). Approximately ten suppliers compete in this area. There are three main players (Hiscom, SIAC and SMS). Continuity of the suppliers is an unstable factor, not only for the small suppliers. In fact the market leader (Hiscom) was taken over by a more general software supplier (Baan).

More advanced information technology in healthcare, beyond basic HIS functionality, is often found in isolated "islands of information". Despite the incorporation of sophisticated technology in almost every other aspect of clinical practice, information technologies have not yet been fully embraced (US Congress, 1995).

The primary process is the responsibility of the professional, and it seems as if this is untouched by changes in information technology. Yet the medical specialists resist the installation of registration systems, as they feel monitored by such systems (Raelin, 1991). Information projects therefore often have a political component. Boonstra (1994)

concludes that projects with a political character in a professional organization have a high failure risk.

In this paper we describe the HIS migration of a hospital with 1100 beds, from two different angles: a systems/technical perspective and a social/political perspective (Spil, 1996). We also describe the university course based on this project. It is the very last course in the first year of the Business Information Technology curriculum at the University of Twente.

In Section 2 the objectives of the university course are described. In Section 3 we elaborate on project-based learning and present a project structure that serves as a basis for the following sections. Section 4 addresses the initial problem situation at the hospital. Section 5 describes the project start of the HIS conversion project. In Section 6 the project follow up is described. Lessons learned and conclusions follow in Section 7.

2. The Integration Project Business Information Technology

The integration project BIT has three main objectives.

- The first objective is to integrate knowledge from several courses in the first year by applying it to a real project. Elements of Information Technology, Management and Information Systems have been taught separately. It is through the work in projects, solving problems taken from real life, that these knowledge elements are combined and internalized.
- The second objective of the integration project is to learn the skills which are needed to work in a professional team. In order to solve a difficult problem in a complex environment in a short period of time, the students need a good planning, task division and cooperation.
- The third objective is to have the students learn by experience the difference between a textbook exercise and a real-life problem This is of predominant importance for learning about the social/political dimension of IT projects. This is a subject very hard to cover in the abstract and in simplified case studies. Engaging in a real project means getting to know an organizational context with real interests and real persons, with all the idiosyncratic detail that makes the difference between theory and practice. The HIS conversion at a regional hospital, that we shall call Medinet here, provides such a real-life problem.

Integration project		
Telematics	Introduction BIT	Business
		Economics
Computer-use	Information	Human resour-
	Systems	ces, Technology
		and Organization
Information	Information	Management
Technology	Systems	

Table 1 - First year of BIT

In addition to the objectives stated for this particular course, there are some general objectives of the Business Information Technology curriculum, to which this project partly contributes. These are:

- Be able to predict and analyze the influence of IT systems on the organizational structure, the social system and the managed processes of the organization.
- Be able to elicit the information requirements on strategic, tactical and operational level from the organization members
- Be able to assess the quality of an IT solution.

The integration project takes part in the very last week of the first year. It is preceded by an introductory part, spread over 6 weeks, in which the students prepare for the project. The introductory part covers the following modules

- *Management and communication skills*, with emphasis on team building, project management, written and oral presentation.
- *Research*, in which students learn to state a research problem before they start working.
- Thematic exercises re-activating knowledge gained at previous courses in management, information technology and information systems.
- An excursion to the Medinet hospital.

Most of the exercises in these preparatory modules are based on material from Medinet, hence the students already have some relevant background knowledge when the "real" project starts.

3. Project-based learning

The first phase of a project, labelled "the beginning" by Barrows (1993), serves as an introduction and to set the climate. In the next stages the project is properly started (encountering and reasoning through). A selfdirected study follows, after which the problem is reassessed (problem follow-up). Finally, a performance is made in report and/or presentation. Table 2 shows these stages.

"The beginning"		
Introduction		
Climate setting		
"The project start"		
Encountering the problem		
Reasoning through the problem		
"The problem follow-up"		
Self-directed study and critique on resources used		
Reassessment of the problem		
"The performance and the presentation"		

Table 2 - Project-based education (Barrows, 1993)

The main difference between case studies and projectbased education is that in case studies, the teacher gives a case with (standard) answers to the student(group). In project-based education, the students have to build the case themselves. The basic information is given but for the HIS migration, the students have to rely on reasonable assumptions (Burton & Obel, 1995) they make and on additional information that they can find (on Internet and in the library).

An essential aspect of project-based learning is working in groups: students have to learn to interact in a way comparable to real-world situations. According to van Woerden (1991), learning in groups implies learning goals of its own, like learn to collaborate, to have discussions and to make decisions, to plan and to organize. Apart from these learning goals, student assessment procedures are different from those in traditional educational settings. As group products are expected from the students as a result of group-wise working, these products are assessed group-wise resulting in a grade per group of students.

Project-based education has specific requirements with respect to the availability of learning aids. Traditional aids like books and lecture notes are usually not sufficient to perform the project tasks. Further information sources and tools are necessary. When even these does not supply the required information to the students, experts have to available to answer relevant questions. These experts may be selected either from the teaching staff of the university, or from the external environment upon which the project tasks are based.

Concrete ingredients of project-based learning should be (van Woerden, 1991 and Delhoofen, 1996):

- a concrete problem is the starting point for problem-based learning;
- knowledge is acquired and applied directly in a situation as it can be found in real-world practice and in a real-world societal context;

- the problem and its solution are approached in a systematic way;
- course knowledge, insights, and skills are closely integrated;
- student work cooperatively in groups, based on explicit arrangements;
- the project is controlled in an explicit way, based on explicit plans.

The tutor is responsible for feedback to the students.

We follow the project cycle of Barrows (1993). Note that the students performed two iterations of this cycle during the project week (see figure 1). In the first run, the functional specifications are defined and a supplier is selected. In the second run, the implementation is started: a high-level design of the new system is delivered. (Obviously there is no time to do a complete development cycle within the limited scale of a university project like this). In the real conversion project at Medinet, the implementation cycle is followed by a third cycle: a follow-up project to add extra functionality. Although the students have no direct involvement with the third cycle, they have to be aware of its implications, i.e., the implementation should anticipate foreseen future extensions. For the sake of brevity and clarity of structure, we follow Barrow's cycle only once, discussing parts of the different project cycles as appropriate.



Figure 1 - Iterated application of Barrow's project cycle

4. Medinet in the 1990ies: "The beginning"

4.1. Introduction

Medinet originated in 1988 from a merger of three regional hospitals and two outpatient facilities in the Netherlands (Sikkel et al, 1998). In 1989 a reorganization process was started to restructure the big organization (1100 beds and more than 3000 employees). The reorganization transformed the hospital from a functional structure to a patientoriented structure in which the medical specialists have a central position. At the same time, specialist were clustered according to profession and redistributed over the redesigned hospital. More than 60% of the employees were organized around the primary process (diagnosis, treatment, care). The other 40% of the hospital employees can be found in the medical technical center (MTC), (25%) and a general support unit (15%). Figure 2 shows the new structure of the organization.

The corporate strategy-plan (1990), emphasizes three changes:

• Grow to be a top hospital with many teaching facilities and with clinical and

technical research of high quality;

- Derive economy of scale reached by the merger of several smaller institutions;
- Deliver high quality healthcare to the patients.

Table 1 shows the core figures of Medinet From 1990 to 1996. The figures are in Dutch Guilders (NLG); NLG 1 roughly amounts to US \$ 0,50. The IT budget for 1990 was 1.2% of the total legal budget, which is average according to Premkumar and King (1991), 33.8% of their survey respondents spend 1-2 % of

Legal budget for Results Admissaverage Number of costs ions stay out-patients (days) NLG -/-23,621 1990 451,731 NLG 247,407,621 27,167 11.0 9.8 1994 NLG 277,000,000 NLG +/+2,812,437 26,791 431,830 9.6 1996 NLG 289,500,000 NLG +/+5,565,309 27,308 437,664

Table 3 - Core figures of Medinet in 1990, 1994 and 1996.

their sales revenue on IT budget. It is also avarage compared to other Dutch hospitals (1.6 million USD)

The introductory part of the integration project starts with a presentation of the information manager of the hospital, so as to focus the students on the people in the hospital. In a first thematic exercise, in order to get acquainted with the complex hospital organization, the students have to analyze the financial annual report and the organizational structure of Medinet.. What they learn is that the budget is tight and getting tighter every year (more activities with the same budget or less); that the



Figure 2 - The organizational structure of Medinet

organizational structure is complex; and the patient orientation is difficult to recognize (These themes have been covered in a previous course called Human resources, Technology and Organization).

Knowledge from other first-year courses (Introduction Business Information Technology and Information Systems) is needed in a second thematic exercise, in which the students have to construct a process model and an object model of the patient-related processes in the organization. In a third thematic exercise, the theoretic knowledge from a course in Computer Networks can be applied to the real network situation of Medinet at the beginning of the conversion project. The multiple locations of the hospital are connected by an Ungerman Bas network (17% of the Dutch market) and communicate through an open system (Ethernet with FDDI backbone).

4.2. Climate setting

After these intensive training sessions, the student teams are ready for the real work. They will not complete all of the real work, because a team of students cannot do in a week what was done by a professional team in 16 months. But a good start can be made.

The student team gets the role of the coordination team of the HIS project. The main objective of the HIS migration is to deliver an operational Hospital Information System to replace the existing software. The following results have to be delivered:

- an operational HIS (hardware and software) has to be installed;
- all users have to be trained in the use of the system;
- the management of software applications other than the central HIS has to be arranged;
- the technical control has to be managed by the data-processing department.

These results have to be accomplished with the current situation as a starting point. (That is, the real situation in Medinet at the beginning of the conversion project, February 1996. This is the point in time at which the integration project is located, hence in the project it is called "current").

5. The HIS migration: "the project start"

5.1. The current situation

The current Hospital Information System is build around the patient registration, the accounting system en the laboratory system (ZILAB). This center of the total HIS communicates with all kinds of modules in the hospital where mainly address data (labelled "naw" in Figure 3) and treatment data (labelled "verr") is exchanged. About 50% of the medical specialists have their own (financial) system, most of these systems delivered by the union of physicians (VVAA). In this hospital 50% of the specialists is not on the pay-roll of the hospital. System Plus is supplier for the supporting departments of the Medical Technical Center like for example the operation room system. In the general support department we find a food system, a personnel system (PRIGEM) and a procurement system (IGB). The box on the upper right in Figure 3 is the management information system (TS-1). This systems runs batches of data from the central HIS for management use. HISCOM will continue to support this system. The new systems must be able to run the HL7 (Healt Level 7) protocol that has been adopted as the standard for network communication. The laboratory system also has to be replaced.



Figure 3 - The HIS at the start of the project

From a system/technical point of view there are many problems to address when a hospital decides to buy a new information system. Definitions have to be made, standard technologies have to be chosen and information requirements have to be found. Given time, most of these problems can be solved. From a social/political point of view there are problems like the introduction of an electronic medical record and a picture and archiving communication system that cannot be introduced without changing the structure and the culture of the organization. In this section both perspectives are shown and related to the assignments of the students.

5.2. Encountering the problem

At Medinet, the project was split into two stages. Because of the narrow time limit (as support for the old system would not be continued), the objective of the first stage was to select a supplier that could implement an functionally equivalent system. In the second stage, at a later date, extra functionality could be added. The intended extensions, however, had to be anticipated, as far as possible, in the implementation in the first stage. At the moment the hospital is still implementing these modules, which is a difficult process. The vendor was selected by many other hospitals and therefore they have problems to support all the new users, and secondly the hospital has a lot of work to prepare, to test and to implement the new software.

In the project week, the students did perform two project cycles, covering the first part of the first stage of the Medinet HIS conversion. The students have to realize that a project like this will demand extra attention for the project organization ("How to eat an elephant"). At least they have to spent some attention on this subject, describing a possible organization like they did in the management theme as an introduction to the project. Another important task for the students is to define a problem statement for the assignment. It takes some time to make clear that defining, selecting and implementing an information system is not the problem.

Medinet had two project-leaders (one for the organization: a division manager with DP-experience and one for the functional integration: the IS-manager). They were supported by a professional planner and administrative project members. The project leader of the selected supplier was added to this central team. For each functional area there was a working group, responsible from specification until implementation. In addition, there was a working group for technical matters and infrastructure. The leaders of this groups came from the Hospital divisions (heads of departments or information staff members of the divisions). They met with the project leaders every week, in order to decide on milestones within the project. Each working group had to organize the user participation and, later in the project, had to train the users.. The user who was a member of the working group had to train the other end users ("teach the teacher" principle). In this way the need for enormous amounts of people, especially during implementation and the real migration was covered.

5.3. Reasoning through the problem

The first problem the hospital faces, is to define its requirements, so as to be able to communicate with HIS suppliers and to ask them the right questions. These requirements can be divided into organizational, functional and technical requirements.

The organizational requirements focus on three main points:

- 1) Allocation of costs; Throughout the hierarchy the cost center is a unique factor and this may not be disturbed by people working in different clusters and support departments.
- 2) Multiple locations; Medinet has three main and several peripheral locations. These locations must be visible in the new system.
- 3) Organizational units responsible for their results. An organizational unit covers a group of medical specialists. Production agreements have to be made with these units, the production has to be administered. The unit is accountable for its results.

The hospital has (as well as the students in their case study) to define the scope of the project in terms of functional specifications. There is a risk that users specify an unrealistic system, adding new functionality that would be useful but is too complex to handle during the conversion. This problem was dealt with by organizing many sessions with the end-users and their representatives, with the objective to obtain three lists of functional requirements:

- 1) The daily used functionality of the old system;
- 2) Necessary extensions;
- 3) Desired extra functionality.

The technical requirements stress the importance of industry standards. Although Medinet realizes that a particular choice for a new HIS has implications for the hardware and software, it wants the new system to conform as much as possible to carefully chosen standards for

- control software
 - Medinet has chosen new hardware for a new (sub)system and expects to expand this new hardware line with UNIX as operating system.
- network and databases

The DP-department has made the choice to move from the IBM-token ring world to Ethernet, Unix and standardization on Oracle databases. They also start selecting new tools for distributing the software and managing the network. Before the project started a blueprint of the all the application software in the hospital has been made. In this blueprint the position of systems, their value for the primary process as well as the technical relations between these systems had been described. The suppliers selected in the short list were requested to follow this blueprint when making an offer for a new HIS. In this way the IS department and the DP people tried to control the information architecture and the technical infrastructure.

The students clearly encounter problems at this stage of the project because they have to make an analysis without having a good reference framework. At this point in their study they have not seen that many organizations and they try to hide in the technical requirements without looking at the organizational problems. Although the three organizational requirements are stated in the basic material of the project, not many teams come up with these requirement at this stage.

6. Preparing for the 21st century: "the project follow up"

6.1 Self-directed study and critique on resources used

The prime question in the first cycle of the students' projects is to select a potential supplier for the new HIS. During an exercise in the management skills module the students have already searched for HIS suppliers in the library and on the Web. In the project week they have to draw up criteria by which to evaluate the suppliers and to evaluate a shortlist of potential suppliers against these criteria.

Furthermore, the organization of the project has to be divided in sub-projects per functional area, and everybody must follow the same rules for describing the functionality and extra's. Medinet spent some time in designing a project organization for this project. A coordination team was assigned to keep the several functional teams and implementation teams in line. At a later stage the procedures for selecting suppliers from the long list and ranking them had to be a transparent, applying the same criteria to every supplier.

In another preparatory exercise, the students have looked at the advantages and disadvantages of the hospital network infrastructure. Now they have to apply this knowledge on the HIS migration problem: they have to investigate how the current system (figure 3) should change with regard to communication. Also, the integration aspect (on functional level) of different systems was decided on IS-level and the hospital made the choice of selecting an integration engine or communication-server with message handling (HL7 standard). In the second cycle, the students have to redo part of this work, without having the information how it was solved at Medinet. They have to do it in a self-directed study.

6.2. Reassessing the problem

One of the most difficult problems encountered at the Medinet conversion project was implementing HL7standard messages. The administrators of peripheral systems in the various divisions were willing to implement this, but everybody had his own "standard". In this process the IS-staff had to screen a lot of data on their definitions, values and coding, which turned out to have a big added value to the management of information. Several functional user groups made these definitions. Separate implementation groups did the implementation.

Due to the decentralized structure of the hospital with a responsibility (also for IS systems) in the divisions the user must be supported by the information staff members. To have the end-user selecting functionality was a major change. Of course it was difficult to combine the requirements expressed by the users with the technical opinion of DP-people and the long-term strategy for the future of the information manager. The hospital always lets the end-users make the first choice. The IS-staff structured the process and of course they set their terms for hardware, standardsoftware and networking.

In a more political perspective a migration of this kind and the Millennium-problems in the hospital are so capacity and money consuming, that there will be a backlog in implementing IS in other areas. This is a major problem to deal with for the management of the hospital. The last stage of the HIS migration, the implementation of extra functionality will be delayed by these problems.

In the information architecture it is described how the management information is to be derived from the operational hospital system (HIS and auxiliary systems) and stored in a data repository. At this moment the data repository has been installed. In collaboration with the management of the hospital divisions the information needs are being fulfilled. In the nearby future a lot of information is gathered automatically. Simple rules for data definition, for formulas used on this data and for the use of reports in top management are the basis to decentralize this process. By doing pilot studies and prototyping the hospitals tries to make a step forward in implementing an Electronic Patient Record with clinical information. They use the key-players and interested users among the medical staff to start the process and let them spread the software among the colleagues. The order management functionality for hospitals will be merged with this system later on. Supporting the nurses with bed-side terminals in their day-to-day work is still a dream for the future.

The student teams only see a small part of the problems mentioned in this section. They are more concerned with some basic questions, like whether the new system should be centralized or decentralized. The project focuses on the patient administration to reduce the complexity.

7. Conclusions: "performance and presentation"

Medinet, the students, and the student project supervisors all have learned from the conversion project. Let us start with the real conversion project at Medinet.

From the systems/technical perspective, the emphasis of this project is on standardization and preparation. Standardization of hardware, software, data and communication infrastructure, in order to define the requirements to the new HIS. Timely preparation of human resources and computer resources to be able to make a quick and painless migration. Medinet had to:

- Pay attention and spend time on definition phase
- Concentrate on infrastructure
- Make decision-files with agreements on tactical level
- Guard its time
- Take care of a backup system during migration.

From the social/political perspective, the emphasis was on the structure of the organization and on how the HIS had to be embedded in this structure. The people working in that structure are the most important and the most difficult is to make them adapt to the new situation. Not only training but also promotion and motivation were critical success factors in the Medinet conversion project. The senior consultant stated in this respect: "the whole house was involved".

We regard it as very important that the students learn to appreciate the social/political perspective of systems implementation. Being engineers, they are inclined to have more affinity with the

systems/technical perspective. Projects like this, based on real-life case studies, are more suitable to illustrate the importance of these matters than textbook examples that have been abstracted from their real-life context. In preparing the HIS conversion, students have to take care of the following issues:

- "Real" time and money is needed for training
- Do not try to use all functionalities of the system if the organization is not yet ready for it
- Make the project known in the organization
- Clarify who takes decisions, who needs to be interviewed and who needs to be informed about the project's progress
- Motivate people by appealing to their interests

The students are very enthusiastic about the integration project. It costs them a lot of time to gather and process all the information but when on the last day the hospital management acts as a forum for their solutions they know why they are studying Business Information Technology. Compared to "regular" university courses, the following characterics stand out

- The students get involved in a "real life problem" based on a recent case.
- There is an initial training in management skills and research skills, but the students effectively learn these by doing, through the team work on a real project.
- Students have to perform in a structured vagueness; they have to make assumptions and decisions in a situation with a certain amount of insecurity.
- Some guidance by the teachers is needed to help the students through this kind of situation which is, for them, a new experience.

It does hardly come as a surprise that from all the courses in the first year, the integration project is the one most liked by the students.

The teachers find the integration project both timeconsuming and satisfying. During a lecture as a teacher you give all but see little in return. In this project you can see how the students make progress, from their first clumsy presentation to the last (nearly) professional presentation to the hospital forum. The teachers

• Have to collaborate with the host organization

- Create a common body of knowledge with colleagues
- Need broad interests
- Do not have the answers to all questions
- Have to have a high commitment
- Have to make a lot of arrangements

Last but not least, the host organization must show goodwill if the case study is to be used for a repeated series of university projects. We try to minimize contacts with Medinet in order to maintain a long-term relationship. Both university and hospital can benefit from such collaboration. The host organization

- Collaborates with the university on different levels
- Wants to spread its knowledge to the students
- Has new problems to address every four years
- Has to document the projects
- Has to be open-minded.

Medinet offered and offers an open laboratory for BIT students for which we are very thankful.

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