Supporting Individualized Learning + Collaborative Learning + Assessment: The case of SCALE

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Abstract: Towards the direction of interweaving individualized learning with collaborative learning as well as assessment, we developed the SCALE (Supporting Collaboration and Adaptation in a Learning Environment) environment where the learning process is realized through the accomplishment of learning activities. SCALE supports (a) individualized learning by enabling learners to work on activities and providing personalized feedback/guidance according to their preferences, (b) collaborative learning by enabling learners to work on collaborative activities, supporting alternative models of collaboration and promoting and facilitating the synchronous communication between the group members, and (c) assessment by enabling the automatic assessment of the activities and the peer- and collaborative-assessment. In this context, a number of web-based tools have been developed including an adaptive text-based synchronous communication tool, an environment supporting peer- and collaborative-assessment and an adaptive concept mapping tool. In this paper we focus on the main functionalities of the SCALE environment by describing the design framework of the activities and the tools accompanying SCALE.

Key-Words: Individualized Learning, Collaborative Learning, Assessment, Peer Assessment, Collaborative Assessment, Collaborative Activities, Communication, Feedback, Adaptation

1 Introduction

The rapid development of e-learning and network-based technologies has offered opportunities for individualized learning as well as for collaborative learning, of locally distributed learners [8], [17]. Moreover, many researchers seem to agree on the notion that 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 [12], [15]. In this context, various research efforts and projects focus on the development of web-based learning environments that support (i) individualized learning [10] taking into account learners' characteristics and needs, or (ii) collaborative learning [11], [13], [19] providing various means to support learners in the accomplishment of collaborative activities, or (iii) assessment [20] 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 this paper, we present SCALE (Supporting Collaboration and Adaptation in a Learning Environment) which is a web-based adaptive learning environment aiming to support the processes of learning and assessment. The activities constitute the basic learning/assessment unit as well as the main interaction unit between learners. The discriminative characteristic of SCALE is that it attempts to interweave individualized learning with collaborative learning as well as assessment. More specifically, the environment supports (a) individualized learning by enabling learners to work on learning activities and providing personalized feedback/guidance according to their preferences, (b) collaborative learning by enabling learners to work on collaborative learning activities, supporting alternative models of collaboration and promoting/facilitating/regulating the synchronous communication between the group members, and (c) assessment by enabling the automatic assessment of the activities, the peer- and collaborative-assessment. A number of tools have been developed including an adaptive text-based synchronous communication tool

supporting the learners' communication, an adaptive web-based concept mapping tool supporting the elaboration of activities based on concept maps and a web-based environment supporting peer- and collaborative-assessment.

The rest of the paper is structured as follows: In Section 2, the theoretical framework and principles for the design of the environment are presented. In Section 3, we analyze the design framework of the activities focusing on the educational framework, the "action" framework and the guiding framework. Afterwards, in Section 4, a brief description of the tools, supporting the main functions of SCALE, is given. The paper ends with the main points of our work and our near future plans.

2 Theoretical Foundations

Activity Theory 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. Also, Activity Theory is used as a conceptual framework to study knowledge building [7]. The basic premise of the Activity Theory stems from Vygotsky's [7] notion that human activities and higher psychological functions have sociocultural origins.

Cole and Engeström [1] developed a model of an activity system that incorporates various *mediational* means within the *subject* and *object* relationship including *tools*, *community*, *divisions of labor* and *rules*. In Fig. 1, the upper triangle describes individualized learning with relations between the subject, the object and the mediational artifacts while the lower half of the triangle adds the conception of the mediating social world in the subject-object relationship, including communal rules, divisions of labor and the community itself [7].

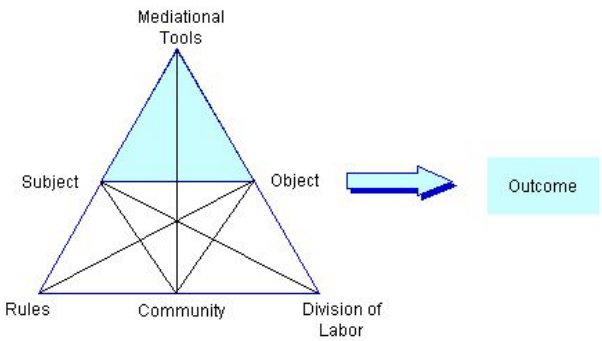

Fig. 1. The Activity Model of Cole and Engeström

In the framework of the SCALE environment, individualized learning is realized by enabling learner (*subject*) to work on 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 (Fig. 2). The mediational tools may include (i) educational software, simulations, web sites, a concept mapping tool, etc with respect to the educational context of the activity, and (ii) the notebook of the activity under consideration, which enables learners to exchange their ideas, proposals, and comments and externalize their points of view regarding the activity itself. 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 activity (*object*) utilizing various tools (*mediational tools*) and undertaking specific roles which determine the responsibilities and duties of each learner (*division of labor*) as well as the *rules* of the collaboration (Fig. 3). In the case of collaborative activities the set of the mediational tools is enriched with the notebook of the group under consideration and the synchronous communication tool, which enables learners to collaborate/ communicate in real time.

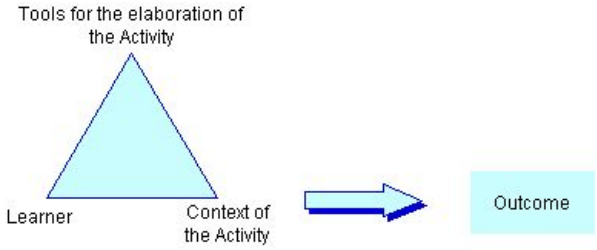

Fig. 2. Representation of the individual activity in SCALE on the basis of the Activity Model

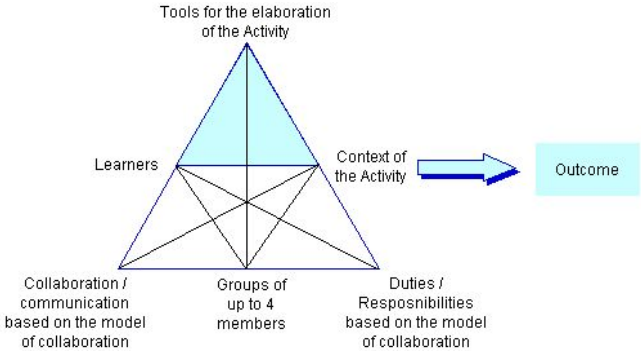

Fig. 3. Representation of the collaborative activity in SCALE on the basis of the Activity Model

The view that assessment is something, which happens at the end of the learning process, is no longer widespread. Current researches suggest that assessment should be represented as a tool for learning [2], [15] and the development of more powerful learning environments should encompass both instruction and assessment [14]. Assessment should be integrated with feedback for permitting learning to become a logical outcome [18] 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 [9]. Furthermore, peer- and collaborative-assessment are two alternatives in assessment that have recently received great attention as both of them are considered as part of a learning process where skills are developed [16]. Towards this direction, the SCALE environment supports the automatic assessment of the activities, the peer- and collaborative-assessment and the provision of feedback tailored to learner's individual characteristics.

3 The Design Framework of the Activities

Based on the learning/assessment goal, learner selects an activity from the provided list addressing the goal under consideration. For example in Fig. 4 the leaner has selected the learning goal of the "Looping construct WHILE", in the context of the "Introduction to Programming" subject matter, and the corresponding activities are presented. The provided activities may be either individual or collaborative. In the latter case, learners collaborate according to the model of collaboration followed which determines the duties of each member of the group (i.e. the members may have the same or different duties with respect to the underlying roles) and the moderator of the group being responsible for the group coordination and the submission of the answer resulted from their collaboration. The learners

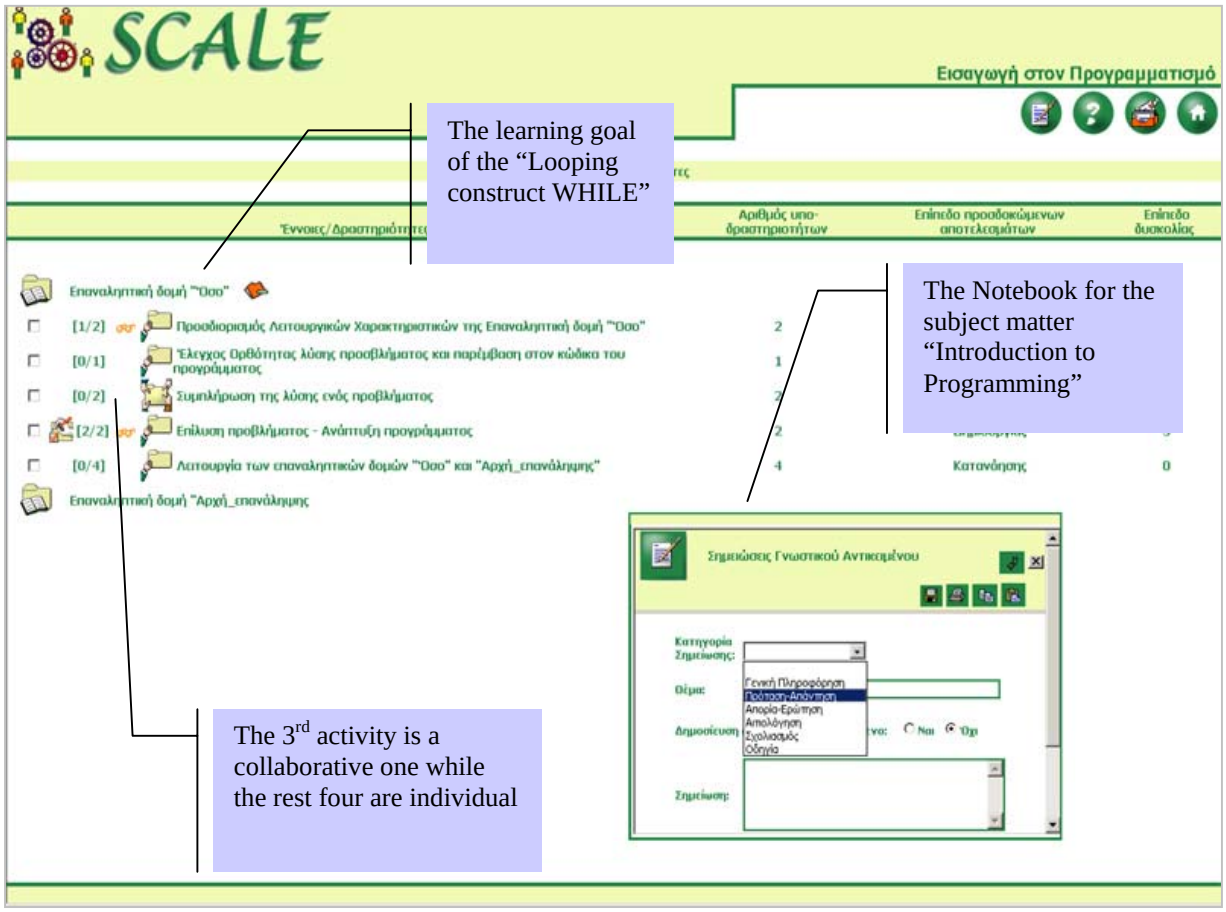

Fig. 4. A screen shot of the SCALE environment depicting two learning goals, a set of individual and collaborative learning activities for the first goal and the notebook for the subject matter under consideration

have at their disposal the tools, which are considered necessary to accomplish the activity (e.g. the ACT tool supports the synchronous text-based communication, the PECASSE tool supports peer- and collaborative-assessment).

In line with the objectives of the SCALE environment to support both the learning and the assessment process, the modeling of the activities (i) follows an *educational framework*, (ii) provides an *"action" framework*, (iii) supports the learning process through a *guiding framework*, and (iv) facilitates the elaboration process through appropriate *tools* (Fig. 5). In the following, the constructing parts of each framework are presented while the functionality of the provided tools is described in Section 4.

3.1 The Educational Framework

The educational framework specifies the context of learning and how the learning process is going to take place, by determining:

- The *subject matter* (e.g. "Introduction to Programming", "Distance Learning").
- The *learning/assessment goal*, which concerns fundamental concepts of the underlying subject matter (e.g. "Do I know the Looping construct WHILE?" in the context of the "Introduction to Programming" subject matter).
- The *educational/didactical approach*, which is followed in the context of the specific activity. For example, in the context of the "Introduction to Programming" subject matter, the activity may follow the ECLiP framework, which adopts characteristics from exploratory and collaborative learning [3].
- The *educational/assessment function* such as ascertaining students' prior knowledge, identifying conceptual changes and motivating learners.
- The *learning/assessment outcomes*, which further analyze the learning/assessment goal addressing cognitive skills that are classified to one of the four levels: Comprehension level (Remember + Understand), Application level (Apply), Checking-Criticizing level (Evaluate) and Creation level (Analyze + Create) [4].
- The *kind of the activity* specifying the individual or collaborative dimension of learning.
- The *educational tools* that are considered necessary for the elaboration of the activity (e.g. educational software, concept mapping tool).
- The *form of the assessment*; that is, whether the activity is going to be assessed automatically, or by the tutor, or by a peer (peer assessment) or by a group of learners (collaborative assessment).

3.2 The "Action" Framework

The "action" framework specifies the context of the activity as well as how learners will collaborate. More specifically, this framework specifies:

- The *sub-activities* of the activity under consideration; an activity may include a number of sub-activities addressing different learning/ assessment outcomes and a sub-activity may include one or more question items.
- The *material* of the activity, which concerns explanations, useful web sites, images, etc.
- The *model of collaboration* followed in case of a collaborative activity; the model of collaboration specifies the number of group members, the role of each member and the moderator of the group.

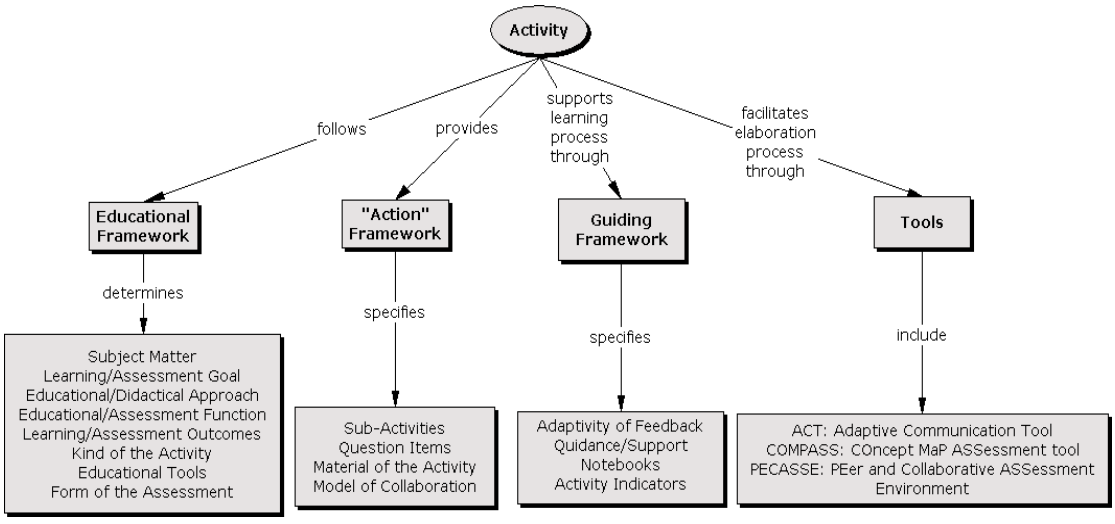

Fig. 5. The frameworks and the tools supporting the modeling of activities in SCALE.

3.3 The Guiding Framework

The guiding framework supports the learning process and specifies the way and the type of feedback provided during the elaboration of the activities. More specifically, this framework specifies:

- The *adaptivity of feedback*, which takes into account learners' individual differences. SCALE supports different feedback types (e.g. example, solution of others, explanations) as well as different ways for feedback provision (e.g. assessment form or letter). The learner during his/her subscription in a subject matter has the possibility to declare his/her preferences for feedback provision. SCALE takes into account learner's preferences and provides the appropriate feedback.
- The *guidance-support* provided during the elaboration of activities. SCALE guides learners by providing feedback whenever the learner asks for.
- The *notebooks*, which give learners the possibility to write down their ideas/comments and to "communicate" with other learners. The notebooks have the form of asynchronous communication chats and learners can characterize and publish their notes in order to exchange and discuss their ideas; a note may be characterized as general information, proposal/ answer, question/clarification, reasoning, comment or guiding. SCALE supports three types of notebooks:
  (i) *Notebook of the Subject Matter*, on which learner has the possibility to maintain personal notes, and to have access to notes that concern the specific subject matter and have been published by others (Fig. 4),
  (ii) *Notebook of the Activity*, on which learner has the possibility to maintain personal notes concerning the specific activity, and to access published notes for the specific activity, and
  (iii) *Notebook of the Group*, on which learner has access to notes that have been published by other members of the group in the context of the collaborative activity under consideration.

  The notebooks serve the learners' collaboration as they enable them to read and answer the published notes and also foster processes of reflection, and cultivate metacognitive skills such as self-regulation and self-control.
- 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 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 for the elaboration of the activity as well as the times that each model has been applied, and the number of messages that have been exchanged between the members of the group. The indicators of the activity aim to (i) give learners the possibility to reflect on their efforts for the accomplishment of the activity, and (ii) motivate them to try again in case of unsatisfactory results.

4 The Tools

The supported tools facilitate the elaboration of the activities and can run as standalone tools or in the context of SCALE. More specifically:

The ACT tool (Adaptive Communication Tool) supports the synchronous communication of learners in groups of up to four persons. The learners communicate in the context of a specific collaborative activity and the group follows a specific model of collaboration during the elaboration of the activity; the learners may collaborate either having the same duties or undertaking different roles. In any case, one of the group members plays the role of the moderator, being responsible for the coordination of the group process (e.g. proceed to the next question), the summarization of the debate and the submission of the final answer.

The ACT tool aims to guide and support learners appropriately during their debate. To this end, the structured form of the dialogue is followed, aiming to (i) eliminate the off-task discussions, (ii) guide learners towards the underlying learning outcomes (i.e. cognitive skills) of the activity or the duties and responsibilities implied by the model of collaboration, and (iii) enable the automatic interpretation of learners' interaction as well as the tracing of the dialogue states. In ACT, the structured form of the dialogue is supported utilizing as scaffolding sentence templates (SST) both the sentence openers and the communication acts. For the determination of the most appropriate sets of the SST, a research-based approach was followed [5],

[4]. More specifically, three empirical studies were conducted during the design phase of the tool in order to determine the appropriate sets of the SST. The supported sets have resulted from the text-based free dialogues and the feedback received from the participants as well as the experience of the authors. The SST are categorized to one or more of the following discourse categories: Proposal (P), Question (Q), Reasoning (R), Clarification (C), Inference (I), Motivation (M), Agreement (A), Disagreement (D), Need (N), Opinion (O), and Social Comments (S). Besides the predetermined sets of SST, the learner may define his/her own ones in case the available ones do not cover his/her needs. The provided SST are adapted on the basis of (i) the level of the learning outcomes (i.e. cognitive skills) addressed by the collaborative learning activity, (ii) the specific roles that learners undertake in the context of a specific model of collaboration, and (iii) the educational tool, if any, used for the elaboration of the activity.

In ACT, learners' interaction is recorded into log files, which are accessible, by the tutor. Moreover, since we are interested in assessing learners' communication in terms of the skills addressed by the collaborative activity or the collaboration model, we keep records of learners' messages as these are classified to the aforementioned discourse categories (e.g. Proposal (P), Question (Q)) and proceed to their quantitative analysis. The data resulted from the analysis are accessible both to learners and the tutor and concern the number of messages sent by each group member for each one of the discourse categories (e.g. number of Proposals), the groups that have worked out the specific activity/subactivity, the models of collaboration followed in the context of the specific activity/subactivity, etc. The learners can have access to these data at any time during their communication. As learners' communication is carried out, the messages are visually represented in a tree structure, grouped according to the reference message. In particular, ACT supports a facility for the automatic construction and update of the Dialogue Tree as learners submit their messages. The messages are grouped into sub-trees according to the message they are referring to. The learners can have access to the Dialogue Tree at any time during the communication. The main advantage of such a graphical representation of the dialogue is that learners can see the dialogue in a different form, can trace the sequence of the dialogue more easily and can have a clear view of the dialogue progress.

The PECASSE environment (PEer and Collaborative ASSessment Environment) supports the peer- and collaborative-assessment. In the context of the PECASSE environment, learners act as "evaluators" being responsible to evaluate, on their own (peer assessment) or by collaborating with other learners (collaborative assessment), the assignments submitted by their peers. The evaluation process may be carried out in three rounds at most. Each round involves the following stages: (i) submission of the assignment, (ii) evaluation of the assignment and provision of feedback, and (iii) revision of the initial submitted version of the assignment. The feedback may be provided as a letter or as a form. The environment enables learners to

- submit their assignment,
- be informed of any pending evaluations,
- define evaluation criteria,
- submit their evaluation as well as the accompanied feedback,
- receive feedback about their own assignments,
- self-assess their own assignments, and
- evaluate their evaluators.

In the case of collaborative assessment, the group may be composed of up to four members collaborating, having the same duties or undertaking specific roles. The teacher may be a member of the group, participating in the evaluation process. The group communication is either synchronous through the ACT tool or asynchronous through discussion fora.

The COMPASS tool (COncept MaP ASSessment tool) [6] is a web-based concept mapping tool aiming to assess learner's understanding as well as to support the learning process. In particular, COMPASS serves the assessment and the learning process by enabling the accomplishment of concept mapping activities. Depending on the learning outcomes, the activities may employ different concept mapping tasks, which are characterized along a directedness continuum from high-directed to low-directed, based on the information/support provided to learners. More specifically, COMPASS supports the construction of a map as well as the evaluation (i.e. the evaluation/correction of a map in case of any errors identified), the extension (i.e. add new concepts and relationships) and the completion (i.e. filling the missing components) of a given map. Also, combinations of the abovementioned tasks are supported. Depending on the degree of support provided, learners may have at their disposal a list of concepts and/or a list of relationships to use in the task (e.g. "concept list construction" task, "concept-relationship list extension" task) or may be free to

choose the desired concepts and/or relationships (e.g. “free construction” task). The provided lists may contain not only the required concepts/relationships but also concepts/ relationships that play the role of distracters (i.e. concepts that can be characterized as superfluous and relationships that are incorrect).

COMPASS supports (i) the analysis of learner’s map, i.e. the identification of any errors on map (error diagnosis) based on the similarity of learner’s map with the expert one and their qualitative analysis, (ii) the diagnosis of learner’s false beliefs and incomplete understanding, based on the errors identified, (iii) the quantitative estimation of learner’s knowledge level on the central concept of the map, which is further exploited for the provision of personalized feedback, (iv) the provision of different informative, tutoring and reflective feedback components, tailored to each individual learner. The personalized feedback accommodates learners’ knowledge level, preferences and interaction behaviour and is provided either in a visual form or through a dialogue framework between the learner and the system. Also, the COMPASS tool facilitates the instruction process by supporting the teacher in the development of concept mapping activities.

5 Conclusions and Future Plans

In this paper a web-based adaptive learning environment, referred to as SCALE was presented. SCALE attempts to interweave individualized learning with collaborative learning as well as assessment. The activities constitute the basic learning/assessment unit as well as the main interaction unit between learners. During the elaboration of the activities, learners have at their disposal tools, which are considered necessary to accomplish the activity such as the ACT tool, which supports the synchronous text-based communication, the COMPASS tool for concept-mapping activities and the PECASSE environment, which supports the peer- and collaborative-assessment. Our near future plans include the full development of the tools/functions presented and the conduction of a series of experiments for the formative and summative evaluation of the SCALE environment.

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