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Case-Based Learning: A Formal Approach to Generate Health Case Studies from Electronic Healthcare Records

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Abstract. There is an increasing social pressure to train medical students with a level of competency sufficient to face clinical practice already at the end of their curriculum. The case-based learning (CBL) is an efficient teaching method to prepare students for clinical practice through the use of real or realistic clinical cases. In this regard, the Electronic Healthcare Record (EHR) could be a good source of real patient stories that can be transformed into educative cases. In this paper a formal approach to generate Health Case Studies from EHR is defined.

Keywords. Case-based learning, Electronic Healthcare Record, Experiential Learning

Introduction

There is an increasing social pressure to train medical students with a level of competency sufficient to face clinical practice already at the end of their curriculum. Active methods of teaching/learning can guarantee the development of high quality expertise, because they are directed to the development of knowledge and also to its use in real or realistic settings. The case-based learning (CBL) is a teaching method that belongs to the more general class of inquiry or discovery learning [1]. The CBL has been defined as an approach to education, which aims to prepare students for clinical practice, through the use of real or realistic clinical cases. These cases link theory to practice through the application of theoretical knowledge to the cases themselves and encourage the use of methods of inquiry based learning [2]. The ideal features of a case for CBL are: a) be authentic (based on real patient stories); b) involve common scenarios; c) tell story, d) be aligned with defined learning outcomes; d) have educational value; e) stimulate interest; f) create empathy with the characters; f) include quotations in the patient voice to add drama and realism; g) promote decision making; and h) have general applicability.

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Learning activities in CBL are essentially ways to "play" a simulation of management of a case, and it is very different from the traditional "case reports", in which clinical features and the decision-making process are illustrated to the “passive” learner.

The selection or production of cases for CBL is a time consuming activity, especially taking into account the time necessary to transform the extracted clinical information into a suitable format for the educational use. Direct cases generation from an electronic database were attempted in radiology, by connecting an educational system to the local PACS. The use of true medical records is not reported in the literature [3].

The Longitudinal Electronic Healthcare Record (L-EHR) could be a good source of real patient stories to generate cases for educational purposes. The L-EHR is a data collection of patient health information generated during all patient’s encounters with caregivers in any care delivery setting. It integrates standard clinical documents produced by different specialists and by different organizations (e.g. laboratory and hospital information systems, GP’s record); these documents have the clinical contact (during which it was written) and the health issue (the origin of the clinical contact) as metadata. The L-EHR can contain the clinical history of a citizen during his entire life.

Obtaining health case studies (HCS) from the L-EHR also helps to have, for each significant problem of health, a wide selection of presentations and clinical courses, probably similar but not identical. This is required for the development of a mature clinical expertise [4]. The extraction of HCS from the L-EHR for educational purposes must allow the learners to practice: a) to identify the essential information and the points of decision; b) to take autonomous diagnostic, therapeutic and management decisions; c) to compare their decisions with those actually made in the reality of that particular case; d) to balance the rationale of their decisions with the available scientific evidence, collected from knowledge bases; and e) to discuss their work with a tutor.

1. Longitudinal Electronic Healthcare Record as an information source for CBL

Each episode of care starts from a clinical problem (e.g. symptom) and then is described by the evolution of this problem along with the clinical events carried out during the care. According to CONTsys "the health issue is the reason for the request for health care"[5]. The health issue is a label assigned by a health professional who participates in the care process in order to describe the patient's health condition, at a given time. The label is subjective because it always depends on the observer point of view (e.g. other professionals could use another label); moreover, over time, the same observer could assign different label for the same condition.

The clinical history of a patient can be described as a sequence of contacts, and also as a network of health issues that provides the complete semantics of the various problems encountered by the patient and their evolution in time. The edges of this graph have different meaning, for example: a) in depth (the problem is analysed in depth and defined more); b) complication (the problem degenerates into a different issue); and c) consequence (some diseases, especially chronic, could produce complications).

In order to classify a health issue one of the most popular classification codes could be used: ICPC (International Classification of Primary Care), SNOMED (Systematized Nomenclature of Medicine) or ICD (International Classification of Diseases).

2. The generation of a Health Case Study.

The extraction of the HCS is realized by selecting the entire path of treatment starting from the initial healt issue. It includes the events that compose the path of care as well as all of the problems associated with it, independently of the doctor who defined them. The construction process of the HCS occurs through the following phases:

- Extraction and anonymisation: a) the selection of the initial health issue from which all the care pathway must be derived; b) export of selected case; and c) anonymization in according to national laws [5].
- Preparation of the HCS: a) the inclusion of comments and notes; b) the connection of the elements of the pathway with external documents, websites and other resources; and c) the transformation of the HCS(e.g., to extract, namely the generation of a sub-HCS; to generalize, i.e. to change a detailed information to its type; to change the absolute times to the relative times).

Obviously, the HCS generated has to be contextualized in the light of a concrete learning path in orde to become a learning resource.

3. The formalization of the health case study

The formalization of the HCS is based on the formal representation of the L-EHR. The HCS is a complex artefact composed by: a) network of health issues, formally a connected graph; b) the clinical events linked to the network of the health issues; and c) the clinical documents linked to the network of the health issues.

Let: a) P a set of Health Issues; b) $ass: P \to P$ a function that link a Health Issue to another Health Issue; then the network of Health Issues is a pair φ: $\varphi =< P, ass >$.

Moreover, let: a E a set of clinical events; b) D a set of clinical documents; c) $e_p: P \to 2^E$ a function that return the clinical events related to the episode of care linked to a specific health issue; d) $g_n: P \to 2^D$ a function that return the clinical documents produced during all the clinical events linked to a specific health issue by means of the e_p function; then L-EHR ψ is a quintuple $\psi = \langle \varphi, E, D, e_p, g_n \rangle$.

Let F the set of possible L-EHR.

The extraction of the health case study is based on the choice of the initial health issue and then on the extraction of all the all the directly and indirectly connected health issues together with the related clinical events and clinical documents.

The first step is the extraction of the related health issues. Given a health issues network $\varphi =< P, ass >$, the function $path: P \to 2^P$ is a function that return all the health issue directly and indirectly connected with the initial health issue.

Let $p \in P$ as the initial health issue,

$path(p) = \{p\} \cup \{x\ P: (\exists y \in path(p) : y = ass(x) \vee x = ass(y))\}$ $\subseteq$P

The network of health issues of the HCS related to the initial problem p is

$\varphi_p =< path(p), ass|z \in path(p) >$.

The extraction of the HCS from the initial health issue p is based on the following function $ext(p): P \to 2^F$.

Therefore, given a L-EHR $\psi = \langle \varphi, E, D, e_p, g_n \rangle \in$ F and a Health Issue p $\in$ P, the HCS ψ_p is $\psi_p = ext(p) = \langle \varphi_p, E_p, D_p, e_p|E_p, g_n|D_p \rangle \subseteq 2^F$; where: a)

$E_p = \bigcup_{y \in path(p)} e_p(y) \quad \subseteq E$; and b) $D_p = \bigcup_{y \in path(p)} g_n(y) \quad \subseteq D$.

4. The use of the health case study

Kolb [7] defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience".

The case based learning allows trainees to activate experiential learning in a more effective way if the cases are based on a real scenario. According to this approach, the analysis of a HCS generated from L-EHR could be a useful tool for building a learning environment; this approach can be applied in the field of training of general practitioner as well as for specialists to allow them to address the complexity of problems that arise in their daily activities.

There are at least three different levels of details that offer a different vision of the answer, depending on which aspects of the learner wants to deepen. These levels, given in order of extent and depth of the response, are: a) the diagnostic process in which the recognized guidelines can be directly used; the goal of the exercise is to train the use of guidelines b) the clinical reasoning, mainly hypothetical-deductive reasoning; the goal is to train clinical argument skill to support the path that goes from identification to interpretation of information and therefore differential diagnosis; and c) deepening in terms of pathophysiological mechanisms, where the goal is to teach in a more systematic way epidemiology, prognostic, therapeutic (medical and surgical) and diagnostics.

The additional external information are therefore characteristics of each level, such as for example: a) database consisting of guidelines (e.g. Cochrane library); b) individual studies, clinical trial; and c) biochemistry at the base of the physio-pathological aspects.

Regarding the metadata describing the HCS must also take account of the presence of educational metadata: a) competence (level 1 of Tuning)[8]; b) work activity (level 2 of Tuning)[8]; and c) theoretical knowledge / factual or use specific skills brought into action [9].

As an example, an educational goal like "how to make a diagnosis," the description of an HSC result in the presence of the following metadata:

- competence: evaluate a clinical presentation and make the differential diagnosis;
- work activity: to recognize the elements of a clinical image, prescribe diagnostic tests, interpret and make the differential diagnosis;
- knowledge: epidemiology and pathophysiology, clinical - it is placed at lower levels of Bloom's taxonomy: remember the terms, facts, mechanisms, criteria;
- skills: correlation between elements of knowledge - it is placed at high levels of Bloom's taxonomy: analyse, interpret, reorganize.

5. Conclusions

In this paper propose a methodology to support the creation of HCS from a L-EHR. The basic idea and its implication from an educational point of view were discussed with experts from the Italian Society for Medical Education (SIPeM). The main value of generating HCS from L-EHR is in the availability of a very wide set of complex cases, representing the real-world situation. According to Kolb [7] the activation of learning through experiences requires to face increasingly difficult challenges. If Ad hoc, manually generated cases can be a starting point and bedside teaching with a direct

involvement of student the final goal, the management of complex, real-life cases, automatically generated from an a L-EHR is a valuable intermediate objective [10]. In order to support this process a formal description of the HSC was defined and some use cases were proposed.

The implementation of the proposed approach requires to use an L-EHR system in which both, the conceptual model and the implemented features allow the implementation of the designed tools.

A prototype of the proposed system has been developed in the framework of the project Smart Health 2.0 funded by the Italian government research and innovation programme "Smart Cities and Communities and Social Innovation". The prototype allows user to skim through then information contained in the L-HER to collect the clinical events considered essential to the definition of the base case. These elements can then be re-processed in a causal network according to the model proposed in this paper to finalize the HCS. The developed features are being tested since June 2015 and the first results will be available before the June 2016.

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