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A Web-based Educational Setting Supporting Individualized Learning, Collaborative Learning and Assessment

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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 enables learners to (i) work on individual and collaborative activities proposed by the environment with respect to learners' knowledge level, (ii) participate actively in the assessment process in the context of self-, peer- or collaborative-assessment activities, (iii) work with educational environments, embedded or integrated in SCALE, that facilitate the elaboration of the activities and stimulate learners' active involvement, (iv) use tools that support the synchronous and asynchronous collaboration/communication and promote learners' interaction and reflection, and (v) have access to feedback components tailored to their own preferences. Also, learners have control on the navigation route through the provided activities and feedback components, personalizing in this way the learning process. The results revealed from the formative evaluation of the environment are positive and encouraging regarding the usefulness of the supported capabilities and tools.

Keywords

Learning, Collaboration, Assessment, Feedback, Adaptation

Introduction

An emerging trend in education worldwide is a movement of the focus from that of teaching to that of learning and from an individualistic and objectivist view of learning to a social constructivism view (Palinscar, 1998; Reigeluth, 1999; Vosniadou, 2001). The underlying principle behind the social constructivism view of learning is that knowledge is constructed by the active interaction of learner with the environment and the idea that the construction of knowledge is socially mediated. It is claimed that effective collaboration has proven itself a successful and powerful learning method (Soller, 2001). Collaborative learning activities immerse students in challenging tasks or questions and enable them to become immediate practitioners and develop higher order reasoning and problem solving skills. In this context, collaborative learning is becoming increasingly used and the advent of communication technologies has made computer-mediated collaboration possible.

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 (Shepard, 2000). Moreover, assessment helps students to identify what they have already learned, to observe their personal learning progress and to decide how to further direct their learning process. As knowledge construction necessitates higher order thinking, new forms of assessment are required. Assessment methods such as self-, peer- and collaborative-assessment have been introduced in recent years aiming to enhance/promote learning and integrate assessment with instruction. Self-assessment refers to the involvement of learners in making judgments about their own work/performance and aims at fostering reflection on one's own learning and work (Sluijsmans et al., 1999). Peer-assessment refers to those activities of learners in which they judge and evaluate the work and/or the performance of their peers, while in collaborative-assessment, learners and instructor collaborate in order to clarify objectives and standards/criteria, negotiate details of the assessment and discuss any misunderstandings that exist (Sluijsmans et al., 1999). Integral part of the assessment process and a key aspect of learning and instruction is considered feedback (Mory, 1996). Feedback should guide and tutor learners towards the achievement of the underlying learning goals as well as stimulate and cultivate processes like self-explanation, self-regulation and self-evaluation (Chi et al., 1994).

Cognitive researchers view each individual learner as paramount in mediating learning. The learner becomes the focus of the learner-instruction transaction and instructional sequence decisions and options are adapted to individual

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learner's characteristics. Also, various motivational theories emphasize the importance of learner control. Control gives individuals the possibility to make choices, to affect outcomes and feel more competent and provokes sustained and intense effort (Lepper, 1985). Merrill (1980) asserted that the control of learning needs to be given to learners since in that way they have the possibility to learn better how to learn. Educational environments that attempt to combine technological learning tools with personalization that caters for individual characteristics and learning preferences have the potential to radically alter the landscape of learning.

In this context, various research efforts and projects focus on the development of web-based learning environments that support either (i) individualized learning (Papanikolaou et al., 2003; Stern & Woolf, 2000; Weber & Brusilovsky, 2001) by making adjustments in the educational environment in order to accommodate a diversity of learner needs and abilities, or (ii) collaborative learning (Rosatelli & Self, 2004; Scardamalia & Bereiter, 1994, Vizcaino et al., 2000) by providing various means of dialogue and actions, facilities for students' self-regulation/guidance, etc to support learners in their communication and in the accomplishment of collaborative activities, or (iii) assessment (Conejo et al., 2004; Sung et al., 2005) 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 (Supporting Collaboration and Adaptation in a Learning Environment) (available at http://hermes.di.uoa.gr:8080/scale), aiming to integrate learning and assessment by offering capabilities for individualized and collaborative learning as well as assessment. More specifically, SCALE enables learners to

- work on individual and collaborative activities which are developed on the basis of contemporary theories of learning and proposed by the environment with respect to learners' knowledge level,
- participate actively in the assessment process in the context of self-, peer- or collaborative-assessment activities,
- work with educational environments, embedded or integrated in SCALE, that facilitate the elaboration of the activities and stimulate learners' active involvement,
- use tools that support and promote the synchronous and asynchronous collaboration/communication,
- have access to feedback tailored to their own preferences, and
- have control on the navigation route through the provided activities and feedback components.

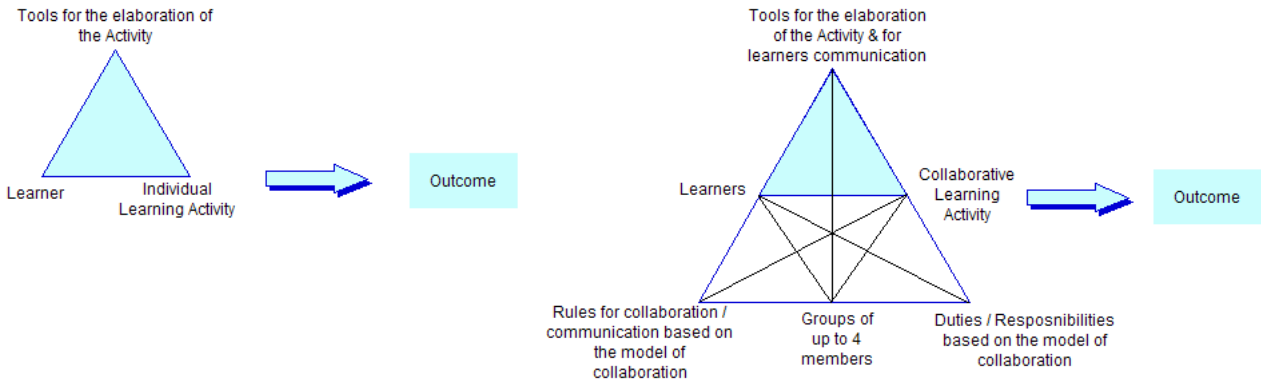
The paper is structured as follows: In the next section, we give an outline of the theoretical foundations that guided the development of SCALE. Following, we describe how the learning setting of SCALE is modeled in terms of (i) the learning activities, (ii) the feedback components supported and (iii) the learner and group model. The tools as well as the environments supporting learning, collaboration and assessment are briefly presented followed by a description of the adaptive capabilities of SCALE. The main functionalities of SCALE are outlined through exemplary screen shots. Finally, the paper discusses the results of three empirical studies that were conducted in the context of the formative evaluation of the environment. The paper ends with the main points of our work and our near future plans.

Theoretical Foundations

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 (Hill et al., 2003), (ii) researchers' suggestions that assessment should be represented as a tool for learning and powerful learning environments should encompass both instruction and assessment (Dochy & McDowell, 1997; Shepard, 2000), and (iii) the view that instruction and feedback should be aligned, as much as possible, to each individual learner's characteristics (Jonassen & Grawboski, 1993).

Central to the Activity Theory is the notion of activity; an activity is seen as a system of human "doing" whereby a *subject* works on an *object*, by employing *mediational tools*, in order to attain a desired outcome. Engeström (1987) developed an extended model of an activity, which adds the component of *community*; then adds *rules* to mediate between subject and community and the *division of labour* to mediate between object and community. That is, rules cover both explicit and implicit norms, conventions, and social relations within a community while division of labour refers to the explicit and implicit organisation of the community as related to the transformation process of the object into the outcome (Kuutti, 1995). In the framework of the SCALE environment, individualized learning is realized by

enabling learner (subject) to work on individual activities with a specific context (object), which results into a specific outcome, utilizing various tools (mediational tools), which are considered necessary for the accomplishment of the activity (Figure 1a). The collaborative learning is taking place through collaborative activities where learners (subject) collaborate, in groups of up to four members (community), in the context of a specific collaborative learning activity (object) utilizing various tools (mediational tools) and undertaking specific roles which determine the responsibilities and duties of each learner (division of labour) as well as the rules of the collaboration (rules) (Figure 1b).



(a) (b)

Figure 1. Application of the Activity Model in SCALE

While traditional assessment focuses on grading and ranking aspects and emphasizes on the need to find out if the student knows, understands, or is able to do, the new role of assessment emphasizes on the need to find out what the student knows, understands or is able to do. Many researchers suggest that students will learn more if instruction and assessment are integrally related and the provision of information about the quality of students' work as well as about what they can do to improve is crucial for maximizing learning (Pellegrino et al., 2001). To this end, assessment should be integrated with feedback for permitting learning to become a logical outcome (Taras, 2002) as learners need to know what they are trying to accomplish, how close they are coming to the goal and be guided/supported towards the achievement of the underlying goal. Moreover, 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 (Jonassen & Grabowski, 1993). Furthermore, self-, peer- and collaborative-assessment are alternatives in assessment that have recently received great attention as they are considered as part of the learning process where skills are developed (Sluijsmans et al., 1999). Towards this direction, SCALE supports the automatic assessment of the activities, the self-, peer- and collaborative-assessment as well as the provision of informative and tutoring feedback components tailored to learner's individual characteristics.

In the following, we present the model adopted and developed for (i) the representation of the SCALE learning setting in terms of the learning activities, (ii) the feedback components supported and (iii) the learner and the group model as a whole.

Modelling Learning Setting in SCALE

The SCALE learning setting aims to serve learning and assessment by supporting an *educational framework,* which determines the *educational function* and the *educational/didactical approach* followed. The educational function concerns either learning (knowledge construction) or assessment (ascertainment of learners' prior knowledge, formative assessment or summative assessment) (Figure 2). For the accomplishment of the educational function, the learning setting may exploit an educational/didactical approach that better supports and facilitates the educational function under consideration (e.g. the educational approach of concept mapping may effectively serve the ascertainment of learners' prior knowledge) and may require the use of a specific *educational tool* that facilitates the realization of the educational/didactical approach (e.g. in case of concept mapping, the COMPASS environment is

used; see section "Tools Supporting Learning and Assessment"). Learner is engaged actively in the learning setting by working out *activities* which have been developed to address and serve the underlying educational functions and have been designed on the principles of the underlying educational/didactical approaches. SCALE attempts to support and guide learners by providing a framework that includes the feedback components (informative and tutoring), the notebooks (described analytically in the following) and the indicators which provide information about the elaboration of the activities (e.g. the number of learners that have worked out an activity, the times that learners asked for feedback and the type of feedback provided, the number of groups that have worked out a collaborative activity).

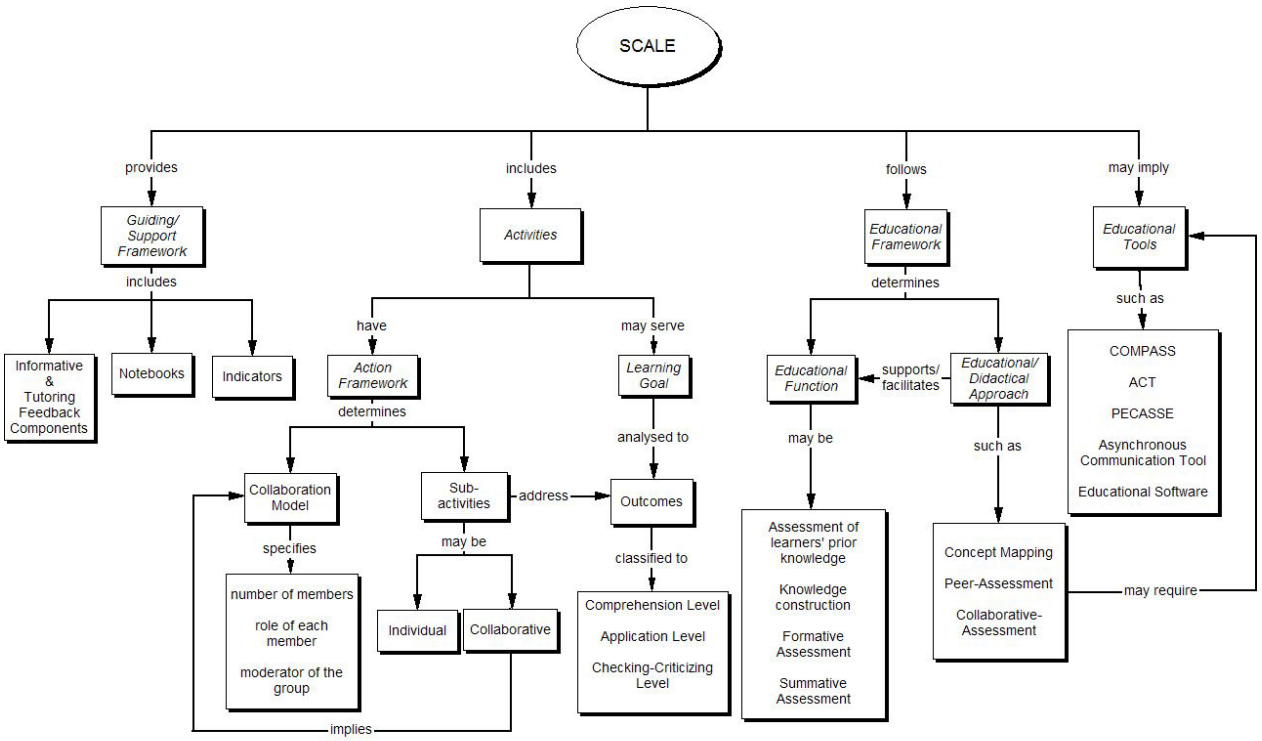


Figure 2. The model of the learning setting in SCALE

Modelling Learning Activities

An activity in SCALE serves a specific *learning goal*, which corresponds to fundamental concept(s) of the subject matter (Figure 2). The learning goal is further analysed to learning outcomes that may be classified to the Comprehension level (Remember + Understand), the Application level (Apply), the Checking-Criticizing level (Evaluate), and the Creation level (Analyse + Create) (Gogoulou et al., 2005a). The activity has the so-called *action framework,* which determines the sub-activities that address and realize the outcomes of the activity. The sub-activities may be individual or collaborative. Each sub-activity addresses learning outcomes that are classified to the abovementioned levels. The activities/sub-activities may have different difficulty level and different degree of importance for the accomplishment of the underlying goal with respect to the educational function and the addressed learning outcomes. In case of a collaborative activity/sub-activity, the action framework also determines the *collaboration model* that learners follow; the collaboration model specifies the number of group members, the role of each member and the moderator of the group being responsible for the submission of their common work and the coordination of the collaborative process. Depending on the educational function that the activity serves and the underlying outcomes, the assessment may be done by one of the following forms:

- *Automatic assessment*: In case of activities including closed questions (i.e. multiple choice, true-false, fill-the-blank), SCALE can automatically assess learner's answer. Also, the automatic assessment of concept mapping activities is supported as these are accomplished by means of the COMPASS environment (see section "Tools Supporting Learning and Assessment").

- *Self-, Peer- and Collaborative-assessment*: Self-, Peer- and collaborative-assessment are three forms of assessment that enable learners to actively participate in the assessment process, to get inspiration from their peers' work, to develop skills such as critical thinking, teamwork, self-monitoring and regulation, etc. These forms of assessment are accomplished by means of the PECASSE environment (see section "Tools Supporting Learning and Assessment").
- *Assessment by the teacher*: In case none of the above forms is supported, the teacher is responsible to assess the activity and inform learner about his/her performance and guide/tutor him/her appropriately.

Modelling Feedback Components

Feedback is considered a key aspect of learning and instruction. Characteristics that influence the effectiveness of feedback concern the type of feedback, the amount of the provided information as well as the adaptation to learners' individual differences. In this context, multiple informative and tutoring feedback components are provided during the elaboration of the activities in 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 at 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) and are distinguished in two categories: explanatory and exploratory. The explanatory feedback may include knowledge modules such as a description or a definition of the concept/topic, and the correct response whilst the exploratory feedback may include (i) an image, (ii) an example, (iii) an advice or an instruction on how to proceed, (iv) a question giving students 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 categories 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.

Modelling Learner and Group of Learners

The Learner Model (LM) 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 LM keeps information about: (i) learner's knowledge level (qualitative and quantitative estimation) with respect to the learning goals and 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 LM 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 LM is dynamically updated during learner's interaction in order to keep track of learner's "current state". During interaction, learners may access their model and see the information held concerning their progress and interaction behaviour. Also, they have the possibility to modify their initially declared preferences regarding the types of feedback components supported. The externalisation of learner model aims to support the self-regulation and reflection processes and enable learner to modify domain independent information kept in LM. The Group Model (GM) holds information for the group as a whole. The GM keeps information about the activities that the group has elaborated on, the learners constituting the group, the model of collaboration followed during the elaboration of the activities and the date/time the group spend on the activity.

Tools Supporting Learning and Assessment

For the elaboration of an activity as well as for the promotion of learner's interaction and reflection, SCALE offers various tools either embedded or integrated in the environment. In the following, an outline of these tools is given.

Concept Mapping Environment

In case the activity/sub-activity concerns a concept mapping task, the COMPASS environment is used (Gouli et al., 2006b). COMPASS (COncept MaP ASSessment & learning environment) (available at http://hermes.di.uoa.gr/compass) is a web-enabled concept mapping learning environment, which aims to assess learner's understanding as well as to support the learning process by employing a variety of concept mapping activities, applying a scheme for the qualitative and quantitative estimation of learner's knowledge and providing different informative, tutoring and reflective feedback components, tailored to learner's individual characteristics and needs.

Depending on the outcomes, the activities may employ different concept mapping tasks, such as the construction of a map, the evaluation/correction, the extension and the completion of a given map. The learners may have at their disposal a list of concepts and/or a list of relationships to use in the task and/or may be free to add the desired concepts/relationships. The provided lists may contain not only the required concepts/relationships but also concepts/relationships that play the role of distracters.

Learner's concept map may be assessed automatically by COMPASS. The analysis of the map is based on (i) the qualitative characterization of the errors aiming to contribute to the qualitative diagnosis of learner's knowledge (i.e. learner's incomplete understanding/beliefs and false beliefs) and (ii) the quantitative analysis aiming to evaluate learner's knowledge level on the central concept of the map (Gouli et al., 2005). The results derived from the map analysis are represented to learners in an appropriate form during the feedback process. The feedback provided in COMPASS aims to serve processes of assessment and learning by (i) informing learners about their performance, (ii) guiding and tutoring learners in order to identify their false beliefs, focus on specific errors, reconstruct their knowledge and achieve specific learning outcomes addressed by the activity/task, and (iii) supporting reflection in terms of encouraging learners to "stop and think" and giving them hints on what to think about (Gouli et al., 2006b). The adaptive functionality of the feedback process is based on learner's knowledge level, preferences and interaction behaviour and is implemented through (i) the technology of adaptive presentation that supports the provision of alternative forms of feedback and feedback components, and (ii) the stepwise presentation of the feedback components in the dialogue-based form of feedback. Moreover, COMPASS gives learners the possibility to have control over the feedback presentation process by making the desired selections.

Synchronous and Asynchronous Communication Tools

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 (Adaptive Communication Tool) tool (Gogoulou et al., 2005a), which aims to promote the cultivation of cognitive and communication skills and guide learners appropriately during their communication. In particular, ACT:

(i) Adapts the communication with respect to the collaborative learning setting: ACT supports both the free and the structured form of dialogue; the structured dialogue is implemented either through sentence openers or communication acts. Depending on the learning outcomes addressed by the collaborative activity and the model of collaboration followed by the group members, the tool proposes the most suitable form of dialogue and type of scaffolding sentence templates (i.e. sentence openers or communication acts) and provides the most meaningful and complete set of scaffolding sentence templates adapted with respect to the collaborative learning setting.

(ii) Enables learners to personalize the communication: the tool offers learners the possibility to have control on the adaptation by enabling them to negotiate on and select the form of dialogue (i.e. structured versus free dialogue) and the type of scaffolding sentence templates they prefer to use and enrich the provided set of scaffolding sentence templates with their own ones in order to cover their own "communication" needs.

(iii) Regulates the communication: ACT monitors and analyses the interaction at various levels and provides alternative and complementary representations of the interaction analysis results as well as proposes remedial actions to guide learners (Gogoulou et al., 2005b).

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) and the exchange of work.

Peer- and Collaborative-Assessment Environment

PECASSE (Peer- and Collaborative-ASSessment Environment) is a web-based environment that supports self-, peer- and collaborative-assessment (Gouli et al., 2006a) (available at http://hermes.di.uoa.gr:8080/pecasse). Learners may act as

- "authors" being able to submit an activity, which has been elaborated either individually or collaboratively,
- "assessors" being responsible to evaluate (i) their own activity in a brief way or according to specific criteria (self-assessment), and/or (ii) the activities submitted by their peers on their own or by collaborating with other learners (peer-assessment) or by collaborating with other learners and the instructor (collaborative-assessment),
- "feedback evaluators" being able to evaluate the quality of the work/feedback, provided by their assessors.

The assessment process may be carried out in three consecutive rounds at most. Each round involves the following steps: (i) activity submission and brief self-assessment, (ii) review of the assigned activities and provision of feedback, (iii) collaboration of authors and assessors, evaluation of assessors and revision of the activity submitted in the first step. In PECASSE environment, the review process may emphasize on the grading of the activities and/or the provision of useful feedback. The provided review/feedback may be structured and recorded either in an assessment form or in an assessment letter.

Notebooks

The notebooks give learners the possibility to write down their ideas/comments, to characterize them and, if they wish, to publish their notes; a note may be characterized as general information, proposal/answer, question, clarification, reasoning, comment or guideline. In this way, the notebooks aim to serve learners' indirect 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.

SCALE supports two types of notebooks at two different levels. At the level of the subject matter, learners have access to 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 activity level, 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 personal thoughts and argumentation on learners' beliefs.

Adaptation in SCALE

In SCALE, a navigation route through the provided activities and feedback is proposed, based on learner's knowledge level and preferences respectively. Learners' 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 underlying 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 3). 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 defined by the teacher. More specifically, initially the adaptation mechanism checks for feedback components compatible to learner's preferences (i.e. whether the types of feedback that learner prefers coincide with the types of the available feedback). 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 teacher's defined order). 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).

As it is considered essential to allow learners to play an active role and take control over their own learning in order to meet their needs and preferences, SCALE gives learners the possibility to have control over the activities and feedback components presented by selecting the preferred activity to work out as well as the desired feedback component.

Working with SCALE

Based on the learning goal that the learner selects (i.e. the learning goal corresponds to fundamental concepts of the underlying subject matter), SCALE provides various activities. Figure 3 is the main screen of the SCALE environment showing information for the Subject Matter that the learner has chosen. More specifically, the Subject Matter "Informatics for Secondary Education" consists of two learning goals; learning goal A (Computer Architecture) and learning goal B (Internet). Learning goal A includes two activities A1 and A2. Both activities are based on the concept mapping approach (i.e. didactical approach), are individual (i.e. type of activity), are assessed automatically by the system and have not yet been submitted by the learner under consideration (i.e. status). The learning goal B includes five activities. Activities B1 and B2 are individual, are assessed automatically by the system, include one sub-activity consisting of various questions and have not yet been worked out by the learner; activity B3 is individual, includes two sub-activities consisting also of questions, is assessed by the teacher and the system (i.e. part(s) of the questions are automatically assessed by the system while other parts need to be assessed by the teacher) and has not yet been worked out; activities B4 and B5 are collaborative, include only one sub-activity assessed by the teacher and have not yet been worked out. According to the adaptation framework, activity B1 is the one proposed to the learner (i.e. it is denoted by an icon) as it is an activity aiming to ascertain learner's prior knowledge on the specific learning goal.

Once learner selects an activity to work on, the corresponding sub-activities are presented. Figure 4 presents one of the sub-activities of the activity B3 (Figure 3). The difficulty level of the specific sub-activity is 2 (out of 5), it is individual and it consists of a question, asking learner to answer to a multiple-choice question and reason his/her answer. The answer given to the multiple-choice question is automatically assessed while the answer given as reasoning has to be assessed by the teacher. While working on the activity, learner may have access to the Learner Model, the Educational Tools required for the elaboration of the activity, the Notebook of the activity in order to record any personal notes or to "communicate" with other learners and the Activity Indicators. Support to learner is provided through the Learner Assistant, which presents the feedback available at activity level. Once learner submits his/her answer to the sub-activity, the feedback available at sub-activity level is accessible (i.e. an icon similar to the Learner Assistant icon appears to the corresponding Feedback column of Figure 4). Figure 5 presents the available feedback for the sub-activity depicted in Figure 4. Three types of feedback components are provided: an instruction/hint, a case study and a similar problem. The feedback components are proposed according to learner's preferences and the sequence defined by the teacher. Learner ignores the recommendation of the system for feedback components (i.e. the case study) and has selected to see the first feedback component providing an instruction/hint.

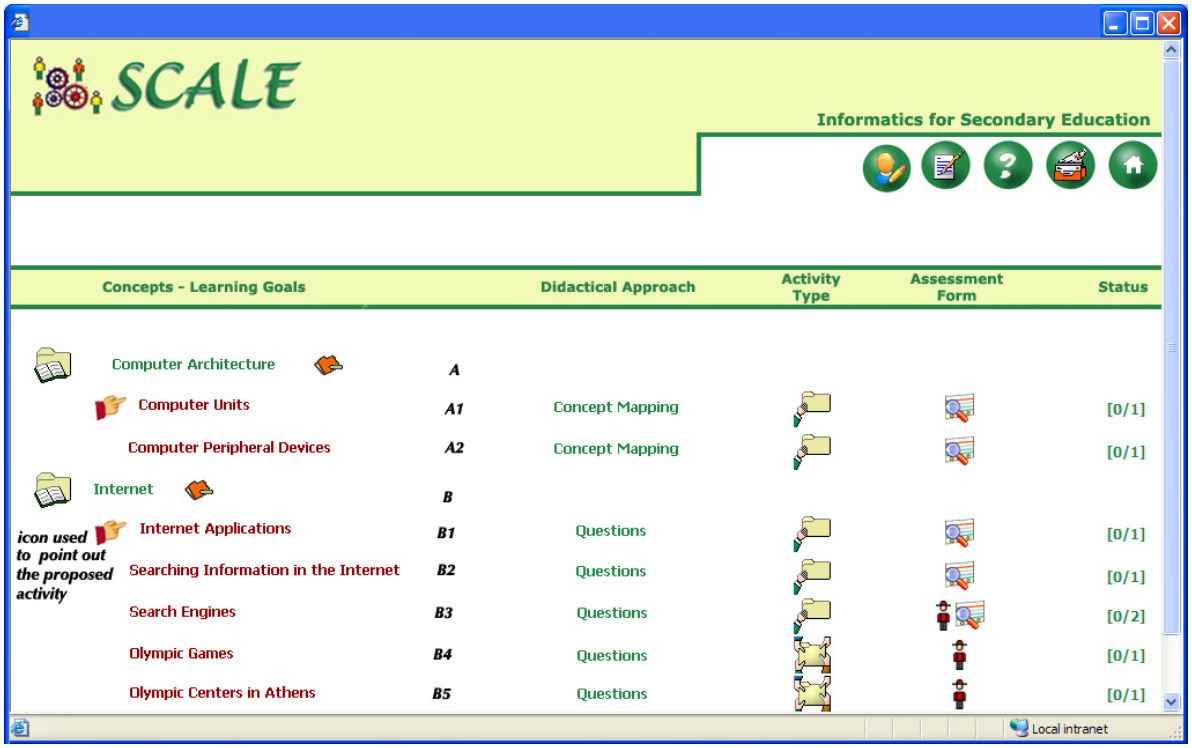


Figure 3. A screen shot of the SCALE environment showing two learning goals for the Subject Matter "Informatics for Secondary Education"

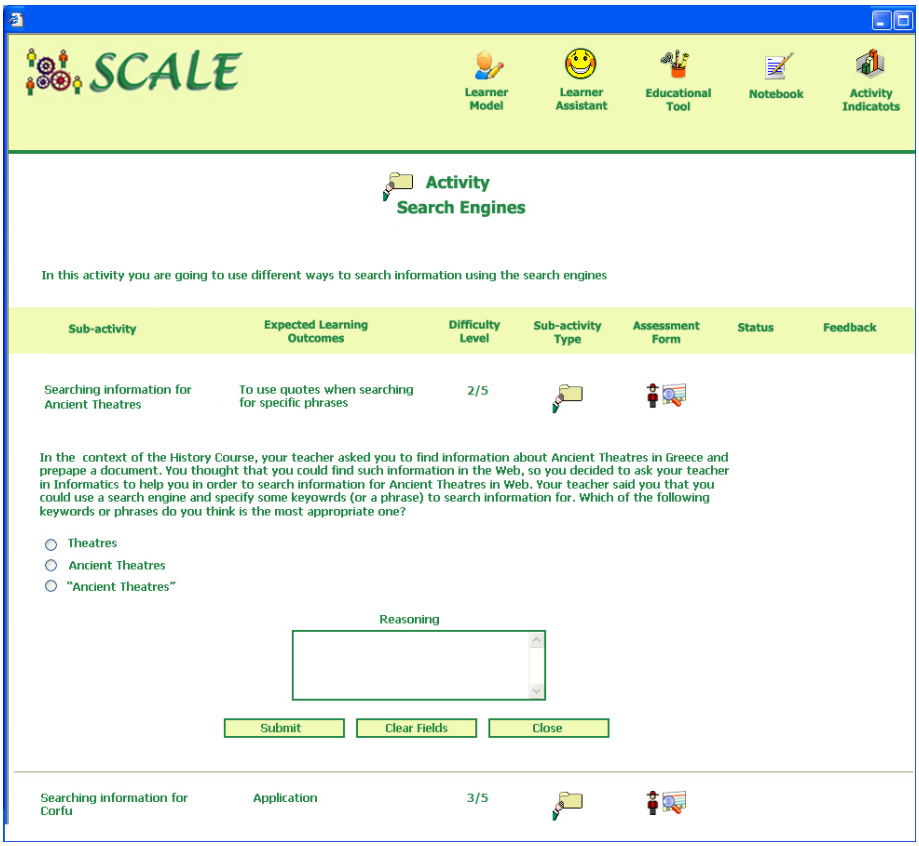


Figure 4. A screen shot of SCALE showing a sub-activity of the activity B3 presented in Fig 3

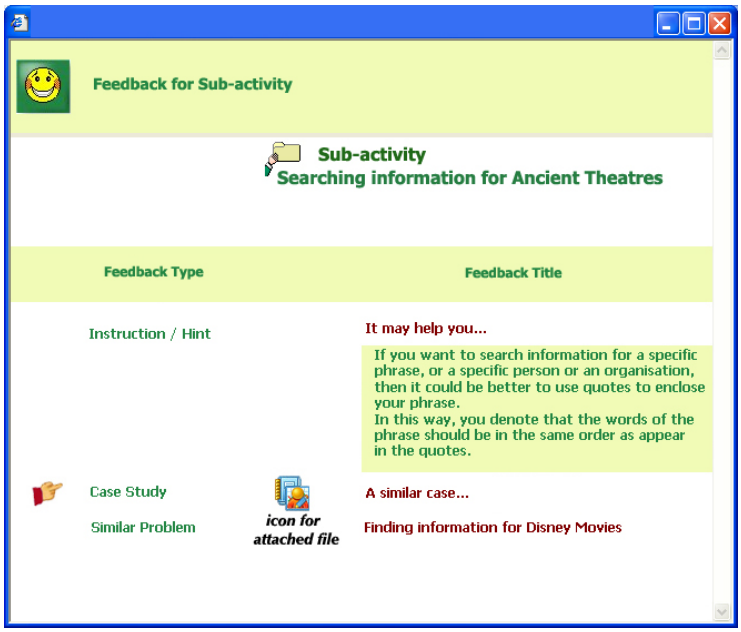


Figure 5. A screen shot of the feedback window showing the available feedback components for the sub-activity of Figure 4

Formative Evaluation

In the context of the formative evaluation of the environment, three empirical studies were conducted at the Department of Informatics and Telecommunications of the University of Athens:

- The 1st empirical study was conducted during the spring-semester of the academic year 2004-2005 in the context of the postgraduate course of "Distance Education and Learning". The study focused on usability issues of the interface, the provided facilities and tools.
- The 2nd empirical study was conducted during the winter-semester of the academic year 2005-2006 in the context of the undergraduate course of "Didactics of Informatics". The study focused on usability issues regarding the PECASSE environment and students' attitude towards the peer-assessment process.
- The 3rd empirical study was conducted during the spring-semester of the academic year 2005-2006 in the context of the undergraduate course of "Informatics in Education" and the postgraduate course of "Distance Education and Learning". The study focused on the structure and presentation of the activities, the provision of feedback and the adaptive capabilities of the environment.

All three studies were qualitative aiming to elicit students' point of view for various functionalities supported by SCALE and the tools embedded or integrated in the environment.

Process

1st study: The 1st study was carried out through questionnaires including closed and open questions asking students to comment and reason their point of view. Thirty-eight students participated in the study, coming from a range of backgrounds and having different expertise in the use of web-based learning environments. The study took place in the main laboratory of the department and lasted 4 hours. Each student worked on his/her own computer on different scenarios. In particular, the working sheet had an activity-oriented behaviour aiming to involve students in different functions supported by SCALE; the purpose of the first and the second scenario was to enable students to explore the presentation/structure of the activities and the way of working out an activity; the third scenario focused on the elaboration of a collaborative activity using the ACT tool; the fourth scenario attempted to investigate the usefulness of the facilities provided by COMPASS environment and thus engaged students in a concept mapping task.

2nd study: Thirty-five students participated in the study, which lasted nine weeks in total. The students had to work on a self- and peer-assessment activity provided in SCALE. Learners were asked to design a lesson plan for a specific topic (half of them worked on the topic "Internet and search engines" and the rest worked on the topic "The concept of variable in programming"). The accomplishment of the activity was supported by the PECASSE environment. Initially students submitted their work and they self-evaluated and gave mark to their own work. Following, they were assigned two activities to assess: one addressing the same topic as their own and the second one addressing the alternative topic. The review process was carried out through an assessment form. As last step, the students received two anonymous reviews for their activity and evaluated their assessors. Upon the completion of the whole activity, students were asked to fill and submit a questionnaire concerning the evaluation of the PECASSE environment. Also, the students were asked to comment on the interface of SCALE and on the capability of the environment to support both the learning and assessment processes and provide various tools in order to serve this purpose.

3rd study: In the framework of the undergraduate course "Informatics & Education" and the postgraduate course "Distance Education and Learning", eighteen students were asked to act as designers for the development of educational material for SCALE. In particular, the students had to explore the environment (i.e. an indicative set of activities had been developed) and to design and develop material, following the principles of the environment, for (i) the topic "Looping constructs in programming" for the secondary education (the undergraduate students) and (ii) the main concepts (e.g. open education, distance education, the role of teacher) of the "Distance Education and Learning" course (the postgraduate students). The students had to submit a set of individual and collaborative activities accompanied with appropriate feedback components. They also had to comment on the SCALE environment regarding the structure and presentation of the activities, the capability of providing alternative feedback types and the adaptation of the environment.

Results

The three empirical studies revealed positive and interesting results, which are presented in the following in terms of the issues investigated.

Support of learning and assessment
The students, who participated in the three studies, found interesting the capability of the environment to support both learning and assessment. The variety of activities/sub-activities that students may work on as well as their active participation in the learning and assessment process was high in most of the students favour. They rated positively the capability of automatic assessment and the provision of immediate informative feedback (i.e. knowledge of correctness/incorrectness of their response). It is worthwhile mentioning that their opinion was that the SCALE environment can effectively support the instruction process in higher education.

Despite the positive comments, the students of the 3rd study acting as designers of educational material for the environment, had difficulties in organizing/structuring their activities to the design principles of SCALE. In particular, they found hard the decomposition of an activity into a logical structure of sub-activities and the specification of characteristics such as difficulty level and outcome level. It seems that their difficulty is mainly attributed to their inexperience in acting as authors of educational material.

Provision of feedback
As mentioned above, the students considered essential the provision of informative feedback. Furthermore, they found very useful the provision of different types of feedback components (e.g. examples, case studies, hints). Especially the students of the 3rd activity, fully explored the alternative feedback components that were available and tried to design feedback material to cover all types. They also found useful and quite guiding the structuring and provision of feedback at activity and sub-activity level. However, some students claimed that they should have access to the feedback of the sub-activity level while working with the specific sub-activity; in the current version of the system, the feedback at the sub-activity level is accessible once they submit their answer for first time.

Support of adaptation
The students of the 3rd study took advantage of the capability of the environment to adapt the delivery sequence of the available feedback components to their preferences, kept in the learner model. They asserted that the use of an indicative icon to point out the recommended feedback component facilitates learner's navigation while simultaneously enables learner to have control on the navigation route and select the desired component. The

adaptivity supported for the recommendation of the most appropriate activity with respect to the students' progress needs to be investigated in a future study, as it was not included in the presented studies.

Presentation/Structure/Accessibility of the activities & sub-activities
Most of the students that participated in the three studies expressed their satisfaction regarding the organization/structure of the activities. They also marked as adequate the characteristics presented for the activities and sub-activities (Figure 3 and 4) and they believe that the presented characteristics depict a reasonable amount of information and facilitate their interaction. Students' suggestions concerned the difficulty level of the sub-activities; most of them asked for more details for the specific characteristic. Regarding the way of accessing and working on the sub-activities, the students participated in the 1st study reported that they should have access to any sub-activity included in an activity instead of following the sequential order imposed by the environment; the corresponding version of the system restricted students to follow a sequential order while the current version of the system enables students to select and work on the sub-activities following their preferred order. The students of the 2nd and the 3rd study commented positively on this change mentioning that it is quite helpful to have a look at the content of the sub-activities and subsequently decide on which one to work. Moreover, the possibility to submit their answer as many times as they wish stood high in most of the students favour; the teacher is responsible to specify for every activity the maximum number of times that students are allowed to access the activity and re-submit their answer.

Facilities and tools supported
Notebooks: Most students (85%) of the 1st study that used the notebooks in a systematic way, believed that this facility can help in the elaboration of the activities as they have the chance to "collaborate", exchange their ideas, ask questions, externalize their thoughts and share their expertise. Most of them appreciated the participation of the teacher in the notebook of the Subject Matter; during the 1st study, the teacher asked students to express their point of view for the variety of activities provided using the corresponding notebook of the Subject Matter and she kept track of the students' notes and participated in the "conversation". Despite the students' positive attitude towards the specific facility, a lot of them found the way of working with notebooks as moderate (62%) as they considered limited the space provided for writing a note and for presenting the list of the submitted notes (these comments were taken into account in the development of the current version of the environment).

ACT tool: In the context of the 1st study, the students worked on a collaborative activity. For the elaboration of the specific activity, the students had to use the ACT tool in order to collaborate and communicate with their partner synchronously. All of the students asserted that they had no difficulties in accessing ACT. As far as the evaluation of the ACT tool is concerned, the analysis of the students' answers revealed that a considerable number of students (83%) characterized the way of working with the provided scaffolding sentence templates as easy. The majority of the students (83%) considered the capability of the ACT tool to group messages into sub-trees and to represent the dialogue in a visual graphical form (Dialogue Tree) very useful because it enables them to monitor the dialogue in an organized and comprehensive manner, to evaluate the collaboration process more easily and to proceed to interventions in order to improve their participation. Only a small number of students (17%) mentioned that there was no need to consult the Dialogue Tree during the elaboration of the activities. As far as the adaptation of the scaffolding sentence templates is concerned, the majority of the students (80%) considered the provided type of scaffolding sentence templates (i.e. sentence openers) appropriate for the corresponding context of the activity and most of them (66%) characterized the facility of enriching the predefined sets of sentence openers with their own ones as useful (50% of them took advantage of the specific facility during the elaboration of the activities).

COMPASS environment: COMPASS was used for the elaboration of a concept mapping task in the context of the 1st study. The students accessed the environment through SCALE and used it for the construction of a concept map. While working, they used facilities for the analysis of the map, the provision of feedback and the quantitative and qualitative estimation of learners' knowledge level. Most of the facilities were characterized as useful: 68% for the analysis of the map, 81% for the provision of feedback, 31% for the quantitative estimation of learner's knowledge level and 56% for the diagnosis of students' false beliefs and incomplete understanding. A considerable number of students (69%) characterized the facility concerning the quantitative estimation of learner's knowledge level as neutral as they believed that the added value in such a tool is the provision of feedback, which helps learners to identify their weaknesses and errors and improve their concept maps.

PECASSE environment: The students of the 2nd study that involved in the self- and peer-assessment process through the PECASSE environment, believe that the peer-assessment process promotes and enhances learning but the majority of

them characterized it as time and effort consuming. A considerable number of students considered that PECASSE fulfils the aims of the peer-assessment process, facilitates the execution of the steps and contributes positively in the realization of the process in a useful/easy way. They found most of the provided facilities useful and usable and they suggested improvements for the management and the completion of the assessment form. Also, 76% of the students believe that PECASSE can be incorporated effectively as an assessment tool in the instruction process and about 60% of the students were willing to work out activities through PECASSE in the future. As far as the review process is concerned, a considerable number of students (89%) were satisfied and considered that the feedback they received was useful and helped them to revise their initial activity.

Conclusions and Outlook

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) supporting various tools, which facilitate the elaboration of the activities and support learner's synchronous and asynchronous communication/collaboration and the processes of reflection and self-regulation, and (iii) serving various forms of assessment such as the automatic assessment of the activities, the self-, peer- and collaborative-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 respectively. So far, the results of the three studies that were carried out revealed that the provided facilities and tools may facilitate and support learning and assessment and stood high in most of the students favour. However, the use of the SCALE learning setting in real classroom conditions under long periods of time is considered necessary.

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References

Chi, M., de Leeuw, N, Chiu, M-H., & Lavancher, C. (1994). Eliciting self-explanation improves understanding. *Cognitive Science, 18*, 439–477.

Conejo, R. Guzmán, E. Millán, E., Trella, M., Pérez-De-La-Cruz, J., & Ríos, A. (2004). SIETTE: A Web-Based Tool for Adaptive Testing. *International Journal of Artificial Intelligence in Education, 14*, 29-61.

Dochy, F., & McDowell, L. (1997). Assessment as a tool for learning. *Studies in Educational Evaluation, 23* (4), 279-298.

Engeström, Y. (1987). *Learning by expanding: An activity theoretical approach to developmental research*, Helsinki, Finland: Orienta Konsultit Oy.

Gogoulou, A. Gouli, E., Grigoriadou, M., & Samarakou, M. (2005a). ACT: A Web-based Adaptive Communication Tool. In Koschmann, T., Suthers, D. & Chan, T.W. (Eds.), *Proceedings of Computer Supported Collaborative Learning 2005: The Next 10 Years!*, Mahwah, NJ: Lawrence Erlbaum, 180-189.

Gogoulou, A. Gouli, E., & Grigoriadou, M. (2005b). Analysing Learner Interaction in an Adaptive Communication Tool. *Paper presented at the AIED2005 Workshop on Representing and Analyzing Collaborative Interactions: What works? When does it work? To what extent?*, July 18-22, 2005, Amsterdam.

Gouli, E., Gogoulou, A., Papanikolaou, K., & Grigoriadou, M. (2005). Evaluating Learner's Knowledge level on Concept Mapping Tasks. In Goodyear, P., Sampson, D.G., Yang, D., Kinshuk, Okamoto, T., Hartley, R. & Chen, N-S (Eds.), *Proceedings of the 5th IEEE International Conference on Advanced Learning Technologies*, Los Alamitos: IEEE Computer Society, 424-428.

Gouli, E., Gogoulou, A., & Grigoriadou, M. (2006a). Supporting Self- Peer- and Collaborative-Assessment through a Web-based Environment. In Kommers, P. & Richards, G. (Eds.), *Proceedings of ED-MEDIA 2006*, Chesapeake, VA: AACE, 2192-2199.

Gouli, E., Gogoulou, A., Tsakostas, C., & Grigoriadou, M. (2006b). How COMPASS supports multi-feedback forms & components adapted to learner's characteristics. In Cañas, A. & Novak, J. (Eds.), *Proceedings of the Second International Conference on Concept Mapping*, Universidad de Costa Rica, Vol.1, 255-262.

Hill, C.M., Cummings, M., & van Aalst, J. (2003). Activity Theory as a Framework for Analyzing Participation within Knowledge Building Community. *Paper presented at the annual meeting of the American Educational Research Association*, Chicago, IL, retrieved October 15, 2007, from http://www.educ.sfu.ca/kb/Papers/Hill_Cummings.pdf.

Jonassen, D., & Grabowski, B. (1993). *Handbook of Individual Differences, Learning and Instruction*, Hillsdale, NJ: Lawrence Erlbaum.

Kuutti, K. (1995) Activity Theory as a Potential Framework for Human-Computer Interaction Research. In Nardi, B.A. (Ed.), *Context and Consciousness: Activity Theory and Human-Computer Interaction*, MIT Press, 17-44.

Lepper, M.R. (1985). Microcomputers in education: Motivational and social issues. *American Psychologist, 40*, 1-18.

Merrill, M.D. (1980). Learner control in Computer Based Learning. *Computers & Education, 4*, 77-95.

Mory, E. (1996). Feedback Research. In Jonassen, D. H. (Ed.), *Handbook of research for educational communications and technology*, New York: Simon & Schuster Maxmillan, 919-956.

Palinscar, A. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology, 49*, 345-375.

Papanikolaou, K., Grigoriadou, M., Kornilakis, H., & Magoulas, G. (2003). Personalizing the interaction in a web-based educational hypermedia system: the case of INSPIRE. *User-Modeling and User-Adapted Interaction, 13* (3), 213-267.

Pellegrino, J., Chudowsky, N., & Glaser, R. (2001). *Knowing what students know: The Science and Design of Educational Assessment*, Washington DC: National Academy Press.

Reigeluth, C.M. (1999). *Instructional design theories and models: A new paradigm of instructional theory*, *vol. II*, Mahwah, NJ: Lawrence Erlbaum.

Rosatelli, M., & Self, J. (2004). A Collaborative Case Study System for Distance Learning. *International Journal of Artificial Intelligence in Education, 14*, 97-125.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the Learning Sciences, 3* (3), 265-283.

Shepard, L. (2000). The Role of Assessment in a Learning Culture. *Educational Researcher, 29* (7), 4-14.

Sluijsmans, D., Dochy, F., & Moerkerke, G. (1999). Creating a learning environment by using self- peer- and co-assessment. *Learning Environments Research, 1*, 293-319.

Soller, A. (2001). Supporting Social Interaction in an Intelligent Collaborative Learning System. *International Journal of Artificial Intelligence in Education, 12*, 40-62.

Stern, M.K., & Woolf, B.P. (2000). Adaptive content in an online lecture system. *Lecture Notes in Computer Science, 1892*, 227–238.

Sung, Y-T., Chang, K-E., Chiou, S-K., & Hou, H-T. (2005). The design and application of a web-based self- and peer-assessment system. *Computers & Education, 45*, 187-202.

Taras, M. (2002). Using assessment for learning and learning for assessment. *Assessment & Evaluation in Higher Education, 27* (6), 501-510.

Vizcaíno, A. Contreras, J., Favela, J., & Prieto, M. (2000). An Adaptive, Collaborative Environment to Develop Good Habits in Programming. *Lecture Notes in Computer Science 1839*, 262-271.

Weber, G., & Brusilovsky, P. (2001). ELM-ART: An Adaptive Versatile System for Web-based Instruction. *International Journal of Artificial Intelligence in Education, 12* (4), 351-384.

Vosniadou, S. (2001). *How children learn,* retrieved October 15, 2007 from http://www.ibe.unesco.org/publications/EducationalPracticesSeriesPdf/prac07e.pdf.