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Healthcare Informatics Project-Based Learning: An Example of a Technology Management Graduation Project Focusing on Veterinary Medicine

Arriel BENIS[a,b,c,1]
[a] *Faculty of Technology Management, Holon Institute of Technology – HIT, Israel*
[b] *Smart, Intelligent, and Adaptive Systems - SIAS Laboratory, Holon Institute of Technology – HIT, Holon, Israel*
[c] *AFRAN Center for Disaster Reduction, Holon Institute of Technology – HIT, Israel*

Abstract. Teaching Healthcare Informatics using Project-Based Learning focuses students on active and inquiry-based learning and allows them to gain some knowledge and skills in the field. From the perspective of Technology Management, which is at the cross-road of Sciences, Engineering and Business Administration studies, Healthcare Informatics is an interesting application domain for developing both innovation and management capabilities. However, the specificities of Healthcare Informatics (standards, methodologies, human- or animal- focused information) require an additional involvement from the students to deliver projects that fit real-world needs and constraints. In this paper, we initially define the Technology Management field and describe how it is related to Healthcare Informatics, then we introduce Project-Based Learning and finally we present an example of a graduation project that focuses on Veterinary Medicine.

Keywords. Healthcare Informatics, Technology Management, Project-Based Learning, Veterinary Informatics

1. Introduction

One of the academic teaching and project mentoring challenges is providing students with scientific, technological and managerial skills, for understanding and dealing with real-world issues.

The healthcare industry is prolific, innovative and dynamic with high economic and employability potential. Healthcare Informatics (HI) –a.k.a. Medical Informatics–and digital health are currently taught either as a dedicated degree or as a series of integrated courses in non-specialized curriculums [1]. A third approach consists of providing examples and carrying out projects in the HI field in order to provide students with some knowledge and skills in this subject matter. This approach is mainly used in courses and curricula which are not focused on these fields. The main objective is to equip students with basic knowledge and tools allowing them to discover, learn about and enable them

[1] Corresponding author: Dr. Arriel Benis, Faculty of Technology Management, Holon Institute of Technology – HIT, Golomb St 52, Holon, 5810201, Israel ; e-mail: arrielb@hit.ac.il.

to deal with specific issues of computerization in the healthcare domain. This approach is a manifestation of the "Project-Based Learning" (PBL) approach, which dynamically involves students in research and/or real world tasks with the goal of providing them with the opportunity to acquire deeper skills and capabilities by exploring a real problem and trying to provide solutions for it [2].

The Faculty of Technology Management at HIT – Holon Institute of Technology, in Israel, prepares undergraduate and graduate students to work in complex environments as managers or as experts (according to their specialization) in "Information Technology", "Project Administration" and "Quality and Reliability". A formal Healthcare Informatics course has not yet been implemented; however, undergraduate and graduate students complete their degree requirements by performing a research or an industrial project that is strongly related to health and involves informatics. The main challenge is to give them the opportunity to actively earn specific knowledge related to Healthcare Informatics during these projects.

In this paper we initially define the "Technology Management" (TM) field and its relationship with HI, then we introduce PBL and present an example of a graduation project, which has been completed at the faculty of Technology Management at HIT, and focuses on Veterinary Medical Informatics. We conclude with a discussion on the added value of PBL for teaching some fundamentals of HI.

2. Technology Management and Healthcare Informatics

Technology Management is at the crossroad of formal, natural and human sciences, engineering and technology, and management [3].

Management means handling the process which will allow the development and/or the improvement of different kinds of activities, e.g. medical appointment procedure and medication delivery tracking, into an organization, e.g. a hospital. Generally, management is built around five main concepts:

- forecasting, by considering scenarios that may happen in the future, and defining which actions should the enterprise take to handle new challenges, e.g. potential epidemics or ageing population,
- planning, by deciding in advance which actions to take in order to deal with the previously pointed-out challenges and converting them into goals (such as innovative product) and an action plan (a strategy), e.g. building emergency response teams or developing geriatric-oriented service,
- organizing, by defining a structure and recruiting/affecting more suitable – human and/or non-human– resources for acting according to the plan, e.g. recruiting potential emergency responders or creating a working group (WG) or a task force,
- coordinating/leading, the structure formerly organized for achieving the different steps of the action plan and goals, e.g. defining and running the training of an emergency responders team or integrating the individual activities of a WG as a whole,

- controlling, by checking that the structure activity fits the goals and examining the progress against the action plan, e.g. continuous training assessment or evaluating by pairs the deliveries of a WG.

HI, from a TM point of view, is a dynamic domain in which management is crucial. First, because it deals with health at the individual or the population level. Second, HI has strong scientific and technological components. HI projects are indeed built around two main objectives: the first consists of improving some health attributes, and the second relates to the computerized solution involving scientific and technological knowledge and skills, e.g. system modeling, programming algorithms and handling data from end-to-end. These objectives must be managed in a similar way to any other kind of non-HI project.

3. Project-Based Learning as a Part of Technology Management Studies, and an Active Way to "Teach" some Healthcare Informatics Concepts

PBL is a student-centered pedagogical methodology involving a dynamic approach that is based on an underlying belief that students acquire a real-world and focused competencies by actively exploring and handling real-world challenges. More accurately, students learn about a subject by working on a project for a prolonged period of time, generally between a few weeks and a few months. This kind of active learning is not a smooth path to knowledge, and is based on the learner engagement and motivation [4].

In the context of TM studies, more specifically at HIT, the students have a large number of courses where projects are a substantial component of their assessment. Accordingly, in addition to the classical in-class or online learning, the students are encouraged to develop their managerial skills, based on the five main concepts presented above, by completing a project in small teams in a technological application field of interest. Number of TM students is interested in working on projects related to HI; however, a large proportion of these students does not have any healthcare sciences and technologies background. Thereby, PBL allows them to gain new knowledge and develop new skills related to HI.

4. An example of a Veterinary Medical Informatics oriented PBL: a household pet feeding monitoring system

Healthcare Informatics is broadly defined as information science and engineering applied to healthcare for managing and using patient information [5]. Hence, Veterinary Medical Informatics (VMI) focuses on health and medical information about animals. Furthermore, there is a growing need to integrate animal medical data into Public Health information systems to facilitate support and to respond to unusual ecological events, which may be related, e.g. to acute pollution or bioterrorism [6, 7].

As a PBL example, three of the students chose to deal with food intake regulation of multiple pets using the same feeder with the goal of maintaining healthy weight for all pets [8]. Students not only had to use their prior knowledge in electronics, computing, information technology, and management to carry-out this project, but were also required to learn during the project some basic animal physiology, behavior science and

healthcare informatics, so as to understand what, why and how the system can be designed, implemented and used by its end-users: pets and their owners.

In other words, the objective of this graduation project was to design a prototype of a feeding station that also serves as a monitoring system, gathering information about feeding habits and weight of the pets, a.k.a. “health indicators".
The system consists of the four main components:

1) a physical Internet of Things (IoT) device that collects the data and sends it to the data management environment build around
   a) a set of electro-mechanic components –motors and valves–, that direct food and water from specific silos to the appropriate bowls when necessary,
   b) a radio-frequency identification (RFID) reader allowing identifying each pet by means of an attached or implemented RFID chip,
   c) a set of sensors for weighing the pet before feeding and/or hydrating, weighing the food before and after feeding, and weighing the water before and after hydrating,
   d) computer capabilities integrating and then sending the information, collected by the RFID and the sensors, to a data management environment (DME).
2) a DME –a database and a data warehouse– for storing the data collected by the IoT device,
3) a data analytics component that receives the data stored into the DME and that includes algorithms helping to detect deviations of “health indicators” from the norm and generate “alarms” by comparing current data to historical data or to data generated by “similar” pets.
4) an interactive interface that includes user-friendly visualizations that report
   a) changes in the health indicators over time, and
   b) the alarms notifying the pet(s)’ owner(s), a veterinary or public health specialist, of any situation requiring his/her attention, e.g. under or over eating and/or drinking, changes in feeding habits, significant weight decrease or increase over time.

During the different steps of this project, the students’ team had to learn to deal with specific medical engineering and user-focused design issues, such as:

- designing the feeding station so that it will be usable by pet, in a similar manner to other feeding system,
- choosing the sensors to fit the type of pet, e.g. in terms of its accuracies,
- supporting feeding of multiple pets by the same station,
- taking into account changes in pet's weight over time and/or taking into account EHR data when available before generating alerts.

Answering such questions, required dedicated learning. From a Healthcare Informatics perspective, and more particularly Veterinary Medical Informatics, this project has given these students, with no medical or medical informatics background, the opportunity to learn some fundamentals of the domain, such as management of a project related to a health information system and tele-monitoring, signal and data analysis, and biomedical data, information and knowledge representation for dealing with (Veterinary) Electronic Health Records [9].

Furthermore, by focusing on a veterinary medicine application [10], this PBL has supported understanding of public health concepts, such as population surveillance. It

pointed out the fact that pets and humans share the same environment and so monitoring changes in animals' health, e.g. habits and/or weight changes, may facilitate early detection of zoonotic diseases thus reducing the risk that these diseases pose to the public. It also may help generate alerts about some potentially dangerous environmental disorders, e.g. polluted water, disasters [11], which affect animals before they affect humans, turning animals to be a kind of sentinels [12].

5. Conclusions

Project-Based Learning is an interesting and engaging way to provide the students with the opportunity to get some fundamental understanding about Healthcare Informatics and to apply new knowledge in a real-world application.

Specifically, Healthcare Informatics Project-Based Learning gives TM students the opportunity to earn specific knowledge, in (1) biomedical sciences, (2) HI standards and methodologies, (3) healthcare analytics, and (4) biomedical data, information and knowledge representation. Students also develop innovative-thinking for efficiently managing a health-dedicated product design and prototyping. The graduation project presented above allowed the students to learn about building an end-to-end monitoring system. This system can be used (1) stand alone for enriching a Veterinary EHR or (2) as a part of a public health surveillance network looking at a population level.

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