Constructing Curriculum Ontology and Dynamic Learning Path Based on Resource Description Framework

Makoto Urakawa, Masaru Miyazaki, Hiroshi Fujisawa,

Masahide Naemura, Ichiro Yamada

NHK (Japanese Broadcasting Corporation), 1-10-11,Kinuta,Setagaya-ku,Tokyo,Japan
{urakawa.m-gi, miyazaki.m-fk, fujisawa.h-ja, naemura.m-ei, yamada.i-hy}@nhk.or.jp

Abstract. Curriculum for school is generated based on the academic year. Because students have to study several subjects each and every year, the relative topics are put into curricula in discrete. In this study, we propose a method to construct a dynamic learning path which enables us to learn the relative topics continuously. In this process, we define two kinds of similarity score, inheritance score and context similarity score to connect the learning path of relative topics. We also construct curriculum ontology with Resource Description Framework (RDF) to make the dynamic learning path accessible and to make education materials integrated with a suitable learning step. Using the curriculum ontology, we develop a learning system for school which shows a dynamic learning path with broadcasted video clips.

Keywords: Ontology, resource description framework, knowledge graph, learning path, linked data, curriculum, education, natural language processing

1 Introduction

In Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) establishes the curricula[1] [2] in HTML and PDF. A curriculum has items according to a subject and academic year. An example of items is “to confirm the process of cell division and relate it to the growth of creatures,” and the topic of this item is “cell division and growth of creature.” Because students have to study several subjects each and every year, the relative topics are put into curricula in discrete. For example, the science curriculum for a junior high school covers “refraction and reflection of light,” “ cell division and growth of creature,” “weather observation,” “DNA,” and so on, and the science curriculum for a senior high school covers “genetic information” and “expanding universe” and so on. If a student, who cannot understand

[1] http://www.mext.go.jp/a_menu/shotou/new-cs/youryou/chu/ri.htm

[2] http://www.mext.go.jp/component/a_menu/education/micro_detail/__icsFiles/afieldfile/2011/04/11/1298356_5.pdf (referred for explanation in English)

"genetic information" in senior high school, reviews the topic of "DNA" studied in junior high school, he/she can strengthen the foundation for learning about "genetic information." The primary objective of this paper is to extract learning paths based on words from the curricula and make the paths accessible by a curriculum ontology of Liked Open Data format. We also propose an approach integrating learning materials with appropriate topic on learning path by utilizing the ontology.

The remainder of this paper is organized as follows. Section 2 discusses related work. Section 3 introduces constructing the curriculum ontology and the application we developed for students. In Section 4, we provide our conclusions.

2 Related Work

The British Broadcasting Corporation (BBC) published a curriculum ontology[3] that describes the United Kingdom (UK) national curricula [1]. It represents the importance of organized learning resources. However, it does not enable us to learn the relative subjects continuously and dynamically. Study of ontology design [2] [3] divides certain ontology, for teachers, learners, syllabus and subject. These approaches focus on a system to manage a layered ontology, and the syllabus is classified by string similarity based on only common words [3]. To focus on building learning sequences [4], an ontology is used to generate course learning paths. However, this can be achieved by experts and needs external resources. We focus on the way of extracting paths from the present curricula and making them easily integrated with learning materials by an ontology.

3 Constructing Curriculum Ontology

To extract learning path from curricula, we interrelate the two items in the curricula using an inheritance score and a context similarity score. Figure 1 depicts the inheritance and the context similarity score to find the relationship between two items. In the process of calculating the inheritance score, we first arrange 232 items in the science curriculum for junior and senior high school in order of their appearance. Then, all words appeared in the items are classified as new entry or previously used ones. The inheritance score is defined by the ratio of common words in the target item and the following item. The parameter *t* in Fig. 1 shows the number of new entry word in the target item and *s* is the number of succeeded word to the following item. The context similarity score is defined by the average value of cosine similarities among all combination of words appeared in the items. Here, each word is represented by a feature vector which is calculated using their grammatical context and has been distributed by ALAGIN forum.[4] Although all the items in the curricula are written in Japanese, the text was translated into English for the present purposes in Fig. 1.

[3] http://www.bbc.co.uk/ontologies/curriculum
[4] https://alaginrc.nict.go.jp/

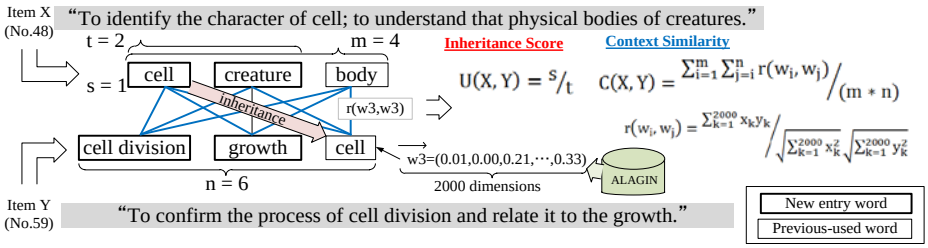

Fig. 1. Overview of process for identifying the relationship between items

We construct the curriculum ontology in reference to item relation with the max score of inheritance and context similarity. Figure 2 presents an example of individual instances generated from the ontology. We defined "http://cur.nhk.or.jp" as a namespace only for this study. The class "cur:ItemOfStudy" is the main role for generating the learning path. The object property, "cur:hasReview" functions as a connector of individual instances belonging to "cur:ItemOfStudy". For example, "cur:Item00060" and "cur:Item00059," "cur:Item00059" and "cur:Item00048" are connected. That is why it is easy to get the item for review before studying "cell division" by SPARQL query. This ontology also covers the necessary information for such subjects, the school level and so on.

Learning materials such as videos should align with a specific item being studied. To solve this challenge, we retrieved the words to study afterwards for each item from the ontology. For example, we can understand that these words such as "sexual reproduction," "meiosis" are the words learned afterwards for "cur:Item00059". Therefore a video clip explaining "meiosis" is not appropriate to integrate with "cur:Item00059" even if the video has the words studied at "cur:Item00059" such as "cell." After calculating the videos suitable for each item, we updated the curriculum ontology. For example, the video about "cell division and chromosome" is integrated with "cur:Item00059" by "cur:hasClip." We actually experimented with videos, which are published by "Japan Broadcasting Corporation (NHK) for School,"[5] by extracting words from them and finding a suitable learning item.

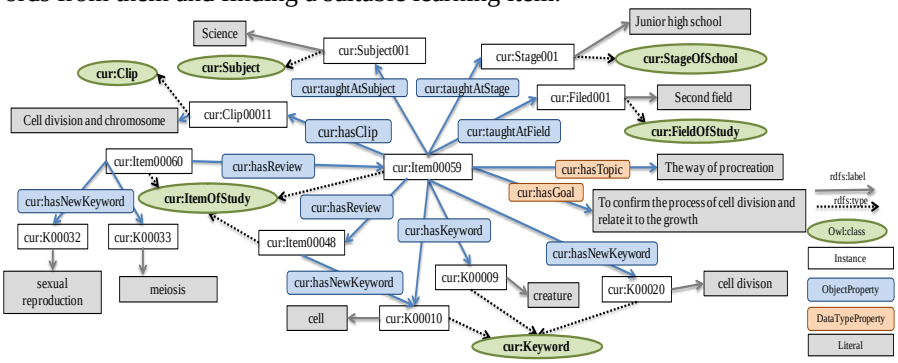

Fig. 2. Example of individual instances of an ontology

[5] http://www.nhk.or.jp/school/

We developed an application that generates learning paths with education videos by retrieving them with SPARQL query. In the Figure 3, the learner can view the relevant videos with several leaning paths from the item they study “cell.” This application helps learners comprehend their learning stages and the subsequent steps. Learners also can utilize educational materials, such as videos, that align with their respective learning stage.

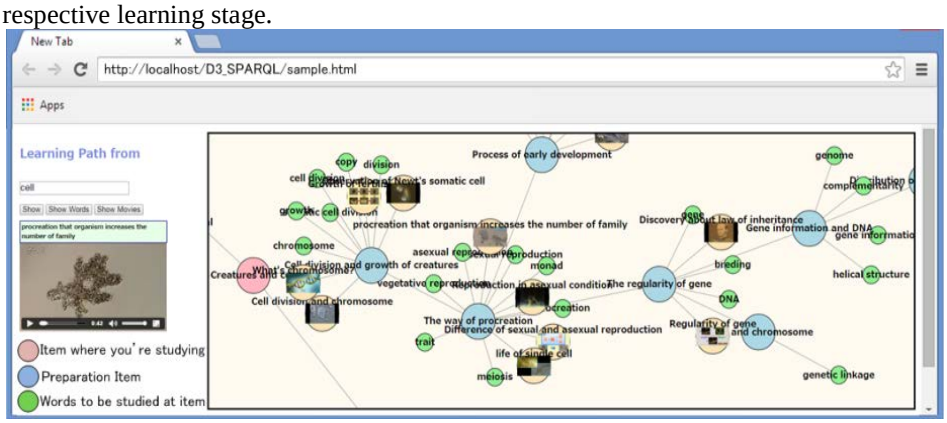

Fig. 3. Application utilizing dynamic learning path

4 Conclusion

In this paper, we proposed a method to construct the learning path by definition of two kinds of similarity score, inheritance score and context similarity score. We also constructed curriculum ontology with RDF to make the dynamic learning path accessible and integrated video materials with a suitable item based on the words that should be studied at the given item. Using the curriculum ontology, we developed a learning system that users can dynamically navigate a learning path with broadcasted video clips for review or preparation. In future work, we plan to experiment the effectiveness for teachers and students, and launch its service in NHK. Furthermore, we intend to link the curriculum ontology to the other subjects such as math.

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