INTEGRATING INDIVIDUAL AND COLLABORATIVE TASKS IN A PROJECT-BASED e-LEARNING CONTEXT

Kyparisia Papanikolaou
Department of Education, School of Pedagogical & Technological Education, GR141 21 N.Heraklion, Athens, GREECE
spap@di.uoa.gr

Maria Boubouka
Department of Informatics and Telecommunications, University of Athens
Panepistimiopolis, GR-15784 Athens, GREECE
mboub@di.uoa.gr

ABSTRACT

In this paper we investigate how individual and collaborative activities could be effectively combined at specific phases of a project-based e-learning environment to promote individual and group development. To this end, an empirical study was conducted in which 82 students of the Computer Science and Telecommunications department, University of Athens, and three researchers participated. During the study students worked on a project about computer programming using the web-based learning environment MyProject. MyProject supports learners in dealing with all the phases of a project aiming to help them progressively understand the implicit issues of the project and organize their work. Students worked individually and in groups undertaking multiple roles. They worked in groups in order to plan goals and define the project, as well as to decide on qualitive evaluation criteria and submit a final solution. Group discussions and students' answers to an evaluation questionnaire and interviews were analysed in order to identify collaboration patterns and evaluate the type of discusions performed and the effectiveness of the proposed mode of collaboration.

KEYWORDS

Project-based learning, collaboration, peer interaction, metacognitive knowledge, asynchronous discussions

1. INTRODUCTION

Project-Based Learning (PBL) has proved to be an effective teaching and learning strategy that combines curricula, teaching methods, and assessment into one single unit. In project-based learning students need to generate questions, make investigations, and produce a final product that represents knowledge integration. In such a learning context, experience, self-direction and high-level metacognitive control is necessary in order learners to effectively undertake PBL (Jonassen, 1999). Many learners, however, lack essential metacognitive skills and a repertoire of learning strategies to enable them to maximise their learning in such innovative learning environments (Hannafin and Land, 1997; McLoughlin and Hollingworth, 2001).

In this context, a number of contemporary designs of web-based learning environments and tools have been lately developed to support learners' self-monitoring and orienting, or planning how to proceed, or self-evaluating their performance in a project-based learning context. These environments usually aim to support learners deal with the issues of a project at individual or group level. KBS Hyperbook (Henze et al, 1999) offer learners projects and the system provides individualized navigation support to the project resources based on the learners' knowledge level and/or learning goals. Several systems focus on the collaborative perspective of project-based learning, providing tools that support communication and interaction at specific phases of PBL such as NetPBL (Lee and Tsai, 2004), HyperNews (Häkkinen, 2002), iExpeditions (Wang, 1999). In particular, NetPBL supports project-based learning in a blended learning context. It supports students' interaction and ideas/artifacts sharing. Students are allowed to (a) carry on synchronous and asynchronous discussions for the subquestions arising from the 'driving question' posed by the teacher, or for several issues that need to be investigated, (b) upload and share their artifacts. HyperNews is a collaborative

discussion environment enabling communication among students, teachers and experts at the planning and evaluation phases of the project work.

MyProject (Papanikolaou and Grigoriadou, 2009) is a web-based adaptive constructivist learning environment that supports learners in dealing with all the phases of a project aiming to help them progressively understand the implicit issues of the project and accordingly organize their work. To this end, MyProject proposes learners a set of appropriate learning activities (at different stages of a learning cycle), and assists them in following their own path through the cycle providing adaptive guidance. Moreover, the system provides learners with hypermedia educational content composed of authentic cases, whilst by opening the learner model to learners it aims to enhance reflection on the learning process. At group level, learners are allowed to publish their own ideas and solutions when working with activities or studying the content. MyProject has been recently extended with a peer assessment functionality (Boubouka et al., 2008) as an alternative evaluation approach appropriate for project-based learning environments.

In this paper we present an empirical study conducted to investigate the use of MyProject in an e-learning context focusing on peer interaction and collaboration. In particular we investigate how individual and collaborative activities could be effectively combined at specific phases of a project-based e-learning context to promote individual and group development.

2. RESEARCH CONTEXT AND AIMS

Metacognitive research emphasizes the need to balance cognitive and social competence as well as the need to create social, interactive and reflective environments with a holistic approach to supporting metacognition (Lewis, 1998). Social interaction promotes the development of individuals' cognitive structures as individuals reconcile differences between their own ideas and the ideas of others - see (O'Donnell and King, 1999) for reviews of these theories-, ask questions and explain their reasoning for solutions (O'Donnell and King, 1999; Teasley, 1995; Teasley, 1997; Webb, 1992). Moreover, it is strongly suggested that work in groups provides opportunities for the development of members' cognitive structures (O'Donnell and Kelly, 1994), cultivates positive attitudes toward the task and stronger task motivation compared to individual work.

Taking into account that metacognitive knowledge such as self- and task- knowledge, strategic knowledge and knowledge of plans and goals are best supported in social settings for learning (McLoughlin and Hollingworth, 2001), an interesting issue to further investigate is the potential and constraints of collaborative and individual work in promoting such knowledge at specific stages of a project.

Towards this direction we currently investigate the introduction of collaborative tasks in specific phases of a project in a way that promotes metacognitive knowledge and allows learners learn from peers in an efficient way (O'Donnell and Kelly, 1999). This work aims to extend peer learning opportunities in the e-learning environment of MyProject which is described below. MyProject is based on the four principles proposed by Barron et al. (1998) for designing, implementing and evaluating *project-based* curricula: (a) defining learning-appropriate goals; (b) providing scaffolds that support learning; (c) ensuring frequent opportunities for formative self-assessment and revision; (d) developing social organizations that promote participation and result in a sense of agency.

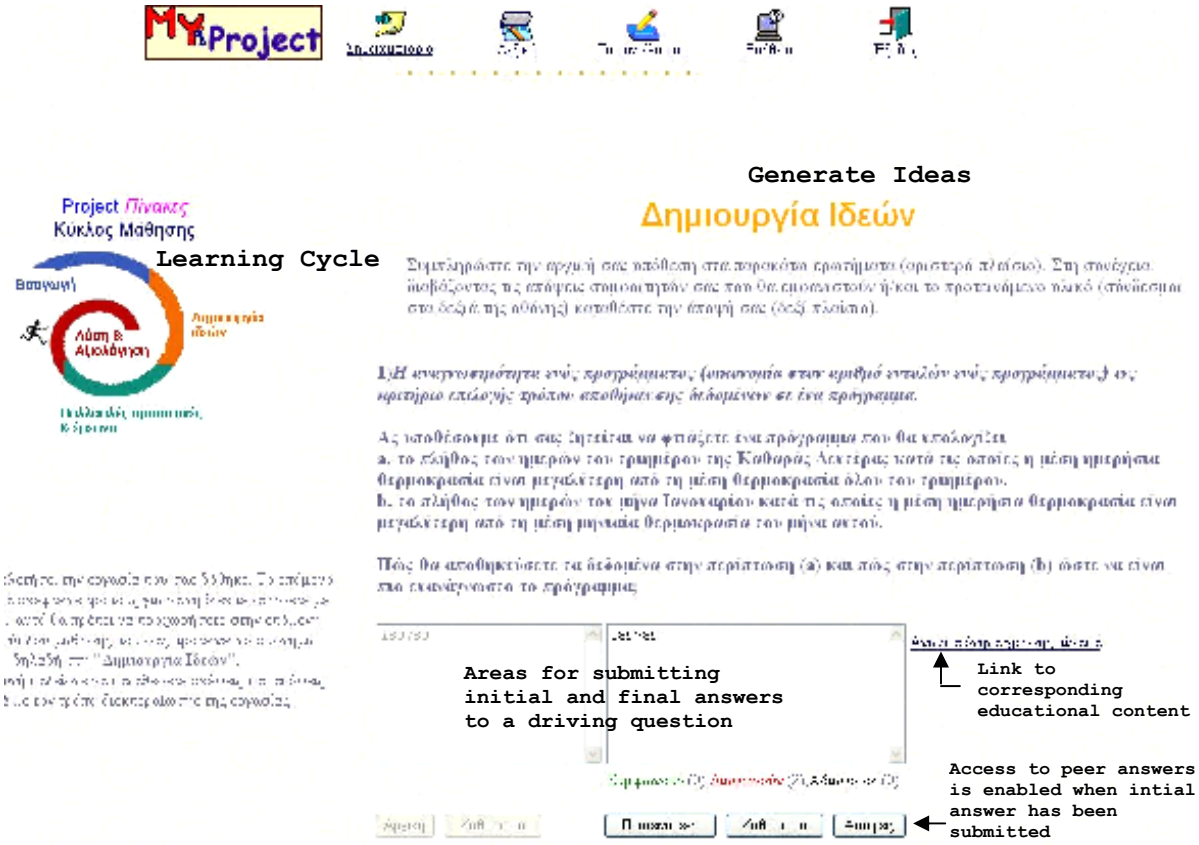
Currently, MyProject supports learners work independently on a project and construct their own knowledge. Peer interaction is promoted allowing learners to publish their ideas and solutions at specific phases of a project and comment on them. As learners usually feel lost in a project-based context, MyProject supports learners in facing the challenges posed by organizing specific activities that gradually lead to the accomplishment of the project in a 'learning cycle', and providing adaptive guidance based on learners' interaction behavior in order to assist them in moving through the cycle. The particular 'learning cycle' consists of several stages that aim to help students progressively understand the implicit issues of the project, and become able to complete the project, reflect on, monitor and evaluate their learning. The sequence of the stages consisting the learning cycle is indicatory and the learners are able to navigate freely through the stages as these are described below:

At the *Introduction* stage an open-ended project is presented, not fully defined in order to *motivate* learners to outline specific issues valuable to further investigate. Along with the project, initial resources are also provided. This stage aims to develop learners' capacity to set and maintain goals and to record what they intend to do through their learning.

At the *Generate Ideas* stage (see Figure 1), learners are promoted to submit their perspective to one or more 'driving questions'. These 'driving questions' aim to cultivate self- and task- knowledge. Learners are promoted to consider the demands of the necessary tasks for accomplishing the project, and at the same time recognise their strengths and weaknesses. Different types of scaffolds are provided. Links to the corresponding educational material appear next to each driving question as a scaffold. After learners have submitted their initial answer to a driving question, they are allowed to access their peers' contributions and comment on them (state whether they agree, disagree or find the answer indifferent). Learners are allowed to answer the driving questions more than one time, whilst initial and final answers are always available so that learners can monitor the evolution of their ideas.

At the *Multiple Perspectives & Research* stage, educational content in the form of realistic cases (Kolodner and Guzdial, 1999), or self-assessment questions (usually embedded in the cases) is provided. Cases are interpretations of experiences consisting of several parts (Kolodner & Guzdial, 2000): (a) the description of the problem that the case encounters, (b) the solution, (c) a sequence of events, i.e. the different steps that an expert has followed to solve the problem, (d) explanations linking results to goals and the means of achieving them, and (e) results of the proposed solution. The self-assessment questions may be of multiple choice form or open–ended. The open ended questions can be reviewed by peers in the same way as the answers to the driving questions in the Generate Ideas stage, whilst the teacher's answer becomes also available when the learner submits his/her answer.

Figure 1. A screenshot of MyProject at the "Generate Ideas" stage, where learners are encouranged to submit their initial & final estimations to the driving questions, access peers' ideas & move to content linked to the driving question



The *Solution and Evaluation* stage is based on a peer assessment approach organised in four phases: initially learners *propose* their solution, then they *evaluate* one or two peers' solutions submitting evaluation and feedback, then they *revise* their work based on the reviews they received, and they finally *reflect* to the final solutions provided by their peers.

3. EMPIRICAL STUDY

This empirical study focus on the introduction of collaborative tasks at specific phases of a project-based e-learning context. The aim is to investigate how a combination of individual and collaborative tasks might promote the development of individuals' cognitive structures and metacognitive knowledge, and cultivate positive attitudes toward collaboration and peer support. In particular, we investigate how individual and socially shared reflective thinking might be combined to support learners in the planning and evaluation phases as most critical for the project work.

Eighty two (82) students of the Computer Science and Telecommunications department, University of Athens, attending the course 'Informatics and Education' during the spring semester of the academic year 2007-2008, participated in this study. Also, 3 researchers worked on the organisation and evaluation of the study. During the study students worked on a project about computer programming using the learning environment of MyProject. Students collaborated in groups at the Introduction stage of the learning cycle for planning together the goals of their work, and at the 'Solution and Evaluation' stage for establishing evaluation criteria and producing the final product of the project. Groups' negotiations took place at the forum of an e-class environment used during the course. Most students organised in groups randomly (42 students - 51%), whilst 24 students (29%) chose their group, and 16 students (20%) in a mixed way. Students worked also individually at the 'Generate Ideas' stage reflecting on the main driving questions of the project and the 'Multiple Perspectives & Research' stage. At the latter stage, students studied individually the content provided (authentic example-cases) in order to deal with the different concepts involved in the project, and they completed the exercise-cases, i.e. the solution part or the steps that an expert has followed to solve the exercise, which are intentionally missing. At both stages peer support is encouranged since students are allowed to share their answers and comment on peer proposals.

3.1 Method

Through the study, students worked individually and in groups undertaking multiple roles. They initially worked as learners undertaking a project about computer programming and then as reviewers-experts evaluating their peers' solutions and the learning experience through MyProject (usefulness, usability, support in working out a project). The whole study lasted about one month.

In particular, students' work organised in three phases as follows.

1st Phase: Initially, students worked as learners undertaking a specific project on computer programming. Students working *individually* for seven days at their place and time they should run the three first stages of the learning cycle: (a) read the subject of the project (learning cycle - Introduction stage), (b) submit their initial ideas to the driving questions (learning cycle - Generate Ideas stage), (c) study the educational material linked to each of the driving questions (learning cycle – Multiple Perspectives & Research). Then, they should *work in groups* in order to discuss the open issues of the project and agree on specific goals (duration: two days). To this end, the forum of the e-class environment of the particular course was used.

2nd Phase**:** Students worked *individually* for completing the project and submitting an initial approach as well as *in groups* in order to define quality criteria for the evaluation of the proposed solutions. In particular, this phase lasted for nine days following the peer review process of the 'Solution and Evaluation' stage of the learning cycle: (a) initially students working individually submitted the definition of the project – product of negotiation among the members of each group at the Introduction phase – along with their solution (duration: three days), (β) then, each student evaluated the solutions proposed by the rest members of their group based on the commonly agreed quality criteria (duration: three days), (c) finally, students had to revise their individual solutions based on the review comments and submit a common solution as a group product - to this end, each group discussed at the forum of the eclass in order to reach a consensus about this final submission (duration: six days).

3rd Phase. After the submission of the final products, students completed an evaluation questionnaire about this learning experience. Also, a meeting was arranged among students and researchers to discuss several issues about this learning experience.

3.2 Data collection and analysis

The data collected from the study include: (a) group discussions consisting of messages posted at the forum of the eclass through the collaborative tasks, (b) individual and group products-solutions, (c) learners' evaluation questionnaires, (d) interviews.

Below we initially focus on the analysis of group discussions, the evaluation questionnaires reflecting students' opinions, and issues discussed through the interviews. In particular, a quantitative and qualitative analysis performed to the messages posted at the asychronous forum in order to explore the type of discussions performed and the metacognitive knowledge developed through the discussions such as *knowledge of plans & goals* (learner's capacity to set and maintain goals and to record what they intend to do through their learning), *task-knowledge* (involves understanding the demands of tasks and what they require), and *self-knowledge* (entails the individual's capacity to recognise their strengths/weaknesses and to evaluate themselves). To this end, we also used the instrument of Gunawardena et al. (1997) which examines the social construction of knowledge in computer conferencing.

Lastly, analysing students' answers to specific questions of the evaluation questionnaire we *investigated* students opinions about (a) the phases of the project that they consider important to incorporate individual or collaborative tasks, (b) modifications that they consider important for the improvement of collaboration.

3.3 Results

Peer support cultivating (a) knowledge of plans and goals, (b) task-knowledge, (c) self-knowledge.
Students collaborated in groups at specific stages of the learning cycle through the discussion forum. In particular, at the Introduction stage, the messages posted provide evidence about the value of collaboration in promoting *knowledge of plans and goals*. At this stage, 29 groups were formed. 867 messages were posted in total, although the type and amount of communication differ from group to group. Analysing the discussions performed, we identified that students concentrated on a variety of topics including those that they were asked to work on. In particular, 28 groups discussed issues concerning the definition of their project as they should to, concluding to an outline of the project they were interested to undertake, 25 groups went beyond that and discussed about how to solve the problem posed, proposing and arguing on alternative strategies. 11 groups discussed how they should proceed with their project and mainly on the work plan, whilst 6 groups discussed technical issues. Only one group faced communication problems resulted in several disagreements among the members of the groups.

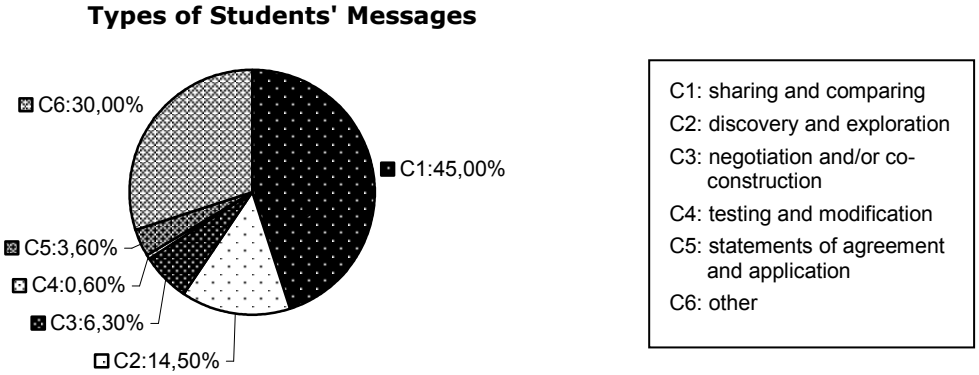
At the Solution and Evaluation stage, the messages posted provide evidence about the value of collaboration in promoting *self-knowledge*. In particular, at this stage participated 26 of the 29 groups. Initially, the 26 groups worked to define quality criteria for their projects. Students proposed criteria evaluating the domain knowledge as well as higher order programming skills. The total number of messages posted was 616. We observed that the number of messages exchanged among the members of each group decrease through the time. Then, 22 of the 26 groups discussed their final submission to the project. The total number of messages exchanged decreased to 453. The collaboration patterns adopted for the final submission are quite interested. 22 of the 26 groups submitted the best solution among those proposed by the members of their group with a little refinement, i.e. the group adopts one member's solution. 2 groups didn't manage to come to a consensus about the final submission and each member submitted a revised version of his/her initial submission. 2 groups decided to synthesize the best of their members' individual solutions and submit a common final solution.

Aiming to evaluate the *quality of the discussions* developed at the forum, we used the instrument of Gunawardena et al. (1997). It is based on the grounded theory and uses the phases of a discussion to determine the amount of knowledge constructed within a discussion. Thus, each message at the forum was categorised according to the scheme: (C1) sharing and comparing of information, which comprises observations, opinions, statements of agreement, examples, clarifications, and identifications of problems, (C2) discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements (C3) negotiation of meaning and/or co-construction of knowledge, which includes negotiation, identifications of areas of agreement, and proposing new co-constructions on topics where conflict exists, (C4) testing and modification of proposed synthesis or co-construction, which is further tested against existing cognitive

schema, experiences, and literature, (C5) statements of agreement and application of newly-constructed meaning, and encompasses summarizing agreements, applications of new knowledge, and metacognitive statements revealing new knowledge construction, (C6) other.

In the forum were posted 2255 messages in total. As Figure 2 depicts 45% of these messages belong to the (C1) category, whilst 30% of them (C6) refer to practical issues about the collaboration such as what time to e-meet and discuss, or how to upload something. 14.5 % of the messages state a disagreement to a previous message (C3). Discussion of types C2, C4, and C5 slighlty developed. We observed that the groups with high communication rate, i.e. posted many messages, they gradually developed discussions of the categories C2, C3, C4 and C5. However, the discussion of those groups that didn't manage to collaborate, were restricted to opinion sharing and practical issues.

Figure 2. Types of messages posted at the discussion forum based on Gunawardena et al. (1997)



Learners answers to specific questions of the *evaluation questionnaire*, provide evidence about the value of the mode of work proposed (combination of individual and collaborative tasks) in promoting *task knowledge*. Most students suggest that group collaboration through the forum was quite supportive at the Introduction stage for defining the project and planning their work (75%). The same at the 'Solution & Evaluation' stage (95%) for defining quality criteria and submitting a final solution. Many students prefer individual work at the 'Generate Ideas' stage whilst most of them (65%) prefer to collaborate with their group at least for the final submission to the driving questions. However, most students took advantage from the possibility of sharing their ideas with peers at the Generate Ideas stage, looking at their peers' answers in order to validate their own ideas but also for commenting on them. At 'Multiple Perspectives & Research' stage, most students seem to easily find their own way. At this stage students prefer individual work when studying the content although they appreciate the option of sharing their answers to assessment tasks.

Usefulness of interaction & collaboration opportunities at various phases of the learning cycle of MyProject. Based on learners' answers to specific questions of the *evaluation questionnaire*, 70 students (87,5%) were positive to collaborative tasks, 7 students (8,75%) negative, 4 students (5%) neutral. Among the benefits of collaboration, students acknowledge that (a) this way many different ideas and opinions were discussed (35 students 43%), (b) supported the establishment of common goals (15 students - 18%), (c) promoted peer learning as they managed to overcome difficulties (11 students - 13%). Other benefits suggested by students during the *interviews* were that the collaborative tasks promoted a sense of community and the immediate feedback they usually received from peers. Students also liked the combination of individual and collaborative tasks and the multiple roles they undertook - 'in a few days you pass from the role of a student to the role of a teacher'.

Negative options were also outlined in cases that the group didn't manage to productively collaborate due to its synthesis resulting to lack of communication or irresponsibility of some members of the group.

Especially at the Introduction stage, only 2 students (2%) were against collaboration prefering a clear project definition provided by the teacher. Although, 57 students (70%) suggest that the way they worked was the appropriate one, alternative ways of collaboration were also proposed such as face to face communication or chat, involve the teacher in this discussion, collaboration among groups. It is remarkable that only one student seem to prefer working individually at the Introduction stage.

As far as the mode of work adopted at the 'Solution and Evaluation' stage (i.e. the particular combination of individual and collaborative tasks) various proposals were submitted. 49 students (60%) prefer the way they worked, i.e. individually (I) at first and then in groups (G) for the construction of a final group product, whilst only 2 (2.5%) students prefer to work in groups (G) at first and then individually (I). 10 (12%) students would prefer to work in groups throughout the 'Solution and Evaluation' stage instead of the final part of the stage when submitting a group product, whilst 10 students (12%) argue that the revised version of their initial product should be individually contsructed. Furthemore, 4 (5%) students would prefer teacher guidance instead of peer interaction. It is remarkable that most of the students prefer to collaborate at this stage although in alternative modes, and none of them prefer to work individually.

Table 1. Students estimations on the effectiveness of various types of peer support

	Positive	Neutral	Negative
Group work for quality criteria	73 (89%)	5 (6%)	4 (5%)
Evaluating peer's solutions	72 (88%)	6 (7%)	5 (6%)
Receiving reviewing comments by peers	70 (85%)	6 (7%)	5 (6%)
Group work for final group solution	70 (85%)	6 (7%)	5 (6%)

Students find also valuable and supportive in improving their individual solutions, the different options of peer support promoted including (see Table 1): (a) group collaboration for defining quality criteria, (b) evaluating their peer's solutions, (c) receiving reviewing comments on their work by peers, (d) group collaboration for the submission of a final group solution.

4. CONCLUSIONS AND FUTURE PLANS

In this empirical study, all the students seem to value collaborative tasks although the individual tasks were also considered necessary at specific phases of the project. Alternative combinations of collaborative and individual tasks were also suggested that is worthwhile to be further investigated.

Students value the opportunities for collaboration and peer interaction offered. They value them as promoting task motivation, facilitating inquiry, understanding and application of programming structures i.e. domain concepts involved in the particular project.

The evaluation of the type of discussions performed reveal that group discussions in most cases were restricted to the submission of opinions, statements of agreement or disagreement, and comparisons among different proposals. Several students stated that they didn't have much experience in collaborating through an asynchronous forum. Especially at the 'Solution and Evaluation' stage, we expected the discussions to develop much further since students had to negotiate on the establishment of quality criteria and construct a common solution. But based on the collaboration patterns adopted by the groups, only two of the 26 groups collaborated at the 'Solution and Evaluation' stage in order to synthesize the individual solutions to one final version. The cognitive load of this process is much heavier compared to the approach adopted by the rest 24 groups that decided to submit the 'best' of the individual solutions. An alternative approach in organising students work at the 'Solution and Evaluation' stage, that might face this issue, is students to work in groups for the initial and revised solutions but work individually at the reviewing phase. As far as the discussions concerned, one possible approach to enhance the development of discussions that cultivate metacognitive skills or deep understanding is the use of specific collaboration scripts.

Morever, important factors influencing the effectiveness of the group work and the individual/group products that were acknowledged are: the design of collaborative tasks and their incorporation at specific phases of the project as a scaffold, the mode of collaboration, the combination of collaborative and individual tasks, the final product that students need to construct.

Building on the results of this study we intend to further investigate alternative modes of collaboration and explore various combinations of individual and collaborative tasks in order to promote the development of individuals' cognitive structures and enhance the effectiveness of peer learning in MyProject.

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