

# MEASURING THE LEARNING PROGRESS IN A “LEARNING BY AUTHORING” SEMANTIC WEB SERVICES BASED ECOSYSTEM

Ivo Hristov, Gennady Agre and Danail Dochev

*Institute of Information and Communication Technologies, Bulgarian Academy of Sciences  
Acad. G. Bonchev St, block 2, Sofia, Bulgaria*

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**Abstract:** The paper presents the approaches and methodology for defining learning tasks and measurement of the learning outcomes in the learning by authoring environment. Assessment of the students work is made in three directions: measurement of relevance of the embedded multimedia files; assessment of the quality of the analysis made by the learner and visual appearance of entire multimedia document. The entire architecture of the project is briefly presented in order to position the tool that realizes the approaches.

## 1 MOTIVATION

The evaluation and assessment of learner’s work has never been an easy task in learning by doing environment. Many practical solutions prioritize the assessment methods suitable primary for automatic processing. In such systems the learner answers are compared to previously defined patterns. In order to facilitate the evaluation of the learner’s performance, many of the assessments restrict the potential steps and the range of activities that the learners can take. This in turn leads to restriction of the innovative thinking and creative ideas that the learners might apply. In our work we are targeting the methodology that has two major goals: first, to allow the learner wide area of possible solutions, and second, to provide as much support as possible to the evaluator when she is evaluating students work addressing learners mistakes and weak points.

The paper presents a part of the ongoing work on the SINUS project, which targets the development of specialized e-learning facilities allowing learning by-doing through learners’ authoring of specific learning materials by intensive use of multimedia digital libraries (D. Dochev and G. Agre, 2009). The SINUS environment is focused on pro-active achievement of these goals by learners’ own actions, supported by the built-in domain and pedagogical knowledge. The present paper discusses the desired functionality of a SINUS

module called pedagogical knowledge editor (PKE) used for defining learning objectives, tasks and criteria for assessing the progress of the learners. Such an assessment primary targets automatic or semi - automatic support of the learners in their work. Students can do self-assessment at every stage of their work, receiving some hints and recommendations from the system aiming at improving the accuracy of the work and suggesting concrete steps for such an improvement. On the other hand, the instructor can see the learner progress on demand; review the mistakes and helps the learner in a proper way. The next section introduces the general structure of the SINUS project in order to position the PKE and its main functionality in the entire architecture. The SINUS underlying infrastructure – software services, ontologies and semantic repositories used by the PKE is briefly described. The third section presents the approach taken for defining learning objectives and learning tasks. The aim of the approach is to enable the teacher to define the learning tasks according to terms in the domain ontology and criteria for successful task execution. The fourth section deals with the assessment of learner’s work. In our case it is a multimedia document created by the student following the learning tasks. The section describes in details the assessment of different stages of the work – on learner’s request or as final grade and explains how the system and the evaluator

measure the achievement of learning objectives. The paper concludes with a short summary of the presented approach and future work.

## 2 ARCHITECTURE OF THE SINUS PROJECT

The SINUS project ([sinus.iinf.bas.bg](http://sinus.iinf.bas.bg)) is an interdisciplinary 3 years research project aiming at advancing the two of the fastest evolving information technologies – Service Oriented Computing and Technology Enhanced Learning by applying the Semantic Web Service Methodology. The project methodology is based on adaptation and enhancement of some original methods and software components developed by the project members under FP-6 IST projects INFRAWEBS ([www.infrawebs.eu](http://www.infrawebs.eu)), LOGOS ([www.logosproject.com](http://www.logosproject.com)) and intensive study of LT4eL project (<http://www.lt4el.eu/>).

### 2.1 Narrative Description of Learning Scenario

According to the scenario the learning domain of the project is the domain of Bulgarian Christian Iconography. The main target group of learners contains students following different classes of arts, art history, theology etc. The learning scenario (Pavlova-Draganova, L. and D. Paneva-Marnova, 2009) defines four groups of learners according to their goals and interests: theological team; art critic's team; art technique's team; artistic team. The learners are given a general task to prepare a project on the Iconography of Christ in the Historical territories of Bulgaria. The set of tasks are different for the different groups and teams. For example the learners are expected to make: analysis of the theological meaning of the Iconography of Christ (theological team); art critic analysis of the development of Christ's image in the different iconographical schools in Bulgaria (art critic's team); study of the main iconographic techniques used in the historical territories of Bulgaria (art technique's team) and etc.

In order to do their work, the learners are expected to prepare a multimedia document – learners' project by following the learning tasks. For example learners are expected to prepare: (Pavlova-Draganova, L. and D. Paneva-Marnova, 2009):

- analysis of the theological meaning of the Iconography of Christ;

- art critic analysis of the development of Christ's image in the different iconographical schools in Bulgaria;

- study of the main iconographic techniques used in the historical territories of Bulgaria

In order to prepare the project, the students have to develop scholarly essays/projects for pre-assigned by the teacher analyses of given characteristics of the objects under study. Each learner has to create beforehand a limited sized task-focused collection of multimedia objects to serve as a base for performing the necessary analysis, as well as illustration of the theses in the final analytical essay. The description of a task aiming at developing a dedicated collection, which is given to the users, may include, for example, activities like:

- Search and preview of objects from given centuries;
- Search and grouping the objects according to the iconographic schools
- Filtering the results and grouping according to iconographic technique.
- Presentation of the search results and grouping of the objects according to given periodization.

According to the learning scenario, the PKE presents learning tasks, links the learning tasks to the predefined learning objective and enables definition of assessment criteria for each task.

### 2.2 Technical Architecture

As presented on the Figure 1, the PKE is built on the top of an extended digital library. By using PKE the instructor creates the learning tasks and objectives and stores them into the Pedagogical Knowledge Repository that is then used by a learning management system (LMS). The extended digital library is a SOA-based architecture able to add and exploit the semantics extending an existing digital library – in our case the digital library of Bulgarian Iconographic objects (digital library service – Figure 1). The digital library is used as an external source and presents its functionalities as a web service. The objects stored in the digital library can be additionally annotated according to terms in selected ontology (in our case Ontology of Bulgarian Iconographic objects – OBIO) by using the Semantic Object Annotator and Resource editor and the new annotations are stored in the New Semantic Annotation Repository. The Semantic Annotations and Resource creation component uses concepts and relations from different specialized domain ontologies stored in the Ontologies Repository. Such

ontologies can be created and edited by means of the Ontology Editor. The extended Search Engine is a middleware software component used by all editors for indexing, searching and retrieving of the resources in all of the repositories.

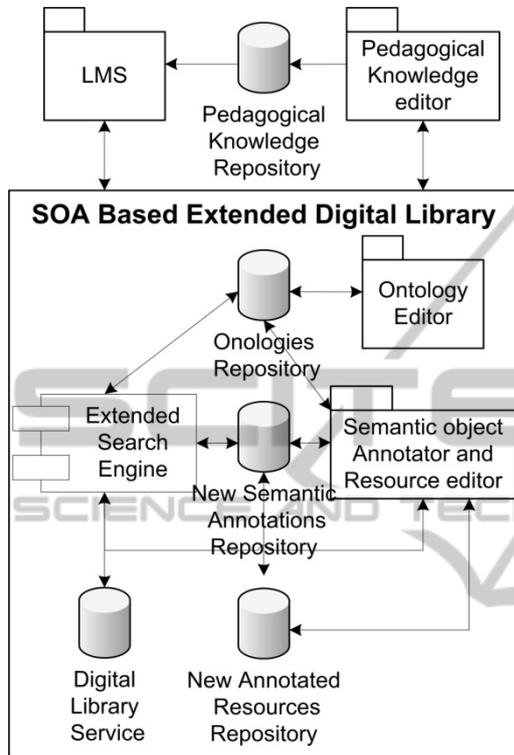


Figure 1: SINUS Project architecture.

### 2.3 Functionality of the Pedagogical Knowledge Editor

PKE is oriented to support the active learning approach engaging the learner into the process of a multimedia document creation. The active learning approach gives people control over their own learning (Bradford S. and W. J. Kozlowski, 2008). It promotes an inductive learning process, in which individuals must explore and experiment with a task to infer the rules, principles, and strategies for effective performance. That is, the learner assumes primary responsibility for important learning decisions e.g., choosing learning activities, monitoring and judging progress. The major guideline in SINUS is to support the learners in their activities. For this reason the learning tasks and the assessment are subordinate to this guideline.

In general the learning task requires the learner to take the appropriate set of actions, which satisfy the predefined knowledge to be achieved in order to

satisfy the learning objective. Every learning task is related to a learning activity. In our approach we state that every single learning task has a range of measurable learning outcome predefined on the task creation. PKE is a design time tool, that implements functionality of a simple specialized learning design editor. In an extended learning scenario, where more complicated learning objects are required, the tool might require integration with an external learning object creation tool as in (Hristov I., 2010).

## 3 LEARNING TASKS DEFINITION

According to (Limberg, L., 2007), even though the conceptions of a task can vary, the common trait is that the task is seen as an activity to be performed in order to accomplish a goal. Tasks are considered as having a recognizable purpose, beginning, and end. From our point of view, the definition of a learning task is based on the following characteristics:

- Every learning task is related to a correspondent learning objective.
- Learning tasks are defined in a way that does not restrict the successful solution to the single possible way for fulfilling the objective.
- Learning tasks contain descriptions of measurable range of qualitative parameters for successful completing the task that can be used by the evaluator for assessing the work

In accordance with the learning scenario the learner is required to analyze some aspects of the learning domain – in our case the Bulgarian iconographic objects (Staykova K. and Dochev D., 2009) and prepare a multimedia document that contains the analysis – i.e. the learning project. Actual learning happens during proactive project creation. Learning tasks are selected and ordered in a way to enable the learner to achieve the learning objectives and facilitate active learning. The learner deals with three major generalized activities types:

- Collection creation – The learner searches the repository for appropriate objects and selects some of them according to the pre-defined learning task. This is an activity that requires the learner to differentiate the important aspects of iconographical objects, their properties and the meanings. The result of such a kind of activities is creation of collection of iconographical objects that is based on a given set of criteria.
- Preparation of analysis – The learner makes an

analysis on some aspect of the collection. The result of this type of activities is a textual description that contains the analysis.

- Document structuring – The learner formats the target document according to some visual requirements and enter the textual description that contains the analysis of the subject. The result of this type of activities is a positioning and sizing of the elements of the analysis

In order to support the evaluation of the learner work, PKE requires every learning task to have criteria for measuring of work success. The criteria are primarily used for automatic support of the learners when they are doing the task and for preparing a list for assessment contours that the instructor might use when tracking the learner progress for final assessment or in order to support them. As a generalization, the PKE has to model three types of activities: Activities that require the learner to search, select and insert multimedia objects from the repository – actions related to collection creation; activities that require performing the analysis by comparing the objects from the collection against the pre-assigned learning task; and activities related to producing and formatting the final multimedia document.

The instructor defines the required activities by textual description of the learning task and the criteria for the assessment. The text description is presented to the learners. The way for defining assessment criteria differs for different types of tasks.

Criteria for assessment, related to the searching, finding and inserting multimedia object tasks – collection creation, are primarily defined by the learning task description, containing instructor recommendations about the possible steps to create limited-sized task-focused collection which is rich enough for the pre-assigned task (in our example case – recommendations about minimal desirable coverage of different authors, iconographic schools, time periods, iconographic techniques etc.). By the user interface of the system the instructor determines the appropriate parameters for the objects, and the system generates a query (formal representation of the learning task using domain ontology terms). The instructor can execute the query, review the result set and refine the query if required. The key factor here is that the system internally stores implicitly the query or the union of queries (if needed) with parameters that retrieve the successful multimedia objects. The formal representation is used later for checking the learner's selection relevance. The major advantage of the approach is that the new

objects, inserted in the repository are automatically used even if they do not exist during the task definition.

The preparation of analysis is another activity that the learner can take. The quality of the analysis prepared by the learner is a major subject of assessment. In such a type of learning task the instructor is required to enter explicitly through the user interface a list of terms from the Ontology of Bulgarian Iconographic objects (OBIO) (Staykova K. and Dochev D., 2009), that have to be present in the learner's analysis.

Another option for the instructor is to provide an exemplary textual analysis of the required task. The text entered by the instructor is annotated automatically (or semi-automatically) with concepts from the domain ontology (in our case - OBIO). The system will infer the terms from the text and use them for the evaluation of the text entered by the learner. An advantage of the approach is that the system can find the frequency of occurrence of the terms used by the instructor for more precise assessment. The usage of the ontology terms for the assessment of the learner is disused in the next topic.

In the learning scenario the formatting activities and visual arrangements are not directly related to the learning goals. The instructor might prepare some templates for storing the analysis, but the visual appearance is intended to be used for engaging the learners in a social collaborative engagement since the assessment is planned to be done by the other learners' groups.

## 4 MEASURING THE LEARNER PROGRESS

In order to support the learners in their work, we propose basic mechanism for tracking their progress by automatic identification and storing the intermediate and final results of collection development, presented by their semantic (meta) descriptions (i.e. the corresponding instances of the domain ontological model). This allows automatic comparison with the formalised task description, represented similarly.

In general this approach means that the system stores incremental actions taken by the learner in order to do the learning tasks. The approach enables the system to recreate the student project following the steps taken by the learner, since it stores the task oriented activities, not only the current state of the project. The system can track the user actions for

every task and generate automatically some hints and warnings for errors. This can be used also for identifying mistakes by the instructors.

Since the actions of the learners are stored task by task, the criteria for task assessment are created on the task definition it is possible to compare the results of learners' work to the results provided on the task creation. The assessment can be done on the entire work or on the set of tasks – partial assessment. By registering the learner's work task by task and relating the learning tasks to learning objectives we can assess the actual learning progress.

#### **4.1 Measure the Relevance of a Task-focused Collection**

The assessment of the relevance of the selected multimedia objects (primary images) is important part of evaluation of the learners work, because it captures the ability of the learner to distinguish different aspects and elements and symbolism of the iconographical objects. The approach for assessment is based on comparing the symbolic representation of the learning task with the objects semantic (metadata) descriptions. In this way the learning environment may evaluate if the developed dedicated task-focused collections of multimedia objects contain sufficiently rich and various illustrative material to back-up the analyses (e.g. checking minimal number of analysed objects, sufficient coverage of authors, iconographic schools, time periods, diversity of desired characteristics etc.).

#### **4.2 Assessment of the Quality of the Analysis**

Analysis made by the learner is a process related to comparing different characteristics of the iconographic objects. The analysis requires the learner to learn essential aspects, features, relations, artefacts and directions in the learning domain. The required knowledge is achieved by performing the learning tasks. As a result of the analysis, the learner prepares a textual description that contains the learner contribution. The quality of the learner analysis is the subject of the assessment. The assessment of text contribution cannot be fully automated. The essential part here is to support the evaluators by presenting to them some measurable counters. We intend to use the methodology described as Knowledge rich approach in (Osenova P. and Simov K., 2010). The knowledge rich

methods rely on the analysis of the text by using knowledge sources, external to this text, such as ontologies, lexicons and grammars. These sources are used to achieve a semantically rich text analysis which to explicate the conceptual content of the learner's answers.

The assessment of the learner analysis is based on finding the terms for domain concepts (and their possibly different linguistic forms) in the text entered by the learner. The evaluator might use the following parameters generated by the system: used (obligatory or desirable) terms, missed terms, frequency of terms occurrences, terms collocations in a paragraph (a hint that they may be also semantically related in the text) used by the learner and instructor and the number of used terms by the learner. It is obvious that, if the number of used terms by the learner and number of terms used by the instructor are approximately equal, the probability of analysis to satisfy the learning objectives is high. The system cannot automatically grade the learner work, but it supports the assessment by presenting to the evaluator meaningful counters, for example – the concepts that the learner missed or terms that the learner overused. The presented counters can help the instructor, but the final grade is done by the evaluator. We intend to continuously use the approach in order to send some hints to the learners when they missed some concepts in their analysis.

#### **4.3 Evaluation of the Visual Appearance of the Entire Document**

Since the learning tasks are not highly prescriptive by definition about formatting the document, the evaluation of visual appearance of already prepared multimedia document has very subjective elements. In general the tasks do not prescribe anything about visual appearance for the texts and the images into the document. Nevertheless, the document is structured in accordance with learning tasks, and also the analysis seems to be suitable, according to the terms uses, the entire document might not has good appearance for the external users. Even the visual appearance of the document is very subjective it seems to be depended of the formatting features like: the size and the position of the images and texts; amount and balance of texts and images, colours of the texts, background and many others. Since there the criteria for assessment of visual appearance are mainly qualitative, and the measure of visual appearance is not the major goal, subject of

learning, we assume that key factor for assessment of visual appearance is the satisfaction of users, who are using the created documents. We propose a mechanism that allows the users to rate the documents. After the document is checked by the evaluator and it is marked as satisfying the required learning tasks, it is opened for previewing and rating by the other groups of learners. The learners might rate the document, write a public or private comment or use the document in their work. Since the work is ongoing, we assume that this approach might highlight the best student project. The students will rate and comment the work of their colleagues, according to their own knowledge. This feature will give to the students some kind of reflectional view of their own work, and the opportunity to change some fragments according to the comments of the others. In our view the social dimensions of the learning are essential factor for the success, so the students are encouraged to rate, comment and use the work of their colleagues.

## 5 CONCLUSIONS

The paper describes an approach for helping the evaluation of specific learning-by-authoring activities, producing analytical essays/projects on limited-sized dedicated collections of multimedia objects, created by the learners according pre-defined learning tasks.

The three types of learner activities are continuously evaluated for giving the support to the learner. The activities related to collection creation are evaluated on the bases on the comparison of the results of learner's queries and formalised learning task description prepared by the instructor. The evaluation of quality of the analysis is made by the evaluator. The evaluator is supported by the system with measurable counters of concepts used or missed by the learners and the percentage of conjunction in concepts. The visual appearance, which, in our case, is not subject of learning, is rated by the other participations in the project.

The described approach is used as a base for implementing the PKE – a part of the SINUS TEL-oriented environment. In the moment the efforts are concentrated mainly on a part related to representation of the pedagogical knowledge describing the process of creation and assessment of the quality of a multimedia object collection that is necessary for writing the analytical essay. The future work will be focused on effective ways for formal

representation and use of pedagogical knowledge needed for analysing the created collection.

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