EFFICIENCY OF DEVELOPMENT OF E-LEARNING MATERIALS BASED ON LEARNING OBJECTS

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Abstract: The paper describes development of e/learning materials at Belgrade Metropolitan Universities based on fine/grained learning objects. Authors use mDite authoring tool developed by BMU to create a multimedia online lesson, dat is managed and delivered to student by LAMS *Learning Activity Management System. Author implemented this approach to develop courses for a short-cycle program "Programming in Java" with 13 short courses, by using existing learning objects developed for a bachelor program "Software Engineering". It is demonstrated that fine-grained learning objects retrieved from BMU Leering Objects Repository significantly increased efficiency of development of learning materials and allowed easy customization of online lessons.

Keywords: *E-Learning, Distance learning, online, learning objects, development of e/learning materials*

1. INTRODUCTION

Fine-grained learning objects have been used for development of learning materials for all courses at Belgrade Metropolitan University. All authors use mDita authoring tool developed at BMU [4] for developing their learning materials that are managed and presented to students by LAMS (Learning Activities Management System) [5]. Each online lesson usually contains 10-15 learning objects. Authors develop new learning objects and store them in BMU repository of learning objects (LOs) for future use also by other authors, if they need. Currently, LO Repository of BMU contains more than 50.000 learning objects. Sharing of LOs increase reusability of LOs and efficiency of development of new learning materials.

Use of fine-grained LOs also allows personalization of learning materials as authors may build online lessons with different learning paths for different categories of students [1]. Each learning path contain common but also specific LOs, so the students may have different sets of LOs, designed according to their need, motivations and capabilities.

This paper[1] presents another efficient use of fine-grained LOs stored and shared in BMU LO Repository in case of development of learning materials for new courses which predominantly use already developed LOs stored in BMU LO Repository. This was the case when BMU had to develop in short time, courses for a new short-cycle program "Programming in Java", with EQF level 5 [8]. In [2] we presented this program with 11 new core online courses. This paper will focus on development of learning materials based on reusable learning objects.

2. DEVELOPMENT OF LEARNING MATERIALS FOR SHORT-CYCLE PROGRAMS

Short-cycle programs aim to educate and train students in short time (up to 18 months) for a specific job. Short/cycle programs have been introduced in higher education of Serbia in 2017 when new Low for Higher Education of Serbia [7] was adopted. Our PT&SCHE Ersamus+ project [6] provided the groundwork for this adoption of short-cycle programs. One of BMU's tasks was to implement a pilot online short-cycle program. BMU chose to develop and implement "Programming in Java" short-cycle program aiming to educate and train future junior Java programmers. The duration of the program is 12 months and it provides 60 ECTS.

The European ICT Professional Profiles [9], which defined 23 work profiles, i.e. jobs at the first two hierarchical levels, leaving the third level to be define by ICT companies and ICT educators. According to this, BMU specified the job profile: "Java programmer" at the third level and launched the SCHE program "Programming in Java". Our work profile "Java Programmer" is the specialization of the work profile

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"Developer", specified at the second level of ICT work profiles.

European ICT Professional Profiles specifies, for each workplace, the following: job description, performance, main tasks and competencies, in the form of e-competences defined in the document *E-Competence Framework (e-CF)* [10]. For the *Developer* position, it has been defined that it must have five e-competencies listed in the *E-Competence Framework document (e-CF*) [7]: B.1. Design and Development, B.2. Systems Integration, B.3. Testing, B.5. Document Production, and C.4. Problem Management.

Having in mind these competences, and the Body of Knowledge (BOM) of BMU BSc program "Software Engineering", a subset of it was created representing the BOM for short-cycle (SC) program "Programming in Java" (Fig. 1). We identified 19 courses of BSc Program "Software Engineering" that use some parts BOM specified for SC program "Programming in Java", lasting 12 months and providing 60 ECTS. We decided to create two versions of SC program: one with 13 core online courses (Fig. 1) and another one with 11 core and one elective online courses. So, the problem was how to map 13 SC courses from 19 BSc courses (Fig. 1).

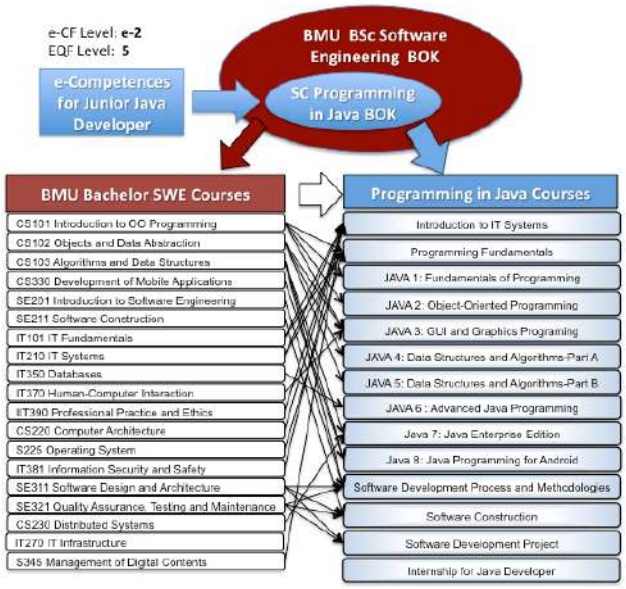

Figure 1: Creation of SC courses by selecting relevant LOs from BSc courses

As all our learning materials consists of small/grained learning objects (LO) the mapping problem became easy one, as we had just to select some LOs for BSc Courses and put them into one of CS courses (Fig. 2).

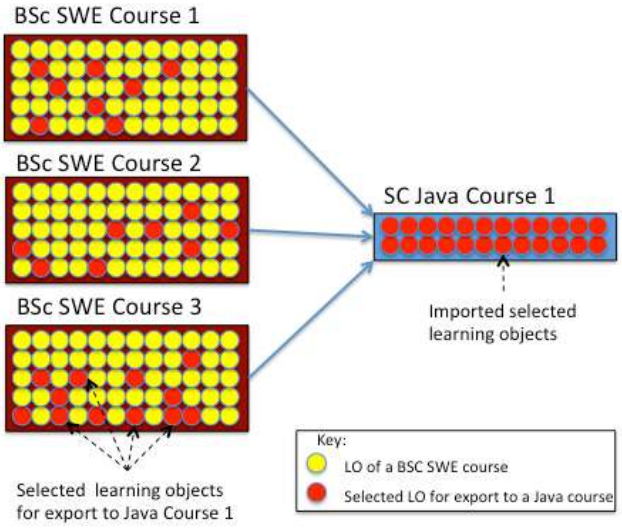

Figure 2: Selection of relevant LOs from BSc courses to create SC course with needed LOs.

The creation of SC course is not finished after putting selected LOs in its basket. We have to decide about the order of LOs. Now we face a specific feature of SC courses and comparison, with BSc courses. As SC courses are created for student that need to get practical knowledge and skills, and have, in general, lower learning capacity then students of BSc courses, we decided to implement a different learning methodology. Instead of putting all lecture objects together, as in case of SC courses, we decided to create at least several smaller groups of learning objects together, followed by relevant exercise objects and assessment objects. So, we got now an online lesson of a SC course with N learning steps, consisting of three sub-steps: learning-exercise-assessment (Fig.3).

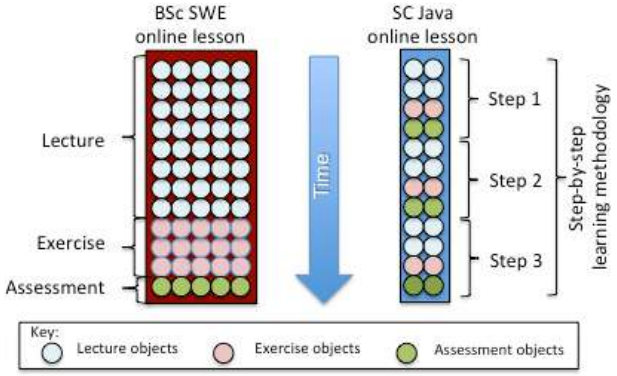

Figure 3: Implementation of "step-by-step" learning methodology in construction of SC courses

Using this development methodology of courses for short-cycle program "Programming in Java" we created its 13 SC courses presented in Fig. 4.

#	Course	Duration (Days)	Online Days (3 hrs/day)	Workshop Days 3hrs/day	Learning Hours 3hrs/day	ECTS
1	Introduction to IT systems	15	14	0	42	4.0
2	Programming Fundamentals	11	8	2	30	3.0
3	Java 1: Fundamentals of Programming	17	14	2	48	5.0
4	Java 2: Object-oriented programming	13	10	2	36	3.0
5	Java 3: GUI Programming	17	14	2	48	4.0
6	Java 4: Data Structures and Algorithms – Part A	16	13	2	45	4.0
7	Java 5: Data Structures and Algorithms – Part B	16	13	2	45	4.0
8	Java 6: Advanced Java Programming	15	12	2	42	4.0
9	Java 7: Java Enterprise Edition	24	21	2	69	7.0
10	Java 8: Java Programming for Android	14	11	2	39	4.0
11	Software Development Process and Methodology	18	15	2	51	5.0
12	Software Construction	21	18	2	60	6.0
13	Software Development Project	6	5	10	45	4
14	Internship for Java Developer (8 weeks)	40	0	0	0	3
	Agregate:	**243.0**	**168.0**	**32.0**	**600.0**	**60.0**

Figure 4: Online teaching hours and ECTS of the courses of the SCHE program "Programming in Java"

As can be noticed, the use of reusable LOs in development of new courses provides the following benefits:

1. **Efficiency:** We spent 1-3 days for developing a new SC course if only available LOs were used.
2. **Design flexibility:** Rearranging of LOs is easy and allows easy configuration of online lessons, supporting different learning models.

3. USE OF REPOSITORY OF LEARNING OBJECTS

One of main benefits of using LOs in development of e-learning materials is the *reusability of LOs.* In order to support of reusability and sharing of LOs BMU developed a repository of LOs, currently storing more then 50.000 LOs. It is important to provide an efficient system for retrieving of LOs. BMU uses the following techniques for searching and accessing required LOs:

1. Use of keywords stored as values of attributes of LOs (metadata), such as: LO title, LO keywords, difficulty level of LOs, and reading duration of LO.
2. Navigational access by using the known taxonomy of BoK.

BMU uses SWEBOK V3.0 [12] (for all SWE knowledge areas) and Computer Science Curricula 2013 [11] (for programming fundamentals) for BSc Program "Software Engineering". It can also be used for development courses of short-cycle programs, as shown in previous section. An alternative approach is to uses LOs stored in a repository of LOs. Authors of LOs are asked to specify a string specifying access path to a set of LOs using the same topic of BOK, as explained in [3]. Fig. 5 shows the structure of SWEBOK V3.0 that is used for navigational access to LOs. BMU defined a taxonomy of strings for specified knowledge areas, knowledge units, and topics.

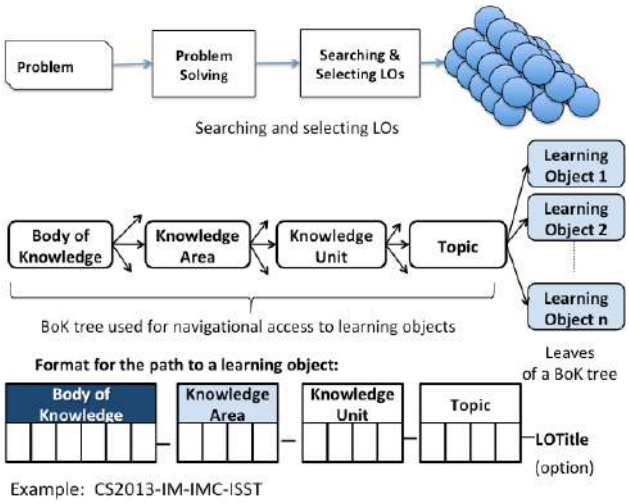

Figure 5: The structure of a BoK and the format of the path to LO

If an author of e-learning materials needs a specific LO, he has to have a look to the specification of all components of a BOK and use it to retrieve all LOs sharing the same topic of BOK, as shown in Fig. 5. Course designer then can choose the appropriate LO and import it into his/her online lesson that he/she is developing. Fig. 6 shows this development process of learning materials based on reusable LOs.

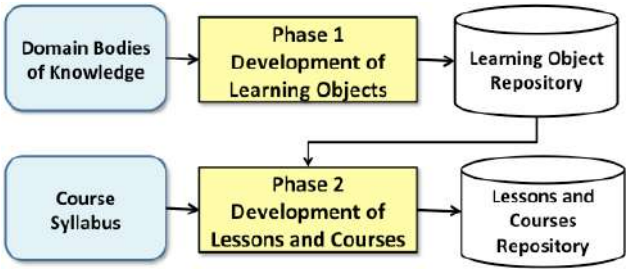

Figure 6: Development of learning materials based on shared learning objects stored in LO repository

The structure of the repository of learning objects allows to search by defined metadata. Apache Solr [13] is used as a search engine to search the repository of learning objects, who communicates with the search interface located within the mDita editor and is accessed by the author of the teaching material. The Alfresco Document Management System [14] is used to store physical files of learning objects. Within the learning object repository, the XML files of the learning objects containing the metadata are searched. The repository also contains HTML learning objects and content which is located in learning objects (images, audio and video materials, additional resources). Figure 7 shows the structure of the repository of learning objects and how the search is performed and the search results obtained are presented. The process of searching the repository of learning objects is presented in red and

the color of the defined search (results of the search) is presented in blue.

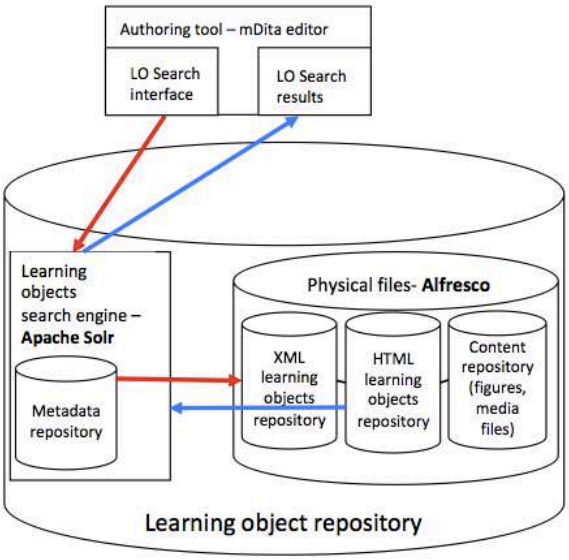

Figure 7: Learning object repository structure

The repository search is done through the authoring tool (mDita editor) which is developed at Belgrade Metropolitan University. The author of the teaching materials can search the repository using metadata (audience, object title, school year, author, goals, keywords, classification - navigation path as explained in Fig.5), goals). It is possible to search the repository also by part of the text in the learning object.

The initial search for a repository is based on the selection by the author of the teaching material, depending on the choice of how the author wants to perform the search. The author of the instructional material may define a search that requires that the metadata or part of the text is strictly matched in the learning object or that there is only a specific part of it (that part of the text entered in the search exists in some learning object and not the text entered completely in the search box). The same goes for other metadata, the author can only enter part of the classification of the learning object and thus obtain all the learning objects that have the specified part in their classification. Figure 8 gives an example of selecting metadata by which to search repositories.

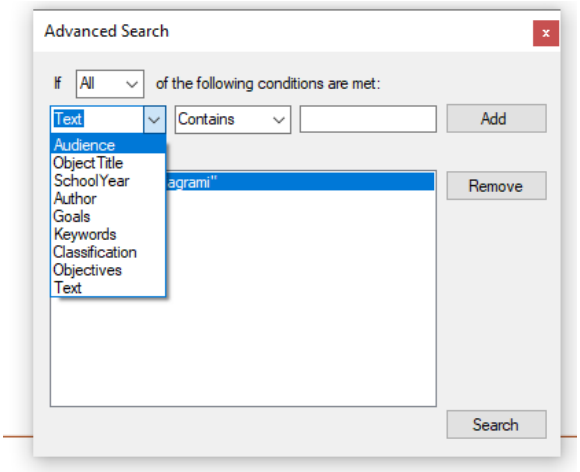

Figure 8: Selecting metadata to search the repository of learning objects

The example in Figure 9 shows a defined search within which to find a part of the learning object text that contains the words "*use case diagrams*", then that the learning object contains the classification "SEP-PIC-MPIC" and that there is an abbreviation for ATM in the name of the learning object.

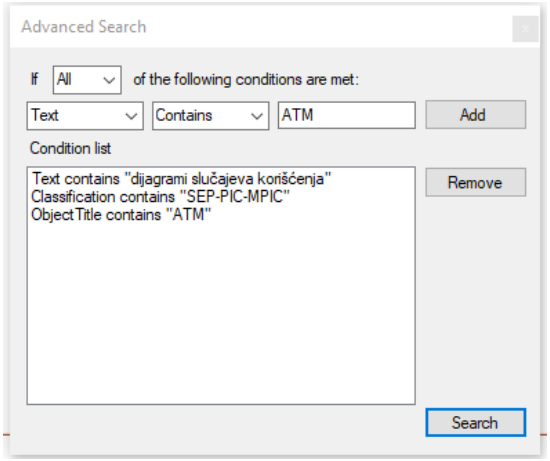

Figure 9: Defining Metadata to Begin Searching for Learning Object Repositories

When the search for the repository of learning objects is complete, the search result represents the learning object “ATM System Development”, which is shown in Figure 10. The learning object has in its name the word “ATM”, in its classification “SEP-PIC-MPIC” and in the text of the word “*use case diagrams*” The author of a teaching material can enter a learning object directly from the displayed search results in his lesson and make changes to the learning object if necessary.

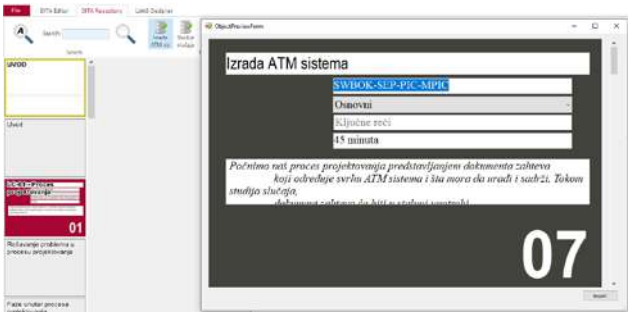

Figure 10: Repository search result obtained

When the author of a teaching material saves a new lesson in which a learning object has been added that was found through a search of a repository of learning objects, a new version of the learning object is remembered in the repository as modified by the author. The old version of the learning object also remains in the repository.

5. CONCLUSION

Development of e-learning materials based on reusable learning objects has been in implementation at Belgrade Metropolitan University since academic 2011/12 year. During these nine years, BMU has been actively

improving this development process, by improving its specialized authoring tool (mDita replaced QDita) and experimenting with personalization of e-learning materials.

In this paper we presented the use of reusable learning objects stored in BMU LO Repository for development of learning materials for the short-cycle program "Programming in Java" that use existing LOs developed previously for courses of BSc program "Software Engineering". We developed learning materials for 13 new courses of short-cycle program "Programming in Java" very easy and fast, as we mostly used already developed LOs stored in our LO Repository. We identified two major benefits of using reusable LOs:

1. Development of learning materials for new courses was easy and fast, lasting one to three days, depending of the duration of new courses. For each courses we had to select needed LO from our LO Repository and import into new learning materials. Our mDita authoring tool and mDita Repository gave us all needed functions.

2. As short-cycle program "Programming in Java" required a specific "step-by-step" learning methodology, sequencing of LOs in each online lesson was done by creating small learning step, each providing 3 sub-steps: learning a new concept, implementation of it through eaxmples and given tasks, and finalizing with assessment of achieved results. The realization this learning method, normally not used in academic programs, was easy and fast, due to the use of fine-grained reusable LOs.

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