Exploring Complexity in Health: An Interdisciplinary Systems Approach
A. Hoerbst et al. (Eds.)

doi:10.3233/978-1-61499-678-1-359

An Ontology-Based Scenario for Teaching the Management of Health Information Systems

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Abstract. The terminology for the management of health information systems is characterized by complexity and polysemy which is both challenging for medical informatics students and practitioners. SNIK, an ontology of information management (IMI) in hospitals, brings together IM concepts from different literature sources. Based on SNIK, we developed a blended learning scenario to teach medical informatics students IM concepts and their relationships. In proof-of-concept teaching units, students found the use of SNIK in teaching and learning motivating and useful. In the next step, the blended learning scenario will be rolled out to an international course for medical informatics students.

Keywords. Health Information Systems, Information Management, Ontology, Education

1. Introduction

According to the IMIA Educational Recommendations, knowledge about the management of health information systems (HIS) belongs to the core knowledge medical informatics students should acquire [1]. Students need to know how strategic, tactical and operational information management (IM) concepts as well as IT governance and IT service management concepts are mutually linked. However, already 15 years ago the polysemous nature of HIS concepts became manifest in imprecise and overlapping definitions of concepts like "HIS", "electronic health record" or "e-health" [2]. Unfortunately, the situation has not improved to the present. Different frameworks and textbooks were published in new editions in parallel, leading to a vast amount of homonyms and synonyms associated with HIS and IM. In medical informatics, there are dedicated textbooks for the management of HIS (e. g. [3], [4]). From a German perspective, the field of business informatics provides further domain-independent views on the management of information systems (e. g. [5], [6]). The topics of these classic textbooks on IM are complemented by recent frameworks such as ITIL [7] or COBIT [8].

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Whereas it is already challenging for IT experts or researchers in the field of HIS to keep on track with concepts and their interdependencies, for medical informatics students, which are new to the field, this task is even more complicated. In order to deal with this complexity, we have developed an ontology called SNIK (German: Semantisches Netz des Informationsmanagements im Krankenhaus) bringing together IM concepts from different literature sources. SNIK is intended to support teaching purposes as well as software development of IM tools [9]. In this paper, we focus on the use of SNIK for teaching the fundamentals of the management of HIS. It is our goal

- to develop a blended learning scenario for using the SNIK ontology in courses on the management of HIS and
- to assess the applicability of this scenario for teaching units in a proof-of-concept with medical informatics students.

2. Materials and methods

2.1. Ontologies and concept maps for teaching and learning

Gruber defined ontologies as explicit specifications of conceptualizations, i. e. formal descriptions of knowledge by classes, relations and other objects [10]. Ontologies can organize knowledge on different levels of formality, whereas axiomatized ontologies have the most formal level [11]. Formal ontologies are not well established in education although they have a great potential for sharing and collaboratively developing knowledge bases [12]. Instead, concept maps, which can be regarded as ontologies with a very low level formality, are often used in learning scenarios.

A Pubmed search revealed that there are basically three applications of using ontologies actively for teaching and learning in life sciences. First, students may either individually or collaboratively construct ontologies or concept maps in order to structure the syllabus (e. g. [13]). Second, preconstructed concept maps or ontologies can provide students with a given terminology (e. g. [14]). Third, formally represented ontologies can be used by lecturers to prepare multiple choice questions automatically [15]. The active use of concept maps constructed by students or preconstructed concept maps in education has been proven to have positive effects on learners. A metastudy showed that the use of concept maps improves knowledge retention in comparison to conventional educational methods like lectures and text work [16]. This holds especially for self-constructed maps. Preconstructed concept maps are advantageous for students with lower language skills and for individual learning. For the effective use of concept maps it is necessary that the concept maps are based on the students' prior knowledge due to the meaningful learning theory of Ausubel [17]. I. e., both in a concept map or a more formal ontology new concepts should be related to already known concepts.

2.2. SNIK as an ontology for the management of health information systems

SNIK, the ontology of IM in hospitals, aims at mapping IM concepts from different books, frameworks and articles. For that, a common metamodel in form of a top-level ontology was developed. "*Function*", "*entity type*" and "*role*" are the three top-level concepts of SNIK. *Functions* describe what is to be done in IM departments (e. g.

"Strategic Alignment"). *Functions* update or use information which is represented by *entity types* (e. g. "Strategic Hospital Goal"). *Roles* (e. g. "CIO") are used to describe responsibilities for functions and entity types. The SNIK top-level concepts are linked by 13 intra-ontology relation types (e.g. isDecomposedIn, uses, updates) and five inter-ontology relation types (e. g. IsSynonym), the latter being used for connecting terminologies from different literature sources. For every SNIK concept, there are annotations like synonyms, definitions and references. In Figure 1, the *function* "Strategic Alignment_1" is part of the *function* "Long-Term HIS Planning_1". The *role* "CIO_1" is responsible for "Strategic Alignment_1" which uses the *entity type* "Strategic Hospital Goal_1" and updates the *entity type* "Strategic Information Management Plan_1". The suffix "_1" indicates that all these concepts are taken from the same literature source.

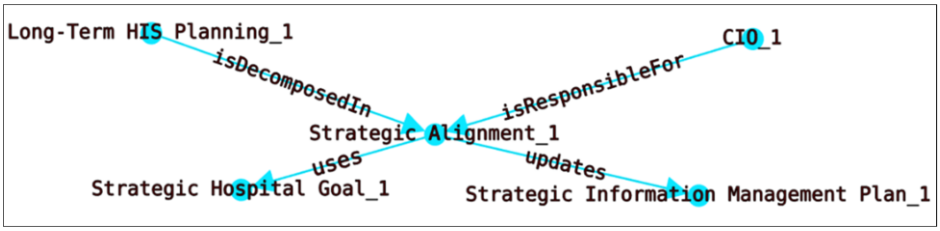

Figure 1. Snapshot of a SNIK graph representation. Vertices represent classes, directed edges represent relations.

So far, SNIK includes 1898 concepts and 3746 relations from two textbooks dealing with the management of HIS ([3] and [4]). On the one hand, SNIK is represented as OWL ontology enabling SPARQL queries and software development based on SNIK. On the other hand, there is a graph version created in Tulip [18] in order to apply graph algorithms to SNIK.

3. Results

Based on the findings from the literature research (see 2.1) and the current SNIK version as graph representation (see 2.2) we developed a blended learning scenario for introducing and using SNIK in two teaching units à 90 min. In the first teaching unit, the students are taught the SNIK top-level ontology and the handling of the SNIK graph in Tulip. At the end of the teaching unit, groups of 3 to 5 students are built and each student is assigned a "SNIK spiderworm". A spiderworm(V, E) is a SNIK subgraph consisting of concepts represented by vertices $v_i \in V$ (short: concepts v_i) and relations represented by edges $e_i \in E$ (short: relations e_i). In a spiderworm, there is a concept v_1 the student has already learned, a new concept v_2 together with its neighbor concepts v_n of distance 1, and a path containing relations e_i and concepts v_i between v_1 and v_2. Each spiderworm is connected with at least one other spiderworm by a concept v_n. See an example of two connected spiderworms in Figure 2 with "Project Portfolio_1" as a concept v_1 and "Tender_2" as a concept v_2 of a spiderworm. The concept "System Selection_2", which is neighbor of "System Selection_2", is also part of another spiderworm. This implies that the lecturer needs to prepare a connected SNIK subgraph consisting of spiderworms ahead of the lesson.

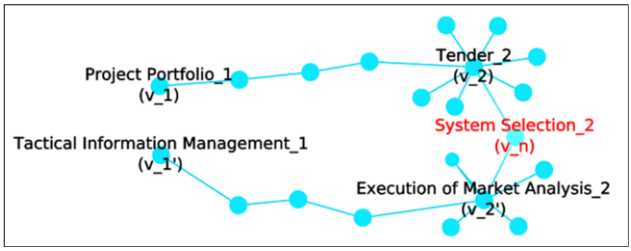

Figure 2. Two connected spiderworms in SNIK

With the help of SNIK material provided in the e-learning platform Moodle and the SNIK graph in Tulip each student prepares a short presentation of the assigned spiderworm at home. The second teaching unit is used for presentation and group discussion. Student 1 starts to describe the concepts and relations her or his spiderworm is composed of. If another student catches a concept included in her or his spiderworm she or he shouts "Bingo!" and is selected to present the second spiderworm. Due to all spiderworms having a connection to at least one other spiderworm, the Bingo game is continued until the last student of the group has presented the last spiderworm. Meanwhile, the growing connected SNIK-subgraph is visualized in Tulip. At the end, the students summarize and discuss the contents of the built graph in group.

We tested the blended learning scenario with a group of three medical informatics students. After conducting the two teaching units, we evaluated the learning scenario in a Moodle survey and an additional discussion with the students. They assessed the learning scenario as a motivating interactive method to learn IM terminology in comparison to conventional lectures. Two of them decided to use the SNIK ontology for the preparation of their exam. For the group discussion in the second teaching unit they missed a couple of predefined questions on the graph's contents to be answered in group which could have led to a more lively discussion. For an evaluation by four lecturers we made a video of the teaching units. The lecturers found that the live visualization of the growing graph in Tulip is hard to follow and should be replaced by a method supporting closer collaboration between the students.

4. Discussion and Outlook

The proof-of-concept illustrated the applicability of SNIK in teaching scenarios. The discussion with the students showed their openness towards the SNIK ontology and the blended learning scenario. However, it still needs some adaptations and an in-depth evaluation. For the next scenario version, we seized the students' suggestion to extend the learning scenario by questions on the observed SNIK-subgraph to be solved in group. Furthermore, the use of Tulip in the lesson was replaced by using moderation cards.

Of course, the proposed theoretical approach to teach the terminology of the management of HIS needs to be integrated in usual courses so that it is complemented by examples from practice. Thus, in the next step, the blended learning scenario is rolled out to the International Frank-van Swieten Lectures on Strategic Management of Health Information Systems [19], a yearly joint lecture of an Austrian, a Dutch and three German universities which also includes practical course work on HIS.

Acknowledgement

This work is supported by the DFG (German Research Foundation) under the Project SNIK: Semantisches Netz des Informationsmanagements im Krankenhaus, Grant no. 1605/7-1 and 1387/8-1.

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