Serving Learning and Assessment in SCALE

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Abstract

In this paper, we present a web-based educational setting, referred to as SCALE (Supporting Collaboration and Adaptation in a Learning Environment), which aims to serve leaning and assessment. SCALE supports individualized and collaborative learning and engages learners in different forms of assessment by providing various functions and by embedding a number of tools. Personalized navigation support and feedback are offered, based on learner's knowledge level and preferences.

1. Introduction

With the vast spread of the web, innovative instructional delivery environments were developed and collaborative learning became increasingly popular. It is claimed that students can achieve higher levels of thought and retain information longer if they engage in a collaborative educational setting. Along with the learning process, assessment is considered an important component of an educational setting. Assessment plays a significant role in helping learners learn when it is interweaved with learning and instruction instead of being postponed at the end of the instruction [9].

In this context, various research efforts and projects focus on the development of web-based learning environments that support either (i) individualized learning [12], [7] by making adjustments in the educational environment in order to accommodate a diversity of learner needs and preferences, or (ii) collaborative learning [8], [10] by providing various means to support learners in their communication and in the accomplishment of collaborative activities, or (iii) assessment [11] by offering opportunities to learners to identify what they have already learned and what they are able to do and to teachers to administer the assessment process.

In line with the above efforts, we developed a web-based educational setting, referred to as SCALE (available at http://hermes.di.uoa.gr:8080/scale), which supports *individualized* and *collaborative learning* as well as *assessment*. SCALE serves these processes by providing various functions and by embedding a number of tools and accommodates learner's knowledge level and preferences in order to offer personalized navigation support and feedback.

The rest of the paper is structured as follows: In the next section, we describe how SCALE supports learning and assessment in terms of the theoretical principles guiding the design of the educational setting, the structure of the domain knowledge, the tools used and the forms of assessment supported. In Section 3, the adaptation scheme supported is presented. The paper ends with the main points of our work and our near future plans.

2. How SCALE serves learning and assessment

The design principles of SCALE lie on (i) the Activity Theory which is used as a framework for modeling learning situations where individualized learning is interweaved with collaborative learning and the concept of activity serves as a unit of analysis [5], (ii) researchers' suggestions that assessment should be represented as a tool for learning and powerful learning environments should encompass both instruction and assessment [1], [9], and (iii)

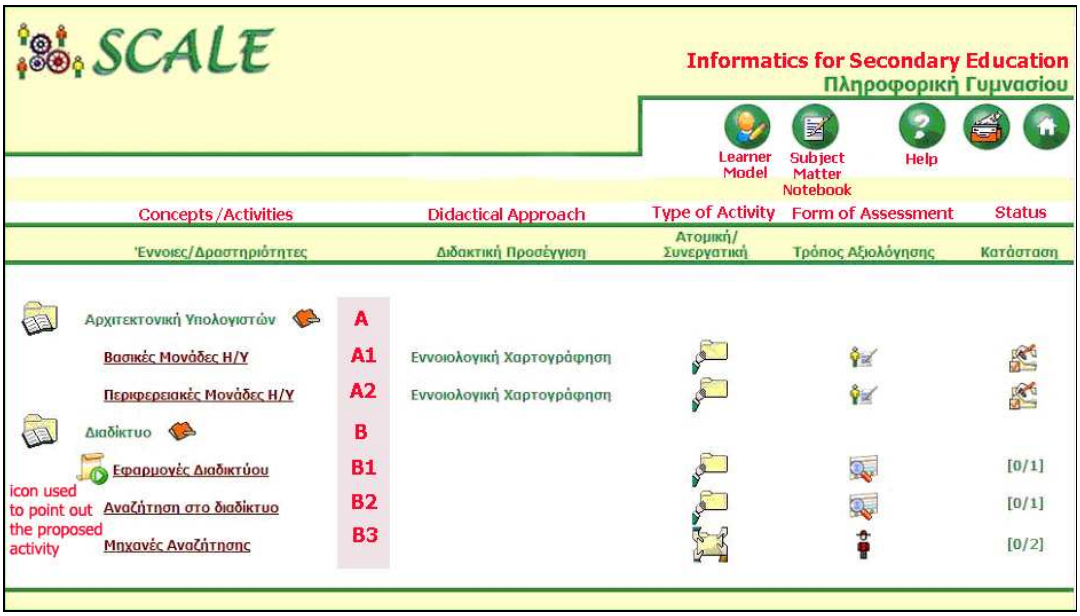

Figure 1. A screen shot of the SCALE environment: a) Learning Goal ***A*** (Computer Architecture) includes two activities ***A1*** (Computer Units) and ***A2*** (Computer Peripheral Devices). Both activities are based on the concept mapping approach, are individual, are assessed by peers (peer-assessment) and have already been submitted by the learner under consideration. b) Learning Goal ***B*** (Internet) includes three activities ***B1*** (Internet Applications), ***B2*** (Searching information in the Internet) and ***B3*** (Search Engines). Activities ***B1*** and ***B2*** are individual, are assessed automatically by the system and have not yet been elaborated by the learner, while activity ***B3*** is collaborative, is assessed by the teacher, includes two sub-activities, which have not yet been elaborated.

the view that instruction and feedback should be aligned, as much as possible, to each individual learner's characteristics since individuals differ in their general skills, aptitudes and preferences for processing information, constructing meaning from it and/or applying it to new situations [6]. To this end, SCALE supports *individualized learning*, *collaborative learning* and *assessment* by enabling learners to (i) work on individual or collaborative activities, (ii) have access to feedback adapted to their individual characteristics, (iii) use tools that promote and facilitate the synchronous or asynchronous communication between the group members and (iv) participate actively in the assessment process.

In the following a description of (i) the structure of the domain knowledge, that is the structure of the activities and the feedback supported, (ii) the various tools, which facilitate the elaboration of the activities and promote learner's interaction and reflection during the elaboration of the activities, and (iii) the various forms of assessment supported, is given.

2.1. The structure of the domain knowledge

The domain knowledge of SCALE is based on the notion of a learning goal that a learner can select (Figure 1). A goal corresponds to a fundamental concept/topic of the subject matter. Each goal is further analysed to specific learning outcomes, which are realised through various learning activities. The outcomes may address the Comprehension level (Remember + Understand), the Application level (Apply), the Checking-Criticizing level (Evaluate), and the Creation level (Analyse + Create) [2]. Moreover, a learning activity may serve specific educational functions; that is, an activity may be devoted to ascertain/assess learners' prior knowledge, to promote learners' knowledge construction on specific concepts or to serve the summative assessment. An activity may be individual or collaborative and may consist of one or more sub-activities addressing cognitive skills (learning outcomes) that are classified to the abovementioned levels. Each sub-activity may include one or more question items (i.e. open or closed questions). The activities may have different difficulty level and different degree of importance for the accomplishment of the underlying goal, depending on the addressed learning outcomes and the educational

functions A didactical approach may be followed in the context of an activity (e.g. concept mapping) and specific educational tools may be considered necessary for the elaboration of the activity (e.g. educational software, a concept mapping tool) (see next section).

As feedback is considered a key aspect of learning and instruction, multiple informative and tutoring feedback components are incorporated into the domain knowledge of SCALE. The informative feedback components (i.e. correctness-incorrectness of response and performance feedback) inform learners about their current state; this information is included in the learner model, which is maintained by the environment during the interaction. The tutoring feedback components aim to tutor/guide learners and are structured in two levels, activity level and sub-activity level. The feedback components of the sub-activity level refer to the concepts of the sub-activity under consideration, while in activity level, feedback components are more general and address concepts/ topics of the activity. The tutoring feedback components are associated with various types of knowledge modules (feedback types), structured in two levels, explanatory level and exploratory level. The explanatory level includes knowledge modules such as a description or a definition of the concept/topic, and the correct response whilst the exploratory level includes (i) an image, (ii) an example, (iii) an advice or an instruction on how to proceed, (iv) a question in order to encourage learners to "stop and think" and give them a hint on what to think about, (v) a case study, (vi) a similar activity followed by its answer, and (vii) any answers given to the specific activity by other learners.

The different levels and types of knowledge modules aim to serve learners' individual preferences and to cultivate skills such as critical and analytical thinking, ability to compare and combine alternative solutions, etc. In any case, the teacher is responsible to design and develop the appropriate knowledge modules of each level, taking into account several factors such as the content of the activity/sub-activity under consideration, the difficulty level of the specific activity, and the addressed learning outcomes.

2.2. Tools supporting the learning process

For the elaboration of an activity as well as for the promotion of learner's interaction and reflection, SCALE offers various tools either embedded in the environment or in conjunction with SCALE.

In case the activity/sub-activity concerns a concept mapping task, the educational tool used is the COMPASS environment [3]. COMPASS supports (i) various concept mapping tasks such as the construction of a map and the evaluation/correction, of a given map, (ii) the analysis of learner's map and the quantitative/qualitative evaluation of learner's knowledge level, and (iii) the provision of individualized feedback.

In the framework of a collaborative activity, learners' communicate in order to exchange their ideas and decide on their common answer. They communicate following a collaboration model, either having the same duties or undertaking specific roles. All the collaboration/communication is carried out in a written form through synchronous or asynchronous means. In case of synchronous communication, learners use the ACT tool [2], which enables them to communicate using the free or the structured form of the dialogue. In case of asynchronous communication, learners use an asynchronous communication tool, which supports the labeling of the messages (e.g. a message may be a proposal, a question, a clarification).

In order to promote learner's interaction and reflection, SCALE offers learners the possibility to "communicate" using the so-called notebooks and access the learner's model and the indicators of the activity. The notebooks aim to serve learners' collaboration by enabling them to read and answer the published notes and also to foster processes of reflection, and cultivate metacognitive skills such as self-regulation and self-control. In this context, the notebooks give learners the possibility to write down their ideas/comments and characterize and publish their notes; a note may be characterized as general information, proposal/answer, question/clarification, reasoning, comment or guideline. SCALE supports two types of notebooks at two different levels. At the level of the subject matter, learners have available the Notebook of the Subject Matter on which they maintain personal notes and access/reply/comment notes published by others concerning the specific subject matter and the concepts within the subject matter. At the level of the activity, learners have at their disposal the Notebook of the Activity, on which they can maintain personal notes and access published notes for the specific activity. This notebook acts as an asynchronous mean for learners' communication in the context of individual activities, aiming to encourage the externalization of the personal thoughts and argumentation on their beliefs.

The learner model reflects specific characteristics of the learner and hence it is used as the main source of the adaptive behaviour of SCALE. The information held is divided into domain dependent information and domain independent information. As far as the domain dependent information is concerned, the learner model keeps information about: (i) learner's knowledge level (qualitative and quantitative estimation) with respect to the learning goals/activities that s/he has worked on, and (ii) learner's behaviour during his/her interaction with the environment in terms of the number of times that feedback was asked, type of feedback proposed/selected, time spent on an activity, etc. As far as the domain independent information is concerned, the learner model keeps general information about the learner such as username, profession, learner's preferences on feedback types, last time/date the learner logged on/off. The learner model is dynamically updated during learner's interaction with SCALE in order to keep track of the learner's "current state". During interaction, learners may access their model and see the information held concerning their progress and interaction behaviour. The externalisation of learner model aims to support the self-regulation and reflection processes.

During the elaboration of an activity, learners may access the indicators of the activity, which provide information about the number of learners that have worked out the specific activity as well as the times that the activity has been worked out, the number of notes that have been published, grouped according to their characterizations, the times that learners asked for feedback and the type of feedback provided. For collaborative activities, there are also indicators, which provide information about the number of groups that have worked out the specific activity, the models of collaboration that have been applied as well as the times that each model has been applied.

2.3. Supporting the assessment process

Depending on the educational function that the activity serves and the underlying learning outcomes, SCALE supports alterative forms of assessment. In particular, SCALE serves:

- *Automatic assessment*: In case of activities including closed questions, SCALE can automatically assess learner's answer and provide the appropriate feedback components.
- *Peer and Collaborative assessment*: Peer and collaborative assessment are two alternatives in assessment that have recently received great attention as they enable learners to actively participate in the assessment process, develop important skills such as critical thinking, teamwork, self-monitoring and regulation, get inspiration from their peers' work, etc. In the context of SCALE, these two forms of assessment are accomplished by means of the web-based PECASSE environment [4]. PECASSE enables learners to act as "assessors" and evaluate, on their own or by collaborating with other learners the activities submitted by their peers.
- *Assessment by the teacher*: In case none of the above forms is supported, the teacher is responsible to assess the activity and inform the learner about his/her performance and guide him/her appropriately.

3 The adaptive capabilities of SCALE

In SCALE, a navigation route through the provided activities and feedback is proposed, based on learner's knowledge level and preferences. Learner's navigation is supported by using a graphical icon to point out the recommended activities and feedback components. Such a personalization aims to support learner in achieving the underlying learning goals following his/her own progress. The learner has the possibility to ignore the system's recommendations and follow his/her navigation route.

The technology of adaptive link annotation is used in order to generate a sequence of activities and feedback components that gradually guide learners to accomplish specific activity-related learning outcomes, and finally meet the selected learning goal. In particular, SCALE plans the delivery of the activities for a particular learner (in the context of a learning goal), based on his/her progress with respect to the educational function served by the activity and its difficulty level. For example, if there is an activity aiming to ascertain/assess students' prior knowledge, then it is the first one recommended as proposed by the environment (see Figure 1). Once learner completes such an activity, and his/her knowledge level is determined both quantitatively and qualitatively, the adaptation mechanism determines the next in sequence proposed activity with respect to learner's knowledge level and the difficulty level of the provided activities. This rule is by-passed if there is an activity that has been defined as proposed by the teacher. The last proposed activity within a learning goal is the one (if any) that aims to draw conclusions

about the degree of achieving the expected learning outcomes (i.e. summative assessment).

For the delivery of the supported tutoring feedback components, SCALE takes into account learner's preferences and the delivery sequence proposed by the teacher. More specifically, initially the adaptation mechanism checks for feedback components compatible to learner's preferences. For a specific feedback type, the sequence of the proposed feedback components is determined with respect to the delivery sequence proposed by the teacher (e.g. in case three examples are available, these are proposed according to the defined sequence). If learner's preferences have been fulfilled, the rest feedback components are recommended with respect to the delivery sequence concerning the rest available feedback types (e.g. first the definition, then the examples and third the correct answer).

4. Conclusions and future plans

The educational setting presented in this paper attempts to interweave individualized learning with collaborative learning as well as assessment. SCALE supports learning and assessment by (i) enabling learners to select the desired learning goal and the activities serving this goal, (ii) providing multiple informative and tutoring feedback components both at the activity and the sub-activity level, (iii) embedding various tools, which facilitate the elaboration of the activities and promote learner's interaction, reflection and self-regulation, and (iii) supporting various forms of assessment. Moreover, SCALE supports the individual learner in achieving the underlying learning goals by proposing a navigation route through the provided activities and feedback, based on learner's knowledge level and preferences. So far, we have investigated usability issues of the educational setting in the framework of a pilot study; the results revealed that the provided facilities and tools may facilitate and support learning and assessment. Our near future plans include the conduction of an integrated study for the evaluation of the various functions supported.

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