Estimating the Curriculum Coverage of a Learning Object Repository

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Abstract. This paper focuses on a method for estimating the level of curriculum coverage for a Learning Object Repository. A case study was conducted on the basis of the national Learning Object Repository called Waramu in Estonia. Localized LRE Thesaurus was used for mapping the national curriculum of primary and secondary schools with e-learning resources stored in Waramu repository. This case study explores the ways of mapping the Learning Objects with curriculum taxonomy and calculating their weights. The proposed method allows to analyze the needs for additional financing and learning resource development efforts in certain curricular domains.

Keywords: curriculum, repository, metadata, learning resource types.

1 Waramu – the national Learning Object Repository

During the last ten years, various standards and specifications have emerged in the rapidly evolving field of Technology Enhanced Learning (TEL). Among these standards and specifications, there are only few that are implemented on the wider basis. There are tens of Learning Object Repositories (LOR) around Europe have application programming interfaces (API) like Simple Query Interface (SQI) [1] that allow federated search between interconnected repositories. Support for metadata harvesting protocols like OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting) [2] is also becoming a common feature of repositories. Although many national repositories have developed their own Learning Object Metadata (LOM) application profile, more than 16 national repositories are compliant with European Schoolnet's Learning Resource Exchange LOM Application profile (LRE LOM) [3].

The similar developments have been taking place in Estonia, within the framework of two joint European projects that were coordinated by the European Schoolnet: Calibrate and MELT. Since 2007, an original standards-compliant repository Waramu has been developed by the Centre for Educational Technology in Tallinn University. Repository was tested and implemented by the Tiger Leap Foundation – an agency responsible for implementing the national ICT strategy for Estonian schools.

Waramu is an open-source repository for storing and sharing digital Learning Objects and/or their metadata. It is licensed under BSD license. Waramu is developed

using Java, it runs on Glassfish application server with MySQL database. Waramu supports IEEE LOM and Dublin Core metadata standards but alternative metadata schemas can be added. It interacts with other applications (e.g. Learning Management Systems) through SOAP Webservice. Through SQI, Waramu is connected to FIRE federation and European Learning Resource Exchange (http://fire.eun.org). Waramu supports OAI-PMH protocol for metadata harvesting which makes it possible to search and browse the metadata of Learning Objects in Waramu via LRE portal (http://lreforschools.eun.org). Waramu was initially developed without having any user interface, as it was meant to be used only by other applications via Webservice. As there are currently only few applications that are able to make use of this Webservice, a Metadata Portal application was developed. The Metadata Portal allows users to upload the resources to Waramu repository, manage the metadata of these resources, browse and search the resources stored in the repository. A pilot instance of the Metadata Portal is available at http://ait.opetaja.ee/MetadataPortal/. It is designed for the needs of primary and secondary schools of Estonia. There is more than 3100 learning resources uploaded to Waramu repository, most of these are developed by the Estonian teachers and uploaded by the subject matter experts from the Tiger Leap Foundation. User can browse the content of Waramu repository by using different meta-data fields as filters: user-defined tags, learning resource type, subject title, curriculum taxonomy, language, age range of the target group. In the example presented in Figure 1 the content of the LOR is listed by subject titles.

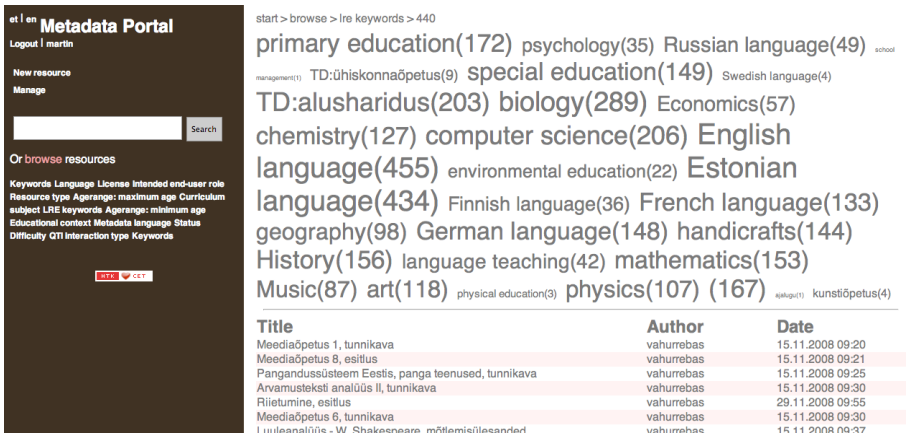

Fig. 1. The tag cloud view to the Metadata Portal.

The source code and additional information about Waramu development project is available from the Web site http://trac.htk.tlu.ee/waramu.

2 The need for estimating the curriculum coverage of LOR

During the Waramu development process, a question was raised by the Tiger Leap Foundation – to what extent the national curriculum of primary and secondary schools in Estonia is covered by the digital learning resources of good quality? What topics are covered and where is need for developing new resources? Existing metadata did not answer those questions. Based on metadata information it was possible to investigate what types of learning resources are available for each curriculum topic.

The titles of curriculum topics in Waramu metadata application profile are based on the LRE Multilingual Thesaurus [5]. This is hierarchical classification with fixed vocabulary for describing the e-learning materials. Fixed vocabulary enables to translate keywords automatically from one language to other. This is necessary for increasing the LOR interoperability in a network of interconnected repositories. Because the national curricula in different countries overlap only in general level the thesaurus taxonomy is not good for answering our research question. An alternative method was needed for deeper investigation.

The goal of our study was to find out how the topics of primary and secondary school curriculum are covered by e-learning materials in the repository Waramu. What is the overall situation and where are the blank spots of on the curriculum map that are not covered by learning resources? The expected outcome was a report that could serve as an input for strategic planning of future investments in the development of digital learning resources by the Tiger Leap Foundation.

3 Description of the study process

Our study was carried out as an action research exercise and consisted four phases:

1. Adaptation of the curriculum taxonomy.
2. Integration of the modified curriculum to the LOR.
3. Connecting the e-materials in the LOR with curriculum topics.
4. Presentation of results, feedback and discussion.

A set of high-quality Web-based learning objects were identified, their metadata was created and submitted to Waramu repository by a group of subject matter experts. These experts have their everyday work as teachers in different schools around Estonia, but they are also hired by the Tiger Leap Foundation as the moderators of the educational portal Koolielu (http://www.koolielu.ee). All of the subject matter experts are experienced teachers in their curriculum domain and also in the domain of educational technology. They are enthusiasts in TEL who are actively developing online learning resources, they use frequently digital resources in teaching and sometimes train other teachers. All together 24 experts were collecting metadata of the 3131 learning objects belonging to 28 different curriculum subjects.

The national curriculum for primary and secondary schools of Estonia is an official document that was put into force by Estonian government on 1th of September 2002 [4]. All teaching in public and private schools in Estonia must be conducted in

accordance with this document. All subject programs, textbooks and final examinations are based on the official curriculum. Although this document is relatively old and the new curriculum is under development we decided to start our curriculum coverage estimation exercise with the existing curriculum.

The national curriculum describes the basic requirements, learning goals, activities and content for each subject. In order to estimate the curriculum coverage of Waramu repository we decided to focus on the content sections. This selection was made because in existing curriculum the part of the learning objectives and activities were too short, confusing and very difficult to taxonomise. We claim that the existing national curriculum for primary and secondary schools in Estonia is mainly oriented on describing the learning content and topics. This is why it made sense for us to use the topic-related taxonomy also for our curriculum coverage exercise. Using the content topics instead of activity-related learning outcomes was also the simplest and fastest way to start the curriculum mapping of the learning resources. The alternative way would have been to develop the new objective-based curriculum taxonomy but this approach was rejected by our subject matter experts as too much work-consuming. In the future, there would be an interesting continuation for our project if we could evaluate curriculum coverage of learning objects according to the type of learning activities they promote. In this case, the curriculum mapping of the learning resources should be conducted on the basis of taxonomy suggested by Van Assche [6], who has combined a restricted taxonomy of action verbs based on Bloom's taxonomy with reduced taxonomy of curriculum topics.

Based on the learning content description the hierarchical classification of the learning topics was created. The overall structure of the Estonian national curriculum learning content is following:

1. First level – subject name (e.g. Math).
2. Outline level 2 – School level (1th level – grades from 1 to 3 – students from age 7 to 9, 2th level – grades 4 to 6, 3th level – grades 7 to 9, 4th level – grades 10 to 12).
3. Outline level 3 – Learning content – broad subpart of the subject (e.g. Geometry)
4. Outline level 4 – Topic (e.g. circle)
5. Outline level 5 – Sub-topic (area of the circle)

The first problem what appeared during making this hierarchical classification was the heterogeneity of the curriculum. The description of the different subjects was presented in different wais. For example in Math it was easy to generate well structured outline list of topics when in some other subject e.g. Russian Language the content was presented in long text paragraphs and to generate outline list from that was almost impossible. The second problem was variation in outline list levels. In some subject the maximum level was 4. Mostly it was 5 but in some subjects it was 6. The third problem was the variation in topic descriptions. Some descriptions were too long, some of them to narrow or to broad.

To ensure the unified structure of the curriculum the subject experts were asked to look trough the initial outlined list of learning topics and modify it as needed. Mostly they created shorter descriptions for the topics (they decreased the descriptions from one sentence to some words), combined smaller topics in to new and bigger one and in some cases divided bigger topics in to smaller parts. In some subjects (e.g. In Estonian Language) expert deleted all topics from the last outline level. This made

overview of the content clearer and shorter. In one subject (e.g. Art) subject expert contacted with other experts of that field and they changed radically the structure of the classification. They clamed that every learning material can be used for every school level and throw away the levels. This generated some problems to other experts who started to use this heavily modified part of the curriculum. Basically artists don't like hierarchical classification while teachers from natural sciences are OK with them.

After the curriculum modification it was integrated to the repository. For this purpose we created new metadata field in the LOR database. In the LRE LOM information model [3] the classification element can be used for this purpose. The initial classification was created according to LRE Thesaurus vocabulary. This was mandatory because of the European projects MELT. LRE LOM XML binding allow up to 40 different classifications. In LOR user interface the curriculum was presented in dialog window. In this window user was able to define the LO position in the curriculum step by step. Te final selection was presented in curriculum field. User was allowed to define more than one connections between LO and the curriculum. Based on user selections the numeric code of the curriculum topic was stored in database. Based on database information the XML stream was generated.

```
<classification>
    <purpose>
        <source>LREv3.0</source>
        <value>discipline</value>
    </purpose>
    <taxonPath>
        <source>
            <string language="en">
                Estonian Curriculum
            </string>
        </source>
        <taxon>
            <id>06030303</id>
            <entry>
                <string language="en">
                    Math-III-Geometry-Circle
                </string>
            </entry>
        </taxon>
    </taxonPath>
</classification>
```

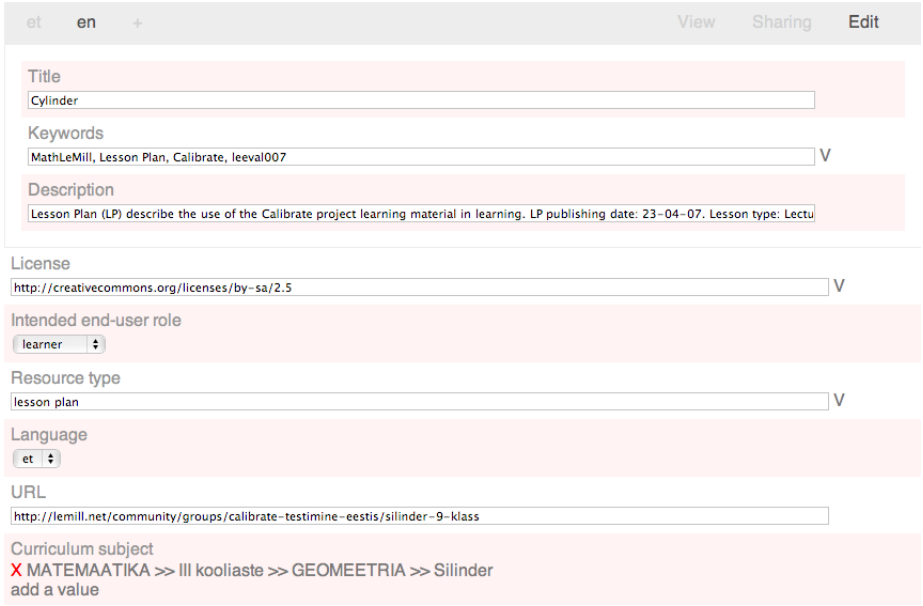

Fig. 2. Repository metadata form. The last field is for Curriculum mapping.

The final task of the curriculum mapping was held in the end of year 2008 when 24 subject experts defined connections between e-materials and learning topics in the curriculum. For this activity they used Metadata Portal – the UI for Estonian repository. Approximately 3000 LO's were mapped with the curriculum topics.

3 Results

Unfortunately not all subject matter experts had time to adapt their part of the curriculum taxonomy or to define the connections between the e-materials and the curriculum. The curriculum on 5 subjects (out of 28 was not modified) and in 7 subjects the mapping was not taking place.

The biggest question was how to measure the coverage of the topic in the curriculum by the digital learning resources? What kind of learning resources should exist until we can say this topic is 100% covered? For this purpose the learning resource type was used. In LRE LOM application profile the vocabulary of the learning material type is fixed. For the coverage analysis the existing vocabulary is too wide. To simplify the situation the resource types were grouped and some types that were never used were left out.

Then the total weights for each resource type were estimated. The weight describes how big part of the topic is covered when one specific type of resource is available. E.g. when the lesson plan for specific topic exists we can approximately say that the 25% of the topic is covered. The authors of this article defined the first set of weights

which was then presented to the subject matter experts who suggested some modifications (12 experts out of 24). We calculated mean from the experts' estimations and use those ratios for calculating the overall coverage of the subject.

In the following list you can see what are the learning resource types and how we decided to group them. They are sorted based on chronological order how they can appear during the lesson or the course. The first number behind the type presents the amount of specific resource type in Estonian repository. The percent describe the weights for the specific resource type or group.

1. Lesson plan (571 LO's) - 10% weight
2. Presentation (934) - 20%
3. Exercise and text (910) - 30%
   a. drill and practice (703)
   b. guide (187)
   c. glossary (20)
4. Assessment (206) - 20%
5. Course (235) - 60%
6. Additional materials (306) - 25%
   a. web page (259)
   b. reference (47)
7. Media files (72) - 25%
   a. image (68)
   b. audio (3)
   c. video (1)
8. (Inter)active (63) - 40%
   a. exploration (30)
   b. simulation (19)
   c. educational game (10)
   d. open activity (2)
   e. demonstration (1)
   f. experiment (1)

In the LRE LOM Resource Type vocabulary there are some type names that make problems when they are used for content description. One of them is "course". It is used widely for describing bigger collection of learning materials. In some cases it is full course with lesson plans, presentations, exercises and assessment materials and they cover fully one or more topics in the curriculum. In some cases they are collections of one specific resource type e.g. collection of presentations. For this reason it's difficult to define the covering weight for that type. Another problematic resource type is Web Page (also Blog and Wiki). They describe more the medium of the material delivery and not the content of the material.

Based on those weights we calculated how well the topics, subjects and full curriculum is covered by the e-materials. For calculation we made formula what counted every resource type or group per topic only once. E.g. when for one topic there was 2 different lesson plans then the coverage of the topic is 25% not 50%. Otherwise the topic will be 100% covered when 5 different lesson plans are related with it. We also did not let the sum get bigger then 100%. For example for one topic there can exist lot of materials from wide range of resource types. All together they can give sum like 200%. Another topic doesn't have content at all – 0% covered. But together they are covered by 100%.

Figure 3 below presents how the national curriculum is covered by digital learning resources stored in the Waramu repository. The average coverage of the curriculum is 16%.

What factors influence the level of coverage of a curriculum subject by learning objects? Based on our data, the first answer could be quite logical – coverage is better when the amount of the content for this subject is bigger. The correlation between coverage estimate and quantity of the resources was statistically important (0.467). It

also seems that the curriculum is better covered when the classification of learning resources is kept simple. When the topic includes less sub-topics then the coverage is better (correlation -0.449).

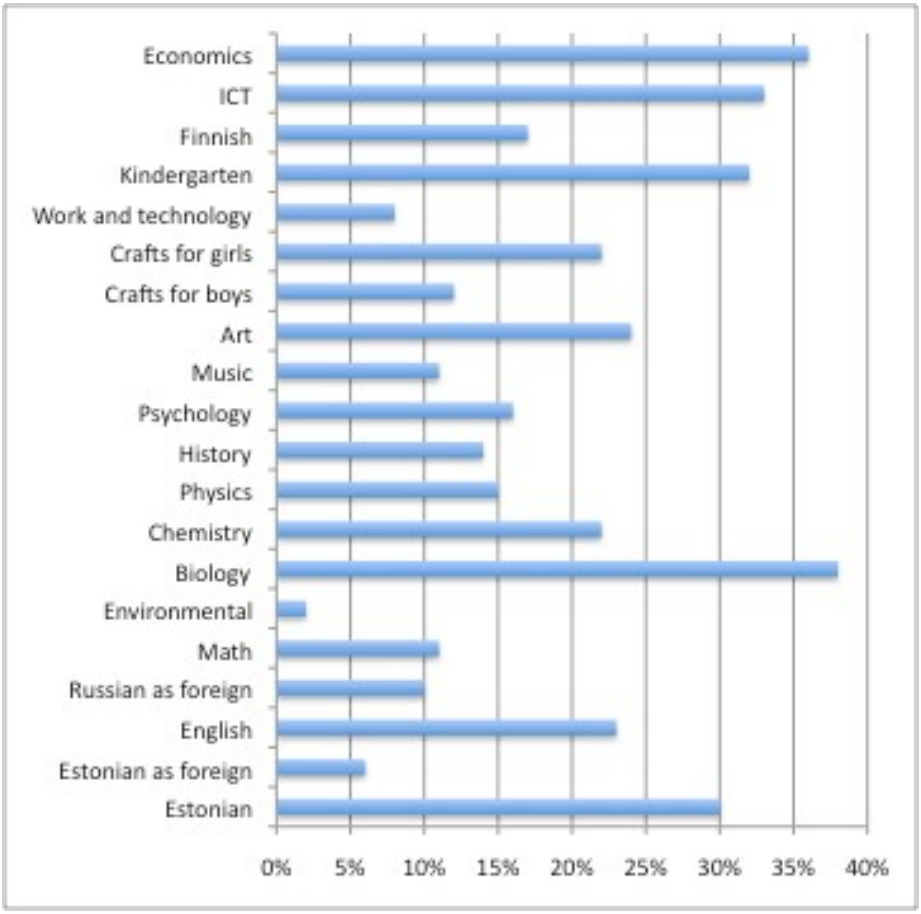

Fig. 3. The coverage of curriculum subjects in the national curriculum with learning objects in Waramu repository.

4 Open issues and future plans

Our exercise of estimating the curriculum coverage by LOR Waramu resulted with a descriptive It doesn't give full picture about the situation in the country. In order to have a wider perspective we need to:

1. Start curriculum mapping in subjects where it was not yet done.
2. Continue with adding metadata of learning materials. There are several additional learning portals or subject community web pages that store learning materials but have no metadata.

Information what was collected during the curriculum mapping will be used for creating the new e-materials. Based on white spots on curriculum map the subject experts can make specified proposals to the content creators. Now we can clarify for what topics and in what format the content is needed? The teachers create most of the e-learning materials in Estonia. The common method for supporting the content creation is different competitions. Previously they were organized in relatively free format – all submitted resources were accepted without any validation procedure. In the future the novelty of the learning material is one very important criterion. E.g. does the material bear on the topic that was not covered previously or some new resource format is used. At the moment the MS Power Point presentation is the most popular format for learning materials. We would like to see more interactive and multimedia rich learning resources. The idea is to shift from e-materials to e-learning.

Collected information can also be used for browsing the learning materials in the educational portal. Teachers can find the e-materials by browsing the curriculum.

The biggest question that reminds is – what is the optimal size of the learning topic? To define optimal size for the topic is not only important for calculating the coverage ratio for the topics but also for users to help them to find content related with specific topic. If the topic is too broad then it is connected with to many learning materials. Users have difficulties with choosing the materials suitable for their needs. If the topic is too narrow then one learning material can be related with too many topics. The orientation in the curriculum is complicated. Topic can be larger unit then lesson. Usually it takes more than one or two lessons to handle the topic. From other hand topic can be small part of the lesson e.g. 20 minutes. Teachers agreed that topic is something that needs a schedule or plan (e.g. lesson plan), at least one introduction or description (e.g. presentation or reading materials), at least one or more exercises or tasks (e.g. drill and practice) and some assessment resources.

The mapping result was presented to the subject matter experts. One goal was to collect feedback from the active users of LOR. 12 experts (out of 24) filled in the feedback questionnaire. Most of them agreed that the average ratio of the curriculum covered by the e-materials describes the real situation. Most of them declared that national curriculum is good interface for browsing and searching the learning resources. Only one expert had opinion that the structure of textbooks should be used for navigation in learning portals. This solution was discussed during the repository development but was left aside because there are different books with different structure for the same subject in the same grade.

The experts who participated in the adaptation of the curriculum taxonomy for their subject were satisfied with outcomes of our study and evaluated our estimation of curriculum coverage as valid one. The experts who didn't have time to change the outlined topic list of the curriculum did not answer to the feedback questionnaire. The only issue where experts didn't find common language was inclusion of the school level (or: age range of the target group) as a category for classification of learning resources. 58% of the experts had opinion that presentation of the school level inside of the content classification makes mapping and browsing easier. 42% of the experts

suggested that school level should not be included in the taxonomy of the curriculum taxonomy, as this information is stored in age range field of LOM.

Expert users did not mention the need for the domain classification by learning objectives or by the learning activities. It seems like Estonian school is not ready for goal-oriented curriculum. Some users desired to present the holistic picture of the curriculum – the hierarchical structure of the content of the entire subject where all digital learning resources are presented next to the topics. This is possible with the hyperbolic tree approach [7] and can be concerned in the future development.

In general, our approach for estimating the curriculum coverage of the Learning Object Repository worked well in the Estonian context and provided the expected results that can inform policy-makers in their decision-making about future investments in Learning Object development. Yet we expect that in the future, when the new national curriculum will introduce a competency-based approach for describing the course of learning in primary and secondary schools, our method should be adjusted to it and combination of the activity-based and topic-based curriculum taxonomies should be considered as an alternative for categorizing the learning resources.

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