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SNIK Quiz: A Multiple Choice Game about Information Management in Hospitals

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Abstract. SNIK is a knowledge base about the management of health information systems generated by extracting Linked Data from textbooks and other sources. SNIK describes functions, roles executing these functions, and entity types, the information used or updated by these functions. We present SNIK Quiz, a browser game in which students answer multiple-choice questions about information management in hospitals based on SNIK. The questions are semi-automatically generated using templates in order to train basic facts, more complex patterns, and connections between textbooks encoded in SNIK.

Keywords. linked open data, information management, multiple choice quiz

1. Introduction

Medical informatics students, who are trained for executive positions in information management (IM) departments of healthcare institutions, such as hospitals, need a clear terminology of their domain. This terminology is offered by SNIK [1,2], the Semantic Network of Information Management in Hospitals (“Krankenhaus” in German), which integrates knowledge extracted from textbooks [3,4,5] and other sources such as interviews in the form of Linked Open Data. In order to specify, which information should be extracted and to facilitate comparisons, we use a common data model. Because processed textbooks contain abstract knowledge instead of information about any specific hospital, all concepts are modelled as classes and instances simultaneously, using OWL punning. We thus call our data model the “meta model” in accordance with the term’s definition as a shared modelling language [4, p. 8]. The central entities of the meta model are enterprise functions, roles executing these functions, and entity types, the information used or updated by these functions, see Figure 1. SNIK version 1.3.0 contains 81499 triples describing 65 properties and 4719 classes, of which there are 260 roles, 1310 functions and 3182 entity types. This paper presents SNIK Quiz, an open source² browser game, see

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Figure 1. The SNIK meta model

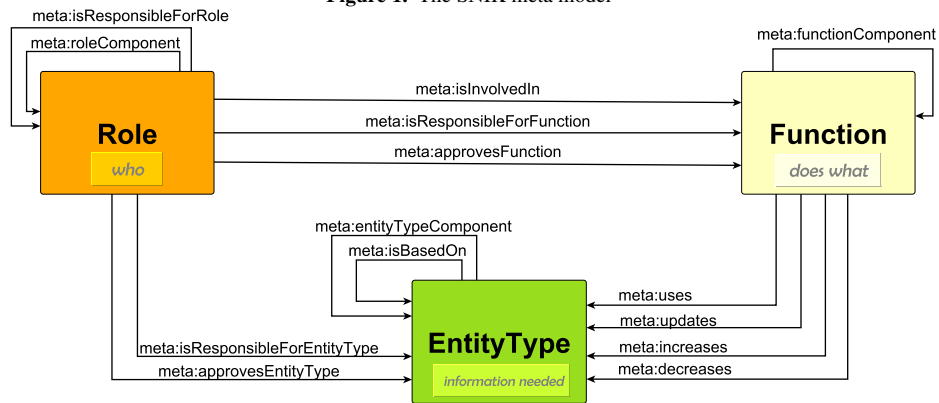


Figure 2. The SNIK Quiz browser game available at <https://www.snik.eu/quiz>.

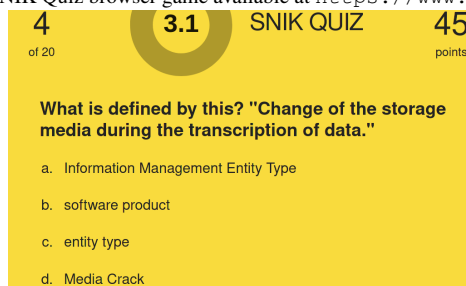


Figure 2, in which students answer multiple-choice questions about health information management (HIM), including an evaluation by domain experts and a student.

2. Methods

SNIK Quiz is an English single-player game for students of Medical Informatics. This group is diverse and includes students without a background in Semantic Web technologies. Target devices are PCs, tablets and smartphones, so multiple operating systems and input methods need to be supported. SNIK Quiz is designed as a multiple choice quiz with at most four possible answers and published as an open source web application. We employ an approach similar to Clover Quiz [6], which shows that Linked Data knowledge bases can be used to semi-automatically generate cross-domain multiple-choice questions on DBpedia [7]. For each question (*stem*), we generate a correct answer (*key*) and one or more incorrect answers (*distractors*). The data is semi-automatically generated using SPARQL queries on SNIK, such as Listing 1, followed by minimal postprocessing to achieve more natural looking questions. The graph structure of SNIK allows the generation of difficult distractors by using entities semantically close to the key, us-

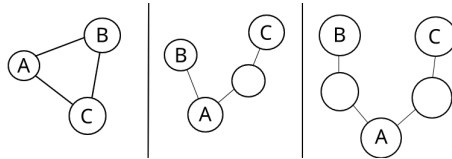
²Source code available under the MIT license at <https://github.com/snikproject/quiz>. The user interface is a fork of <https://github.com/davidrayoussef/react-quiz>.

Listing 1: SPARQL query generating the key and distractors for the *definition* questions.

```

SELECT SAMPLE(REPLACE(STR(?def),STR(?cl),"X","i") AS ?def) SAMPLE(STR(?cl
) AS ?cl) SAMPLE(STR(?a1l) AS ?a1l) SAMPLE(STR(?a2l) AS ?a2l) SAMPLE(
STR(?a3l) AS ?a3l) {
?class a owl:Class; rdfs:label ?cl.
FILTER(LANGMATCHES(LANG(?cl),"en"))
?class skos:definition ?def.
FILTER(STRLEN(?def)>10&&STRLEN(?def)<600).
FILTER(LANGMATCHES(LANG(?def),"en"))
?class (!(meta:subTopClass|rdf:type)){1,2} ?a1,?a2,?a3.
owl:Class ^a ?a1,?a2,?a3.
FILTER(?class!=?a1&&?class!=?a2&&?class!=?a3&&?a1<?a2&&?a2<?a3)
?a1 rdfs:label ?a1l. FILTER(LANGMATCHES(LANG(?a1l),"en"))
?a2 rdfs:label ?a2l. FILTER(LANGMATCHES(LANG(?a2l),"en"))
?a3 rdfs:label ?a3l. FILTER(LANGMATCHES(LANG(?a3l),"en"))
} GROUP BY ?class LIMIT 1000

```

Figure 3. Left to right: correct answer, difficult and easy distractor for the *intertwined* question type [8].

ing path lengths of at most 2 in the graph. Evaluation uses semi-structured interviews with standardized questions but partly open answers: Expectations for “good” simple and complex questions are asked. Then, each question category is rated on a scale of 1 to 10. Each question is commented based on the individual criteria of the first step. Finally, the subjective influence is noted on: length of the question and answers, interconnectedness of the content and semantic similarity of the key and distractors.

3. Results

The resulting question data is generated by templates, see Table 1, which are designed to either train basic facts or more complex patterns. The question types definition and subject were presented in a first prototype to students of Medical Informatics during the international Frank van Swieten lectures in 2019 and were positively received. An extended version of SNIK Quiz including the query types definition, definitions, subject, intertwined, closeMatch and occurrence was rated by two experts of hospital information management and one student of Medical Informatics, see Table 2.

4. Discussion

Like Clover Quiz [6], SNIK Quiz contains basic questions that refer to singular facts. These questions were received positively during the Frank van Swieten lectures and the

Table 1. Quiz question templates with examples. By default distractors are neighbors of degree at most 2.

Template	Description
Subject	Ask for the subject of a (subject, relation, object) triple given the relation and object.
Stem	<i>Who is responsible for Medical Admission?</i>
Key	<i>Physician</i>
Distractors	<i>Surgeon, Health Care Professional, Senior Physician</i>
Object	Ask for the object of a (subject, relation, object) triple given the subject and relation.
Stem	<i>The Specification Team is responsible for...</i>
Key	<i>Functional Specification Document</i>
Distractors:	<i>Project Team Member, Sponsor, Defining Project Organization</i>
Definition	Ask for the entity that fits the given textbook definition.
Stem	<i>What is defined by this? "X assures a defined quality of all processes and outcomes of the hospital"</i>
Key	<i>Internal Quality Management</i>
Distractors	<i>Activity, Complaint, Diagnosis</i>
Definitions	Present different definitions and ask, which of them fits the given entity.
Stem	<i>What defines the term Data Warehouse System?</i>
Key	<i>Application component that contains data which have been extracted from other application components, in order to support either hospital management or clinical research.</i>
Distractors	<i>Defines the hospital's long-term strategic goals, An application component where the controlling rules for data processing are implemented as executable software, Summarizes monitored key performance indicators (KPIs) and compares them to the expected future state</i>
Intertwined	The correct answer and distractors are connected as shown in Figure 3.
Stem	<i>In the context of Strategic Information Management, which one of the following triples belongs together the most?</i>
Key	<i>Chief Information Officer – Department of Information management – IM Staff</i>
Distractor 1	<i>Chief Information Officer – Strategic Gap – Corporate Strategy</i>
Distractor 2	<i>Chief Information Officer – Ticket Evaluation – Project Monitoring</i>
Occurrence	Ask whether a given term is defined in one of the textbooks [3,4], both or neither [8].
Stem	<i>In which contexts does the term "Health Insurance Company" occur?</i>
Key	<i>Strategic Information Management</i>
Distractors	<i>Tactical Information Management, Both Contexts, Neither</i>
CloseMatch	Transfer knowledge about one textbook [3] to the other [4] by confirming or denying statements about entity pairs that are marked as near equivalent [8].
Stem	<i>In the Strategic Information Management, the Consultant is associated with the Long-Term HIS Planning, while in the Tactical Information Management, the Consultant is responsible for the Functional Specification Document. (Key: True, Distractor: False)</i>

evaluation ratings on subjective complexity show promising results. Questions that test the understanding of relationships involving multiple facts have been successfully evaluated for middle school questions using an ontology of biology [9], however the style of questions was deemed to be repetitive by two of the evaluating teachers. SNIK Quiz uses multiple templates in order to achieve a more varied question style. A limitation of

	definition	definitions	subject	intertwined	closeMatch	occurence
interview 1	4	3	5–6	7	8	7
interview 2	6	4	7	7–8	7–8	5
interview 3	3	3	6	8	8	7

Table 2. Interviewee rating on subjective complexity of the questions on a scale between 1 and 10 [8].

SNIK Quiz is that qualitative feedback on complex questions is mixed. One of the experts questioned the didactic value of the *intertwined* questions, as the users cannot know the exact graph structure of SNIK and thus may have difficulties deciding, which triplets of concepts are most strongly connected. While the complexity of *closeMatch* was rated the highest, it was seen as mostly grammatical rather than caused by relationships between entities. Contrary to the initial assumption, shorter questions were preferred as they could be read more quickly. Questions should also clarify that the least specific correct answer is expected in cases such as the example for the subject template in Table 1: As a subclass of the correct answer “physician”, each “senior physician” is also implicitly responsible for medical admission and for “health care professionals” (superclass of physician) this is at least partly true. As SNIK can only cover the domain of HIM as described by the underlying textbooks, distractors may actually be correct answers in the real world.

5. Conclusions

SNIK Quiz shows that HIM knowledge can be used to semi-automatically generate multiple-choice questions. Analysing questions also helps to uncover and fix missing and incorrect facts in SNIK. While preliminary evaluations show promising results, complex question types need to be investigated further. Future work should also include a quantitative evaluation of learning efficiency when supplementing courses with SNIK Quiz.

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