15

Informing Instructional Design Using Microgenetic Analysis of ICT-based Collaboration: A Misconceptions Perspective

Sofia Hadjileontiadou
Hellenic Open University (HOU)
Greece

1. Introduction

According to Reigeluth, instruction is "anything that is done to help someone learn", and Instructional Design (ID) theory is "anything that offers guidance for improving the quality of that help" (1997: 44). ID refers to the practice of analysis of the learning needs upon which, tools and content are systematically built in order to facilitate learning. Different learning theories informed the proposition of many ID theories and templates (Gagnè, 1985; Keller & Suzuki, 1988; Merrill, 1983; Reigeluth & Stein, 1983; van Merriënboer et al., 2002).
A quite rich discussion took place at the late nineties of the twentieth century, concerning two main directions; the orientation of the theories employed in the field of the ID and the role of the forthcoming information age to it. In the first direction, Seels (1997: 12) defined the theoretical orientations of ID as *positivist* (determining laws of cause and effect), *interpretative* (uncovering the choices involved in human action), and *critical* (analyzing the ways in which social structure constrain and direct human action). Wilson (1997: 24-25), however, argued that *positivism* "if not checked, would tend to see things in terms of their instrumental value" (24), whereas a post-modern *critical* approach "brings balance to the picture by closely examining the details" (25). On the other hand, the shift to the information age was envisaged as a learner-centered customization of the instruction rather than standardization (Reigeluth, 1997: 45). This is related to Winn's (1997: 37) assertion that "the activities of the instructional designer need to take place at the time the student is working with the instructional material", i.e., on-the-fly.
From the aforementioned theoretical orientation and the information age perspective, it is evident that the ID, being a design process, initially involves precision and expertise, no matter what media of instruction are used for its implementation (Smith & Ragan, 2004). Moreover, adaptations of the instructional system need to be embedded in the ID process in order to capture the different characteristics of the learner (prior experiences and conceptions), motivation and behavior. Within this framework, the ID should be informed by experience gained during instruction that mediates learning, i.e., by the experienced instruction and not by the designed one only (Spector, 2005).
However, despite the differences of the proposed IDs, they foresee tools and content as

mediators towards a shift of the learner from a current (input) to a next learning state (output). A traditional approach to detect this transition is based upon input-output observations, i.e., it focuses on the *product*. Nevertheless, the microgenetic analysis approach, as opposed to the traditional one, allows measuring of changes *while* learning, i.e., it focuses on the *process* (Flynn et al., 2006). Under this perspective, a mechanism that manages to follow the learning procedure and collect data may facilitate the detection of the mechanisms that trigger facets of change. Hence, more refined information upon the learning procedure could be revealed, which in turn, may inform the analysis part of the ID.

The microgenetic approach has been proposed in 1948 (Werner, 1948) and recovered in 1970. During the last years, due to the new behavior capturing and computational possibilities, there is a shift towards its wide use (Siegler, 2006). A detailed review of various implementations of the microgenetic method can be found in Siegler (2006), including collaborative settings. Such settings, when mediated by ICT, usually include a communication model, which facilitates the collaborators to perform a common task. In this case, collaborative learning can be allocated either at the task and/or the collaborative skills level that are performed through interactions with the communication model. The latter may provide the participants with opportunities to improve their collaborative skills and thus be prepared for future relevant experiences at the professional level. Considering the divergent characteristics of the participants, such training requires provision of 'proper' support. Quite often, these environments provide support that concerns the task of the collaboration. However, when the focus is on the collaborative skills themselves, the collaborative process may be seen as an opportunity for experiential learning on how to collaborate and in this case, the support is moved to the collaborative skills. This approach, in turn, may influence the outcome of the collaboration, as it increases the ability of the participants to sustain the quality of the collaborative procedure.

Recent studies ground the design of the support to be provided by the system on the analysis of the participants' collaborative interactions (Dillenbourg et al., 1996; Hadjileontiadou et al., 2003; Puntambekar, 2006). Such analysis, as far as the system is concerned, may be either of a 'static' form, e.g., statistical analysis of the collaborative interactions, or of a 'dynamic' one, e.g., intelligent inferences upon the collaborative interactions. Moreover, as far as the participant is concerned, the support is quite often of a *passive* character, e.g., s/he receives evaluative results upon his/her activity. On the other hand, support of a *participatory* character may engage the participant in an active self-supporting procedure. The latter approach, when combined with systems with intelligent ID, results in the formulation of an adaptive support. This type of support may challenge mental effort to the participants and thus, by means of their engagement in monitoring and management of the collaboration, the initial aim of improvement of their collaborative skills may be promoted. This approach entails the idea of the use of metacognition upon the experiential learning of how to collaborate.

Metacognition, is a term that was introduced by Flavell (1979). It comprises mainly of metacognitive knowledge and metacognitive experiences (Flavell, 1979; Flavell, 1987). Metacognitive knowledge refers to the knowledge of how a person learns, the different learning strategies s/he can apply and their efficiency. Metacognitive experiences refer to the practice of the metacognitive strategies. Applying these strategies, the person, defines the working task and makes predictions, plans his/her actions during the learning procedure and chooses learning strategies to complete the task, monitors and readjusts his/her working activity on the basis of his/her knowledge, regulates his/her working pace and evaluates the learning procedure (Brown, 1987).

From the aforementioned, it is evident that the metacognitive level constitutes a mechanism to monitor and adjust the cognitive one. At this level, daily life experience contributes to the development of concrete mental structures that allow the individual to explain real-world phenomena. When such knowledge meets the scientific one, misconceptions might be revealed. Provided the truth of the latter type of knowledge, these misconceptions are rooted in cognitive epistemological obstacles (hereafter obstacles) (Bachelard, 1983). These are highly connected to the above mental structures, i.e., are of an internal mode and might block learning, from conceptual, methodological and physiological point of view. An obstacle functions as an excessive commodity of thinking and holds a transversal character. As such, it explains and stabilizes many perceptions that are manifestations of it (Aristolfi & Peterfalvi, 1993). The latter are embedded in cognitive structures where they are organized to form coherent systems that facilitate understanding of phenomena and orientation of actions (Astolfi & Peterfalvi, 1993).

Within this framework, metacognition may contribute to the development of the competence of the student to identify the obstacles in order to avoid them in case they reappear. While research work has been done on the obstacles identification in the wider area of treating misconceptions in the science education (e.g., Astolfi & Peterfalvi, 1993; Skoumios & Hatzinikita, 2008), no relative work has been made at the collaborative skills in ICT mediated environments.

This chapter proposes a new approach to enhance the ICT based ID on collaborative skills enhancement, from the perspective of obstacles identification. More specifically, it focuses on the misconceptions that may be revealed through the discrepancy between the actual collaborative performance and the conceptions about it that holds the collaborator. Through a microgenetic approach, it aims at detecting the manifestation of the obstacles connected to such misconceptions and enhances the relative metacognitive skills towards better learning of how to collaborate.

The chapter is organized as follows. The next section, enriched with theoretical orientation, provides a useful background concerning the aforementioned concepts. The third section, introduces the proposed approach, whereas the fourth section, paradigmatic in character, exemplifies and discusses the way the proposed approach could be realized within a case study of collaboration. Through this, interesting possibilities to inform the ID, as far as the enhancement of the collaborative skills is concerned, are revealed. Finally, section five summarizes the core issues of the proposed approach and highlights extensions and future work.

2. Background Information

In this section, a theoretical background is presented. It is based on an ID for the enhancement of the collaborative activity and is provided to facilitate reader's comprehension.

Figure 1, contributes towards such effort by depicting the overall approach. Moreover it aims at providing cohesion to the subsections that follow, which describe in details its building blocks.

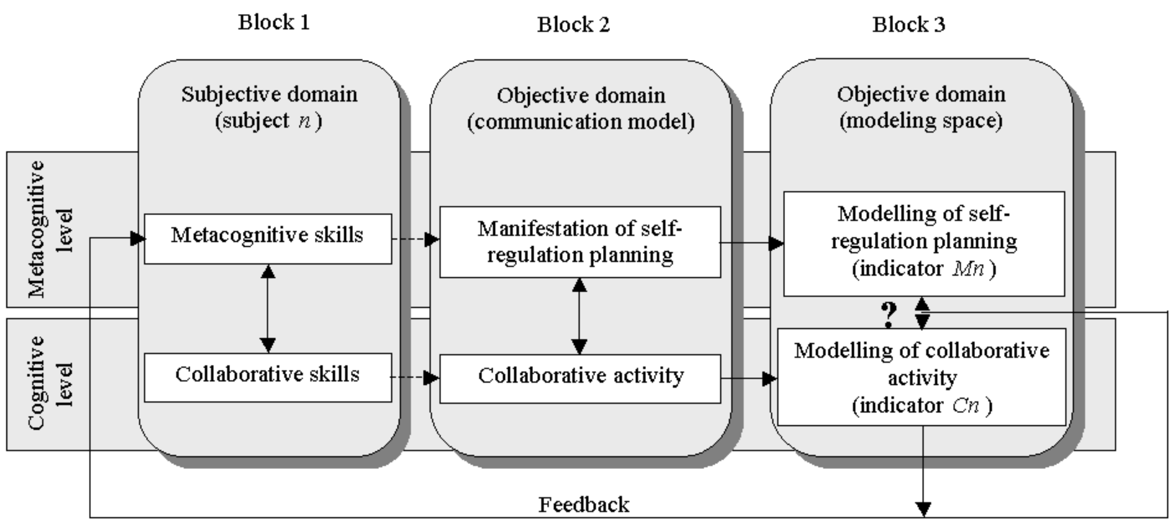


Fig. 1. The outline of an ID for the enhancement of the collaborative activity

2.1 The collaborative activity

The focus of this work is to enrich the ID of a system in order to enhance the collaborative skills of the subjects that use it. A common ID for an ICT-mediated collaborative activity foresees a communication model. It is materialized by appropriately designed interfaces, according to which, specific collaborative interactions are performed to unfold the collaboration upon a task. Such interfaces, e.g., for written collaboration may vary, providing the user with the choice to express him/herself, from totally structured, to semi-structured or totally free workspaces to submit a contribution. It is evident that the structure of the interface explicitly provides the tools to the user to collaborate and, in parallel, implicitly, entails the evolution of specific collaborative skills. Thus, irrespectively of the task, an ID that focuses on the enhancement of the collaborative skills initially has to define the communication model to be used.

Upon such materialization, the ID may foresee the provision of appropriate support to further enhance the collaborative skills. The subject performs the collaborative activity on the basis of his/her collaborative skills, i.e., s/he performs in the subjective domain (see Figure 1-Block 1). In order to realize if those skills need to be improved, they must be logged at the objective domain (see Figure 1-Block 2), where they can be assessed by the system. An indicator, namely hereafter as Cn that aggregates the computer mediated collaborative activity for each subject n, may be calculated by the system (see Figure 1-Block 3). Such computation modelling of the collaborative activity results in a more refined information at a higher level of abstraction (Soller et al., 2004).

Appropriate visualization settings may feedback the collaborators about the values of the indicator. Both these divergent means, the subject and the system, perform at the cognitive level (see Figure 1). However, the above informative feedback is expected to help the subject shift to the metacognitive level (see direction of feedback loop in Figure 1).

2.2 The metacognitive activity

The feedback on the collaborative performance is expected to trigger metacognitive activity of the subject i.e., to motivate self-regulated improvement of the collaborative skills, through individual self-appraisal and self-management of his/her thought and action (Paris & Winograd, 1990). The level of a learner's performance can be improved through metacognitive interventions (Paris & Winograd, 1990). Metacognition has been linked to academic performance both theoretically and empirically (Osborne, 2000). In general the difference between the 'good' and the 'bad' learners is, among other, due to fact that the good students do more self-monitoring and regulation of their strategy to ensure that the task is performed properly. These findings have been verified for all ages, from elementary school to individuals who perform at higher levels in academic domains (Osborne, 2000). Moreover, empirical findings suggest that metacognition has the potential to improve near-transfer, i.e., successful performance to a similar, yet a more difficult task (Osborne, 2000).

Metacognition can be taught, yet not only through knowledge provision but also through experiences on the implementation of cognitive and metacognitive strategies and evaluation, as well (Borkowski & Muthukrishna, 1992). Under this perspective, the overall collaborative procedure within the ID under consideration, can be seen as a process of successive experiential learning sessions of a) concrete collaborative experience at the cognitive level, b) reflective observation of the experience, that is, the deliberate and conscious mental reconstruction of the collaborative experience, so that the subject may realize the learning benefits from it, c) abstract conceptualisation of the efficient collaboration theory behind the experience, and d) planning, which enables the subject to assimilate the new understanding and translate it into planning of how further collaborative activity is to be handled, at the metacognitive level. Since metacognition is a conscious procedure, it is reportable and countable (Borkowski & Muthukrishna, 1992; Carr et al., 1994; Davidson et al., 1994). Therefore, when metacognitive planning of improvement is projected from the subjective to the objective domain it can be also aggregated in an indicator, namely Mn for each subject n, through modelling procedures (see Figure 1-Block 3).

The aforementioned ID depicted in Figure 1 constitutes a session where a collaborative activity is performed and aggregated (from the collaborative skills perspective) by the Cn indicator. Successive collaborative sessions may provide the possibility to optimise this indicator according to specific criteria that are set within the ID and reflect the quantitative aspect of efficient collaboration (specific values of Cn). Towards this effort, the metacognitive planning of improvement, provoked and aggregated by the Mn, is expected to function as a means of self-regulation. Thus, the collaborator initiates collaboration upon his/her existing collaborative skills and enhances them through the above ID.

The comparison of the two indicators Cn and Mn, may reveal possible discrepancy between planning and actual collaborative performance that may hinder the self-regulation procedure. Such possibility, introduces a uncertainty (notated by a question mark in Figure 1-Block 3), to indicate the point for further ID analysis that may unlock existing misconceptions at the metacognitive level, towards the provision of an even more refined support.

2.3 Revealing misconceptions

Misconceptions, quite often, are rooted in obstacles, which form a kind of a 'hard core' of existing conceptions (Aristolfi & Peterfalvi, 1997; Peterfalvi, 2001; Skoumios & Hatzinikita, 2006) and hinder the learner to shift from the experiential (existing conceptual network) to the scientific (desired conceptual network) aspect of the subject to be learned. However, as opposed to the negative nature of these obstacles, Martinand (1986) proposed their utilization under a dynamic perspective within an educational setting, towards the detection of these conditions that may facilitate their overcome from the learner. In this way, the obstacles become objectives of a learning procedure (Martinand, 1986), which, among other instructional procedures, may anticipate a phase of identification of the obstacles by the learner. Such ID aims, at shifting again the learner at the metacognitive level, where s/he performs activities in order to acquire competences that will allow him/her to realize manifestations of the obstacles and to avoid their reappearance (Skoumios & Hatzinikita, 2008). In experimental situations in the area of science education, three dimensions of the obstacle identification procedure are detected (Peterfalvi, 1997; Peterfalvi, 2001). The first procedure is a *reflective detachment* from their original conceptions manifested in the difference between the subject and the content of a proposition concerning the explanation of the phenomenon under analysis. The second one is a *displacement* from local to transverse formulations, i.e., displacement from certain objects to more general ways of thinking. Finally, the third procedure is a *movement* from expressing close judgements like 'right/wrong' to formulations referring to dynamic and functional aspects of the obstacles (i.e., judgements and explanations about the occurrence of wrong answers). These procedures were challenged by the ID and proved to contribute effectively in the learner's realization of the obstacles under treatment (Peterfalvi, 1997; Peterfalvi, 2001).

Within the collaborative ID setting that is depicted in Figure 1, the metacognitive realization of the collaborative activity may be warped, due to obstacles, as far as the comprehension of the proper collaborative activity is concerned. Here, the integration of the above approach within the collaborative framework is examined. More specifically, it could be triggered, when enhancement of the self-regulation procedure at the metacognitive level is the focus under question (see Figure 1-Block 3). The microgenetic method could be used for a detailed follow up of the evolution of this activity in time.

2.4 The microgenetic method study of transition

The microgenetic approach tries to detect a cognitive change as it evolves in time, from a current state (input level) to a next one (output level) (Siegler, 2006). When the variable under change is modelled through an indicator, a detailed monitoring of the variations of its values can inform a microgenetic approach of the mechanisms that trigger the change under consideration. Such monitoring entails a data collection system that functions according to a sampling procedure. More specifically (Siegler, 2006): a) the sampling must cover the time span in which the change is expected to take place, b) within this time the density of the sampling should be relative to the rate of change and c) the data of the sampling procedure should be analysed in detail in order to detect the mechanisms that caused the change. Such analysis is performed on the basis of statistical methods, graphical representations with the use of fuzzy logic and other approaches as they are reviewed by Cheshire et al. (2007).

During the microgenetic analysis, the following five dimensions are detected (Siegler, 2006):

– The *source* of change. It refers to the causes of the cognitive change.

– The *path* of change. It refers to the cognitive sequences that are followed by the subject in order to acquire a skill. The depiction of the path of change includes new distinct approaches and changes in the frequency of their use of both with previous ones.

– The *rate* of change. It refers to the rate of discovery, i.e., the amount of experience before the frequency of the use of the new approach reaches its asymptotic level, namely *rate of uptake*.

– The *breadth* of change. It refers to how widely the new acquired approaches can be generalized to different problems of the same task.
– The *variability* of the change. It refers either to the different strategies that are used by the subject of the differences among subjects towards the other dimensions of change.

The microgenetic method can be used with subjects of any age, with different lessons, in laboratory or in real classroom settings (Siegler, 2006). In the area of the data analysis methods, the techniques employed to analyse microgenetic data remain fairly unsophisticated (Cheshire et al., 2007). The inferential statistical techniques, include the, commonly used in microgenetic studies, class of the techniques called *event history analysis* (Singer & Willett, 2003), which is used to one-time events, i.e., to discover a strategy use for the first time. Moreover, techniques based on the general linear model as regression and ANOVA have been used. However, the use of statistical measures should not violate basic statistical assumptions thus, an effort has been put to alternative approaches (Cheshire et al., 2007), that include graphical methods (Opfer & Siegler, 2004), case studies (Kuhn & Phelps, 1982), fuzzy sets (Van Geert, 2002) and modelling of data (Cheshire et al., 2005).

The *graphical methods* constitute a means to represent the examined aspects of change. An example of such approach is the backward trial graphing (Opfer & Siegler, 2004), where an orthogonal system with two axes is employed; x axis denotes the time whereas y the variable under investigation, e.g., the percent of the use of a strategy. The event of interest for each participant, e.g., the establishment of a specific strategy is depicted as the zero point, whereas negative and positive points depict the events preceding and following the zero point, respectively. Siegler & Stern (1998) exemplify the use of the backward trial graphing, whereas Siegler uses the graphical method to depict change as it occurs within the framework of overlapping waves theory (Siegler 2006).

The *case study* method focuses on the individual change and tries to analyze it in depth. It is argued, however, that this approach can be extended to combinations of the individual analysis in order to examine group differences and study transitions of more than one individual (Lavelli et al., 2005).

The *fuzzy sets approach,* considers the fuzzy character of the boundaries of all the estimations and procedures that vary according to the participant and the context of study and produces inferences that are resistant to noise within the data. In this way small variances of the individual performance can be analyzed while seeking for the transition procedures in rapid changes (Van Geert, 2002).

3. The Proposed Approach

The integration of the microgenetic method within the ID, in order to follow up the obstacles identification concerning the discrepancy between the collaborative activity and its monitoring at the metacognitive level, is the core of the proposed approach. In particular, the metacognitive procedures, triggered by the student within a collaborative framework, could activate the procedures of obstacle identification, i.e., *reflective detachment, displacement, movement* (see §2.3), in an effort for self-improvement at the collaborative domain. Nevertheless, these procedures are time-dependent; hence, they constitute changes over time and for each one, the five dimensions of microgenetic analysis, i.e., *source*, *path*, *rate*, *breadth*, *variability* (see §2.4), could be detected. In this way, the microgenetic approach can

contribute to the extraction of more refined information concerning the metacognitive activity and further enhance the feedback module of the system.
To embed the above concept within an ID for the enhancement of collaborative skills the following structure should be adopted. In particular, ID should be built upon two levels, i.e., a low and an upper one. ID at a low level foresees a computer-mediated collaborative activity that is performed in a predefined way in order to contribute to the improvement of the collaborative skills. At the upper level, metacognitive activity is also performed, in order to monitor and adjust the lower one. This activity is a self-regulation procedure that is supported by the system through appropriate feedback. Possible misconceptions that may exist at the metacognitive level may hinder the monitoring and the self-regulation procedure. A deep investigation to changes that are performed at the metacognitive level may contribute to the enhancement of the provided feedback and increase the possibilities to handle future similar misconceptions. Two basic assumptions should also be adopted. The first one is that the ID of the collaborative setting foresees triggering of the metacognitive activity of the collaborator in order to follow and self-regulate the collaborative one. The second one is that the misconceptions, concerning the way of collaboration, are allocated to the subjective metacognitive plane and hinder the above self-regulation procedure. Figure 2 builds upon the ID structure depicted in Figure 1 to present the allocation and aim of the analytical approach that is triggered when such misconceptions are manifested and modelled at the objective domain.
The modelling component is build upon cross-thematic knowledge, i.e., the elaboration of misconceptions and the microgenetic method. Misconception identification is performed on the basis of an instructional theory to guide the treatment of the misconceptions. A first step towards this treatment is the identification of the obstacles that serve as the background to the misconceptions. The present approach, by extending the approach of Peterfalvi (1997; 2001) towards the obstacles identification in the science education area, proposes its integration within the ID under consideration. This approach lends knowledge to specific artefacts (like questionnaires or structured feedback forms) and provides the ID with variables that may describe the transition to the identification of the obstacles at the metacognitive plane. The latter possesses a subjective character and only manifestations of it are used for its understanding and support; hence, crisp boundaries of the values of the above variables could not be determined. In this case, the use of the fuzzy sets theory (Zadeh, 1965) is proposed. More specifically, the values of variables that describe the transition to the identification of the obstacles at the metacognitive plane and other intermediate variables can be used as inputs to a Fuzzy Inference System (FIS) (see Figure 2) or successive ones (where the output of a FIS can serve as input to another) to infer upon the aspects of change. This approach sets an enhanced ID Framework (e-IDF) that has low computational cost and the ability to lend the ID with adaptivity to the learner's characteristics and automated possibilities that function on-the-fly. As an extension to this approach, intuitionist fuzzy systems (Atanassov, 1999) could be used to model student's hesitation that may be hidden in the metacognitive activity.
Microgenetic analysis provides the method to monitor the transition in learning (e.g., on how to collaborate) and analyse it in-depth, in order to understand the underlying mechanisms that challenge it. This is realized as a sequence of the e-IDF depicted in Figure 2 across the sessions (denoted as *s* steps) of a collaborative activity, creating the Dynamic e-IDF (De-IDF); this is illustrated in Figure 3. In this way, the dynamic character of the

monitored parameters (at all domains) is revealed, thus, (non)causal and/or (non)stationary events are expressed through their (in)dependency and (in)variability across the *s* steps.

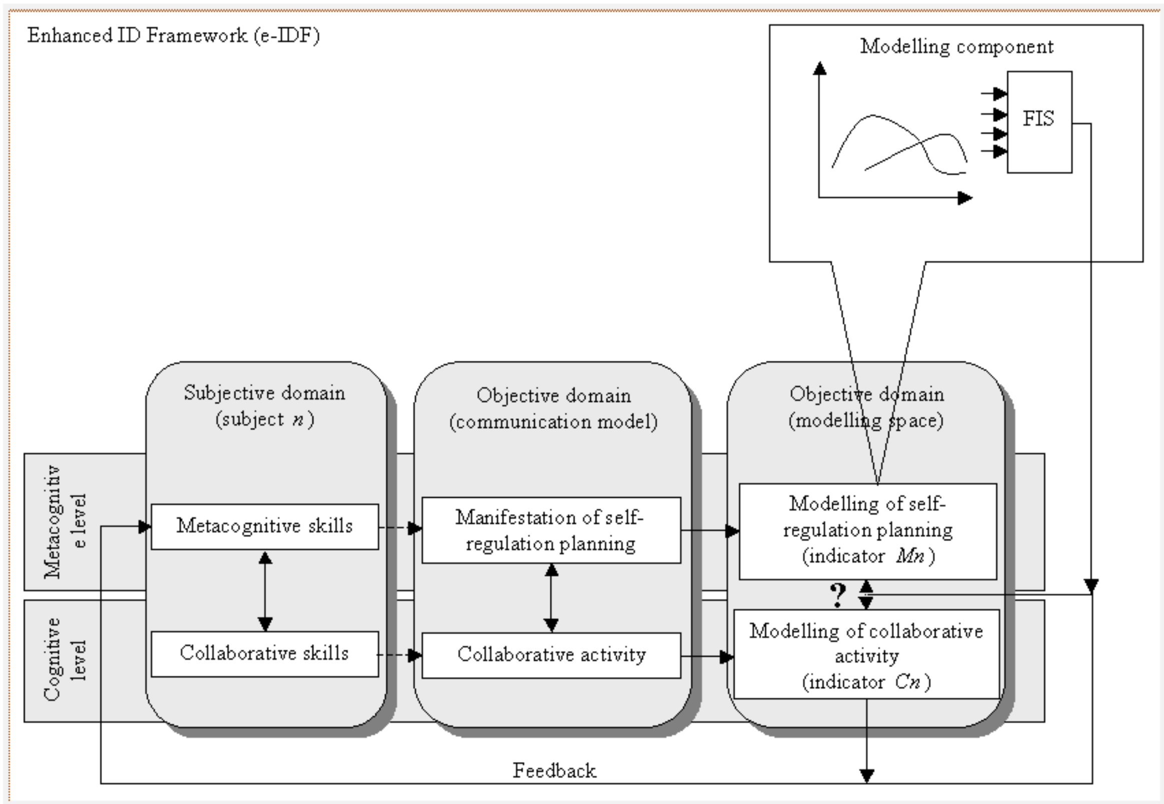


Fig. 2. The allocation and aim of the proposed modelling component, resulting in a more enhanced ID framework (e-IDF).

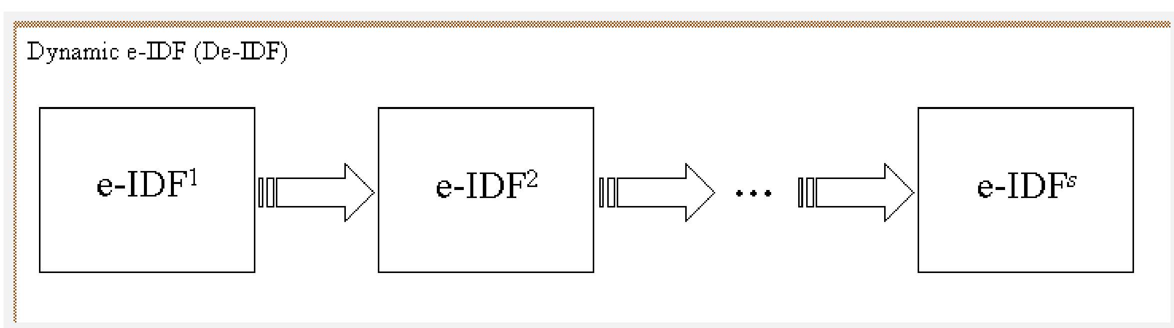


Fig. 3. The proposed dynamic realization of the e-IDF, namely De-IDF, during a series of *s* steps of a collaborative activity.

In the following section, the possibilities of the materialization of the proposed De-IDF within an ICT-based collaborative environment, namely Lin2k, are examined through the presentation of a case study.

4. The Lin2k Case Study

The Lin2k constitutes a computer-mediated collaborative learning system that supports asynchronous, written communication of pairs on a case study (Hadjileontiadou et al., 2003). It is adopted here as a test-bed to show the potentiality of the De-IDF to integrate elements of microgenetic analysis of the misconceptions at the metacognitive level during collaborative learning. In the subsections that follow, a short description of Lin2k is initially provided; then, the aspects of De-IDF from the perception of misconception and microgenetic analysis of empirical data are discussed.

4.1 The Lin2k Collaborative Environment

Lin2k aims at the improvement of the written collaborative skills. To this direction, it introduces an environment to the peers, which, implicitly by its design and explicitly by its materialization, provides collaborative experience, i.e., it contributes to the experienced instruction. More specifically, it focuses at the following issues:

The task. It engages the peers in the solution of a case study that is open-ended and thus can sustain rich collaborative activity towards a commonly agreed best solution. Moreover, Lin2k instructs the approach of the case study by structuring its route into s successive sessions (steps) of collaboration (default value s=6). At each step, the peers are asked to collaborate on a specific aspect of the case study in order to synthesize their opinions in a text that is submitted as intermediate delivery. The six intermediate deliveries constitute at the end of the last step, the final delivery, i.e., the outcome of the case study.

The collaboration model. A communication model, which foresees common and individually sighted workspaces, facilitates the collaboration. The threads of the contributions, along with the intermediate and the final delivery are displayed at the workspaces of common sight, which implicitly support the history of the collaboration. The individually sighted workspaces are semi-structured, i.e., they provide tools to the collaborator to characterize each time the type of the written contribution s/he submits as, *proposal*, *contra-proposal*, *comment*, *agreement*, *clarification* or *question*. Moreover, they are enriched by information relevant to the role of each of the above types to the communication and a weighting system, which differentiates them on the basis of the cognitive load that is needed to structure and submit each of them. The communication model allows the peers to switch between either collaboration upon the task or upon the coordination of their collaborative procedure. In this way, the communication model implicitly instructs practices of efficient collaboration, irrespectively of the content of the collaboration. These practices may be further enhanced at the end of each step, through an optional shift at the metacognitive level, where each participant is engaged in self-adjustment procedures. More specifically, at this point, each peer is challenged initially to reflect upon his/her way of collaboration at the current step and then is called to plan his/her improvement at the next step of collaboration, on the basis of using a form. The latter includes 33 statements of good practices of collaboration and are arranged in groups under the four variables, *quality of contribution* ($M1_n^s$), *coordination* ($M2_n^s$), *contribution to the advance of collaboration* ($M3_n^s$), and *attitude towards the collaboration* ($M4_n^s$), where $n = A, B$ stands for the peer and s for the step. When a statement is checked in the form, relative improvement is planed at the next step.

The support. The efficient collaboration practices are further enhanced by the Lin2k supporting mechanism as depicted in Figure 4. More specifically, upon the peers' activity in each step, empirical data are logged. At the end of each step, these data feed the Collaboration/Metacognition-Fuzzy Inference Model (C/M-FIS), which on the basis of the Fuzzy Logic (Zadeh, 1965) materializes an expert system that aggregates the collaborative and the metacognitive performance of each participant (Hadjileontiadou et al., 2004). The collaborative activity is aggregated, on the basis of the weighting system of the types of contributions, to an indicator (C_n^s), where $n = A, B$ stands for the peer and s for the step. In particular C_A^s and C_B^s are complementary percentages up to 100%, denoting the balance of the quality of the collaborative activity that is formulated within the group dynamic. Values of the C_n^s indicator for each participant within the range 40-60% are acceptable, while values below or above it indicate low and dysfunctional collaborative activity, respectively (see Figure 4(a)).

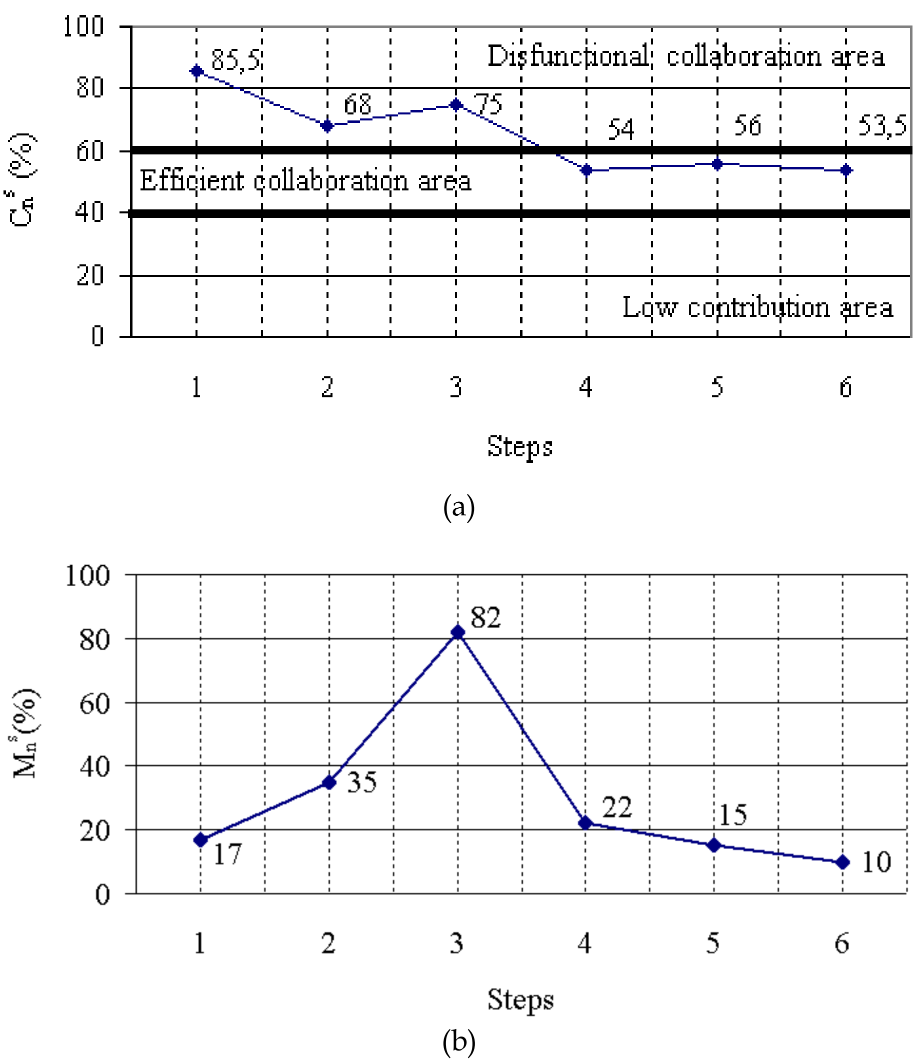


Fig. 4. Peer's feedback (n=A) from an experimental use of Lin2k in six steps (Hadjileontiadou et al., 2004). a) Collaborative performance, b) metacognitive performance.

The C_n^s indicator is depicted to each peer at the end of each step (see Figure 4(a)), aiming at initiating the shift to the metacognitive level where the reflection and the plan for improvement takes place. The performance at the metacognitive form is also weighted and aggregated by the C/M-FIS model, in the (M_n^s) indicator, where $n = A, B$ stands for the peer and s for the step. The M_n^s value is again a percentage indicating the cost of improvement (Hadjileontiadou et al., 2004) according to the statements that were chosen (e.g., $M_A^3 = 100$ % indicates a plan for severe intension of improvement according to all the statements submitted by peer A after the end of step 3). The M_n^s value is also depicted to each peer as feedback at the end of each step (Figure 4(b)).
From the aforementioned it is evident that Lin2k challenges the improvement of the collaborative skills by providing the environment of their practice, and motivations for their improvement trough the optimisation of the C_n^s indicator along the step. To this vein, self-regulation procedures at the metacognitive level are provoked by appropriate interfaces and supporting mechanism. More information concerning the Lin2k can be found in (Hadjileontiadou et al., 2003; Hadjileontiadou et al., 2004).

4.2 Deepening in misconceptions from the De-IDF perspective

Now it is considered that the question marked misconception in Figure 1 (Block 3) is triggered, as in the experimental case of Figure 4, where a thorough observation of Figures 2(a) and (b) can inform about a discrepancy between the actual collaborative performance and the planning for improvement of student A. Such misconception may be rooted in obstacles, which lay at the metacognitive plane of student A and may be detected on the basis of the obstacle identification procedures proposed by Peterfalvi (1997; 2001) (see §2.3).
The first procedure of this perspective (*reflective displacement)* indicates a displacement from the initial position, i.e., inability to realize the discrepancy between the C_n^s and the M_n^s values, to a new, i.e., adjustment to more compatible ones, along the steps. Student A performed this displacement, as it is evident from Figure 4. In particular, in steps 1 and 2, where the collaborative performance lied outside from the accepted area (Figure 4(a)), small intention for improvement was recorded (Figure 4(b)). The latter was exaggerated in step 3, also being quite far from a correct estimation of the quality of the actual collaborative activity. The discrepancy, however, was minimized in the rest steps, with the step 4 initiating the displacement. These findings suggest that the student detached from his initial position and a transition took place towards the obstacles identification, concerning how to collaborate.
The second procedure (*displacement from local to transverse formulations*), may be detected on the basis of a deeper analysis of the Lin2k metacognitive form. More specifically, some statements constitute *local* formulations, referring to the local level of the Lin2k setting, whereas others, of a *transverse* character, include more general conceptions and references to general ways of thinking. Indicative examples of both these formulations, from all the categories of variables, are provided in Table 1.
On the basis of the classification of Table 1, the completion of the metacognitive form from student A in all steps, provided information concerning his displacement from local to transverse statements along the steps, for the variables under consideration, $M1$ - $M4$ (Table 1).

Type of formulation	Variable	Statement
Local	$M1$	I realize the difference between the choices I have in the communication model to contribute an interaction at the task level
	$M2$	I realize the difference between the choices I have in the communication model to contribute an interaction at the coordination level
	$M3$	I work out all the types of contribution provided by the communication model for collaboration
	$M4$	I realize my role within the specific pair
Transverse	$M1$	I introduce new ideas to the collaboration
	$M2$	I question the collaboration rate
	$M3$	I extent the thoughts of my collaborator
	$M4$	I get in my peer's shoes while testing an idea

Table 1. Classification of excerpt of statements from the Lin2k metacognitive form according to the type of formulation and variable

In Figure 5, a rough depiction of the displacement, per variable, is depicted along the steps. The depiction was based on the assumption that the majority of the type of the statements under each variable characterizes as such the entire category of the variable. From Figure 5 it can be noticed that the intention of improvement was moved from statements at the *local* plane to more *transverse* ones in all the variables, around the fourth step.

In particular, the statements referring to the *quality of contribution* ($M1^s_A$), shifted to the transverse type of formulation at the third step, whereas those of the *contribution to the advance of collaboration* ($M3^s_A$), and the *attitude towards the collaboration* ($M4^s_A$) at the fourth step. The type of statements of the *coordination* variable ($M2^s_A$) fluctuated between the second and the fourth step where it was stabilized. In general, the *local* type of statements predominates, with some variability, up to the fourth step; there a shift to the *transverse* type is established.

This *displacement* seems to have favoured the obstacles identification from the student A per variable, as it is concordant to the *reflective detachment* that was detected from the more general depiction of Figure 4.

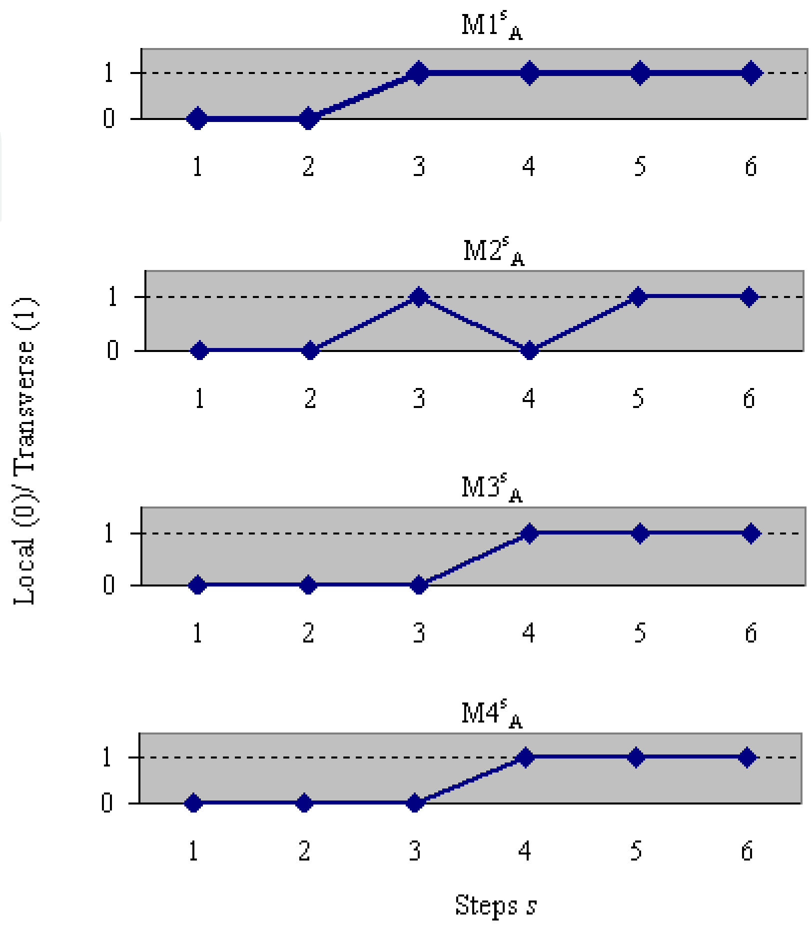


Fig. 5. The displacement of student A, from local to transverse statements, along the six steps for the variables $M1_A^s$ - $M4_A^s$ (*s*=1-6).

The third procedure (*movement from close, static to more dynamic judgements)* concerning aspects of the obstacles can also be detected through the analysis of relevant statements at the Lin2k metacognition form. Indicative examples of both these formulations, from all the categories of variables, are provided in Table 2.

On the basis of the classification of Table 2, the completion of the metacognitive form from student A in all steps provided information concerning his displacement from *static* to *dynamic* statements along the steps, for the variables under consideration, $M1$ - $M4$ (Table 2). In Figure 6, a rough depiction of the displacement, per variable, is depicted along the steps. The depiction was also based on the assumption that the majority of the type of the statements under each variable characterizes as such the entire category of the variable. From Figure 6 it can be noticed that the displacement to the dynamic statements is established in the fifth step for all the variables. This finding indicates that the transition to the obstacles identification was initiated by the *displacement from local to transverse statement* at the fourth step and further established by the *movement from close, static to more dynamic statements* from the fifth step.

Type of judgement	Variable	Statement
Static	$M1$	I do not plagiarize
	$M2$	I keep the timetable
	$M3$	I submit questions
	$M4$	I document my ideas
Dynamic	$M1$	I work out literally my texts
	$M2$	I take initiatives when to improve the efficiency of the collaboration
	$M3$	I use questions to provoke my peer's contribution
	$M4$	I disagree with my peer's ideas and not himself

Table 2. Classification of excerpt of statements from the Lin2k metacognitive form according to type of judgement and variable

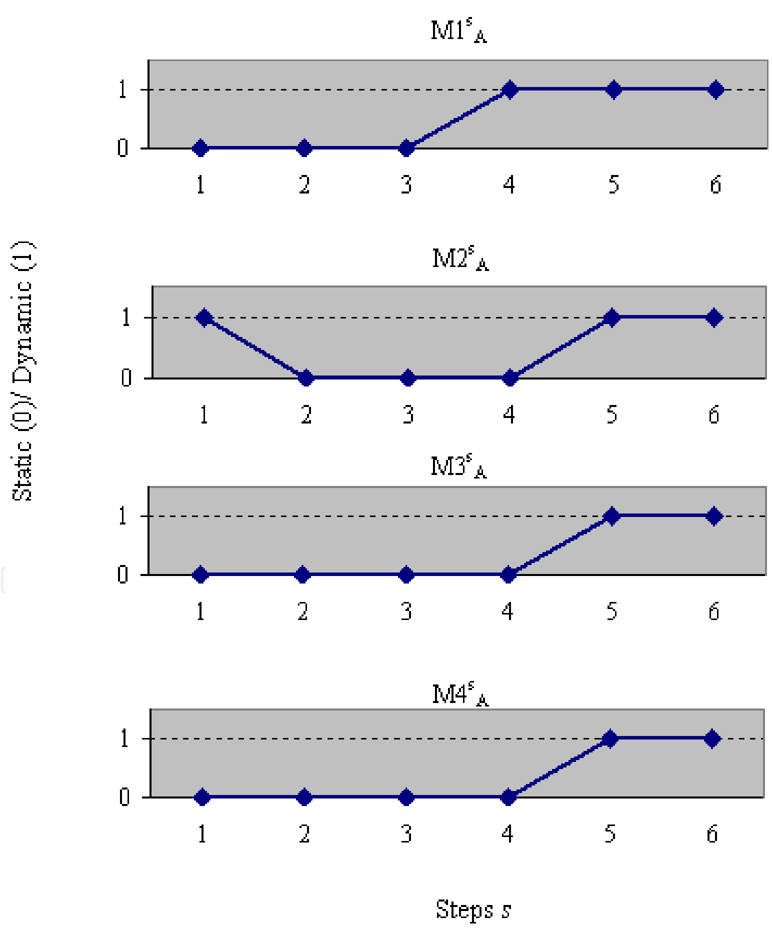


Fig. 6. The displacement of student A, from static to dynamic statements along the six steps for the variables $M1_A^s$ - $M4_A^s$ (s=1-6).

The above analysis of the performance of student A revealed the potentiality of the obstacles identification to provide opportunities to unlock the misconceptions that appeared in his case, justifying the focus area of the e-IDF (question mark in Figure 2).
Considering the fact that the steps provided the iterations of the collaborative and metacognitive performance, the above procedure allowed the detection of the change that occurred at his metacognitive performance, which was then reflected at his collaborative activity. This fosters the adoption of the concept of microgenetic approach in the structure of De-IDF; this is further discussed in the succeeding subsection.

4.3 Deepening in the microgenetic approach from the De-IDF perspective

The boundaries to characterize a study as microgenetic are somewhat subjective, as indicative research in the area showed (Siegler, 2006).
A basic criterion to decide if a study is microgenetic is to realize if it "intervenes change process through detailed, data-based specification of the representations and processes that led to learning" (Siegler, 2006). This effort entails both qualitative and quantitative data to capture the changing strategy in the competence under consideration. As previously discussed, in the case of student A, the $M1$ - $M4$ indicators (both from Tables 1 and 2) were used to detect the strategy change at the metacogntive level, while student A moved towards the obstacles identification.
Another criterion is the fulfilment of the data sampling procedure to follow up change on-the-fly, i.e., while the learning process is progressing. In the case of student A, the sampling of the $M1$ - $M4$ indicators covered the time span the change took place (onwards from the fourth step, Figures 4 ad 5). The density of the sampling was performed on the basis of the steps and was relative to the rate of the change, which was triggered by the end of each step through the reflection phase and the completion of the metacognitive form. Finally, the sequential use of e-IDF within the De-IDF secures the detailed analysis of the data per step, both contributing to repeated measurements and capturing the evolution of the underlying mechanisms that propel change across steps (time).
The dynamic character of the De-IDF can also be reflected to the adaptivity of the supporting mechanism that informs the peer. For example, the supporting mechanism of Lin2k employs the C/M-FIS (a set of FIS) to infer the C_n^s and the M_n^s indicators (Hadjileontiadou et al., 2004). In particular, these FIS are successive inference mechanisms that model an expert's evaluation procedure of the individual's collaborative and metacognitive activity. C/M-FIS takes simultaneously under consideration all the weighted scores of the incoming variables to infer the aggregated score of the variable of interest. Moreover, its adaptive and automated character, allows for its use whenever in the time span of interest (in the case of student A at the end of each step).
In general, C/M-FIS materializes the modelling approach at low computational cost, instead of the statistical one, in the analysis of the microgenetic data, an approach that is also visited elsewhere (Cheshire et al., 2007) and remains free from the constrains of the statistical approaches. More information on the C/M-FIS can be found in (Hadjileontiadou et al., 2004).
Irrespectively from the method to be used and the constrains for its implementation, qualitative and quantitative aspects of change, i.e., the *source*, the *path*, the *rate*, the *breadth* and the *variability*, constitute aims of the analysis. The case of the student A provides the possibilities for the detection of these aspects.

For example, the *source* of change can be allocated to the sequential procedure of Lin2k, which initially anticipates the reflection phase and then the metacognitive planning of improvement by the completion of the metacognitive form by the peer. The feedback on the discrepancy between the action and the belief about its quality is expected to function as the source of change.

The *path* of change can be derived from the analysis of the values of the $M1$ - $M4$ variables along the steps (Figures 4 and 5).

From the same figures, the *rate* of change for each variable can also be estimated, i.e., the steps that precede before the establishment of the new approach (e.g., the establishment of the *transverse* type of statements at the fourth step for the first variable in Figure 4).

The *breadth* of change can also be discussed since the change (converge between action and belief about it) that occurred at the fourth step was established and used at the next steps, where different aspects of the case study that served as the task for collaboration were examined. The latter include evaluation of alternative approaches to the case study (step 5) and synthesis to the final solution of it (step 6).

Finally, the *variability* within the performance of student A may pose questions referring to its relation with the experience (Siegler, 2006), as many examples show that when experience is established the variability decreases. Under this perspective it could be implied that the stability of all the values of the variables seen at steps 5 and 6 (Figures 4 and 5) are due to the experience gained progressively from step 4. To further investigate this, analysis whether the *variability* is of static or adaptive character may be performed at a more detailed level. In the case of student A, as it is foresaid, the types of transition in both Figures 4 and 5 resulted from the majority of the relevant choices in the metacognition form. A more refined way to aggregate the performance per variable could reveal the qualitative difference of the character of the variability, e.g. the variety of effective adjustments to the metacognitive planning through different choices per step towards self-improvement.

From the above analysis it is evident that the presented case study reveals the potential of the proposed De-IDF to serve as an efficient ID, shedding light upon its structural aspects under realistic collaborative scenarios.

5. Concluding Remarks

This chapter aimed at informing the Instructional Design (ID) of ICT–based collaborative environment about the possibilities of the microgenetic method to detect the transition towards the treatment of misconceptions that may be revealed at the metacognitive level and hinder collaboration.

Initially, a theoretical background was provided; then, the dynamic, enhanced ID framework (De-IDF) was proposed and a case study within a computer mediated collaborative environment (namely Lin2k) was used to present and discuss issues concerning the integration of De-IDF in realistic scenarios. The latter could include many thematic fields, spanning from collaborative to learning ones.

De-IDF truly enhances the mechanisms of the knowledge acquisition, as its serves as a kind of ‘denoising tool’ that reveals the misconceptions and serves to their overcome with a dynamic way. This adaptivity makes it favourable for many applications within ICT-based collaborative learning environments.

The implementation of De-IDF that integrates the misconceptions perspective and the microgenetic approach needs to be systematically built within the constrains that poses each approach.
The final educational setting from such implementation is expected to provide advanced learning opportunities by holding both an interpretative character, i.e., trying to uncover the choices involved in human action, and a critical one by directing the human action towards improvement.

6. References

Aristolfi, P. & Peterfalvi, B. (1993). Obstacles et Construction de Situations Didactiques en Sciences Expérimentales. Aster, Vol. 16, 103-141, Paris, INRP

Aristolfi, P. & Peterfalvi, B. (1997). Stratégies de Travail des Obstacles: Dispositifs et Ressorts. Aster, Vol. 25, 193-216, Paris, INRP

Atanassov, K. (1999). Intuitionistic Fuzzy Sets: Theory and Applications. Springer-Verlag, ISBN-10 3790812285, Heidelberg

Bachelard, G. (1983). La philosophie du non. Essai d'une Philosophie du Nouvel Esprit Scientifique, P.U.F., ISBN-10 2130369456, Paris

Borkowski, J. & Muthukrishna, N. (1992). Moving metacognition into the classroom: 'Working models' and effective strategy teaching, In: Promoting academy competence and literacy in school, Pressley, M., Harris, K. & Guthrie, J. (Eds.), 477-501, Academic, ISBN-10 0125644388, San Diego California

Brown, L. (1987). Metacognition, Executive Control, Self-regulation, and Other More Mysterious Mechanisms, In: Metacognition, Motivation and Understanding, Weinert, E. & Kluwe, H. (Eds.), 65-116, Lawrence Erlbaum Associates, ISBN-10 089859569X Hillsdale, New Jersey

Carr, M.; Alexander, J. & Folds-Bennett, T. (1994). Metacognition and mathematics strategy use. Applied Cognitive Psychology, Vol. 8, No. 6, (February 1994) 583-595, ISSN 0888-4080

Cheshire, A.; Ball, L. & Lewis, C. (2005). Self-explanation, feedback and the development of analogical reasoning skills: Microgenetic evidence for a metacognitive processing account, Proceedings of the twenty-seventh annual conference of the cognitive science society, pp. 435–441, ISBN 0-9768318-1-3, Stresa Italy, July 2005, Lawrence Erlbaum Associates, Mahwah New Jersey

Cheshire, A.; Muldoon, K., Francis, B., Lewis, C. & Ball, L. (2007). Modelling Change: New Opportunities in the Analysis of Microgenetic Data. Infant and Child Development, Vol. 16, No. 1, (February 2007) 119–134, DOI: 10.1002/icd.498

Davidson, J.; Deuser, R. & Sternberg, R. (1994). The role of metacognition in problem solving, In: Metacognition: Knowing about Knowing, Metcalfe, J. & Shimamura, A. (Eds.), 207-226, MIT, ISBN-10 0262631695, Cambridge, Massahussets

Dillenbourg, P.; Baker, M., Blaye, A. & O'Malley, C. (1996). The Evolution of Research on Collaborative Learning. In: Learning in Humans and Machine: Towards an Interdisciplinary Learning Science, Spada, E. & Reiman, P. (Eds.), 189-211, Elsevier, ISBN-10 0080425690, Oxford

Flavell, H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychologist, Vol. 34, No. 10, (October 1979) 906-911, ISSN 0003-066X

Flavell, H. (1987). Speculations about the nature and development of Metacognition, In: Metacognition, Motivation and Understanding, Weinert, E. & Kluwe, H. (Eds.), 21-29, Lawrence Erlbaum Associates, ISBN-10 089859569X, Hillsdale, New Jersey

Flynn, E.; Pine, K. & Lewis, C. (2006). The microgenetic method. Time for change?. The Psychologist, Vol. 19, No.3, (December 2006) 152-155, ISSN

Gagnè, R. (1985). The Conditions of Learning and the Theory of Instruction; Holt, Rinehart, and Winston, ISBN-10 0030636884, New York

Hadjileontiadou, S.; Sakonidis, H. & Balafoutas, G. (2003). Lin2k: A novel Web-based Collaborative Tool- Application to Engineering Education. Journal of Engineering Education, Vol. 92, No.4, (October 2003) 313-324, ISSN 1069-4730

Hadjileontiadou, S.; Nikolaidou, G., Hadjileontiadis, L. & Balafoutas, G. (2004). On Enhancing On-line Collaboration Using Fuzzy Logic Modelling. Journal of Educational Technology & Society, special issue on Technology-Enhanced Learning, Vol.7, No.2, (Apr 2007) 68-81, ISSN 1176-3647

Keller, M. & Suzuki, K. (1988). Use of the ARCS motivation model in courseware design, In: Instructional Designs for Microcomputer Courseware, Jonassen, H. (Ed.), (401-435), Lawrence Erlbaum, ISBN-10 0805800867, Hillsdale, New Jersey

Kuhn, D. & Phelps, E. (1982). The development of problem-solving strategies. Advances in Child Development, Vol. 17, 1–44, ISBN: 9780120097173

Lavelli, M. ; Pantoja, F., Hsu, H., Messinger, D. & Fogel, A. (2005). Using microgenetic designs to study change processes, In: Handbook of Research Methods in Developmental Science D. M. Teti (Ed.), 40–65, Oxford: Blackwell

Martinand, J. (1986). Connaître et Transformer la Matière. Peter Lang, ISBN 3-261-03623-0 Berne

Merrill, D. (1983). Component Display Theory, In: Instructional Design Theories and Models: An Overview of their Current States, Reigeluth, C. (Ed), 279-334, Lawrence Erlbaum, ISBN-10 0898592755, Hillsdale, New Jersey

Opfer, J. & Siegler, R. (2004). Revisiting preschoolers' living things concept: A microgenetic analysis of conceptual change in basic biology. Cognitive Psychology, Vol. 49, No.4, (December 2004) 301–332, ISSN: 0010-0285

Osborne, J. (2000). Assessing Metacognition in the Classroom: The Assessment of Cognition Monitoring Effectiveness. Thesis Dissertation, University of Oklahoma

Paris, S. & Winograd, P. (1990). How Metacognition can Promote Academic Learning and Instruction, In: Dimensions of Thinking and Cognitive Instruction, Jones, B. & Idol, L. (Eds.), 15-51, Erlbaum ISBN-10 0805803467, Hillsdale, New Jersey

Peterfalvi, B. (2001). Obstacles et Situations Didactiques en Sciences: Processus Intellectuels et Confrontations. L'exemple des Transformations de la Matiére. Thèse de Doctorat. Univesité de Rouen

Puntambekar, S. (2006). Analyzing Collaborative Interactions: Divergence, Shared Understanding and Construction of Knowledge. Computers & Education, Vol. 47, No. 3, (November 2006) 332-351, ISSN 0360-1315

Reigeluth, C. & Stein, S. (1983). The Elaboration Theory of Instruction, In: Instructional Design Theories and Models: An Overview of their Current States, Reigeluth, C. (Ed.), 335-382, Lawrence Erlbaum, ISBN-10 0898592755, Hillsdale, New Jersey

Reigeluth, C. (1997). Instructional Theory, Practitioner Needs, and New Directions: Some Reflections. Educational Technology, Vol. 37, No.1, (January-February 1997) 42-47, ISSN 0013-1962

Seels, B. (1997). Taxonomic Issues and the Development of Theory in Instructional Technology. Educational Technology, Vol. 37, No.1, (January-February) 12-21, ISSN 0013-1962

Siegler, R. & Stern, E. (1998). A Microgenetic Analysis of Conscious and Unconscious Strategy Discoveries. Journal of Experimental Psychology, Vol. 127, No. 4, (December 1998) 377-397, ISSN 0096-3445

Siegler, R. (2006). Microgenetic Analysis of Learning. In: Handbook of Child Psychology. Cognition, Perception and Language, Kuhn, D. & Siegler, R. (Eds.), 464-510, John Wiley & Sons Inc., ISBN 0471349801

Singer, D. & Willett, B. (2003). Applied Longitudinal Data Analysis, Oxford University Press, ISBN-10 0195152964, New York

Skoumios, M. & Hatzinikita, V. (2006). Research-based Teaching About Science at the Upper Primary School Level. International Journal of Learning, Vol. 13, No.5, 29-42, ISSN 1447-9494

Skoumios, M. & Hatzinikita, V. (2008). Development of Pupils' Competences to Identify Obstacles during Research-based Science Teaching. The International Journal of Learning, Vol. 14, No. 9, 237-248, ISSN 1447-9494

Smith, P. & Ragan, T. (2004). Instructional Design. Wiley/Jossey-Bass Education, ISBN 0-7879-7230-4

Soller, A.; Jerman, P., Mühlenbrock, M. & Martínez, A. (2004). Designing Computational Models of Collaborative Learning Interaction: Introduction to the Workshop Proceedings. Proceedings of the 2nd International Workshop on Designing Computational Models of Collaborative Learning Interaction, pp. 5-12, Maceió, Brazil, August 2004

Spector, M. (2005). Innovations in Instructional Technology: An Introduction to This Volume, In: Innovations in Instructional Technology. Routledge, ISBN 9780805848366, London

van Geert, P. (2002). Developmental Dynamics, Intentional Action, and Fuzzy Sets. In: Microdevelopment: Transition processes in development and learning, Granott, N. & Parziale, J. (Eds.), 319–343, Cambridge University Press, ISBN-10 0521103282, Cambridge

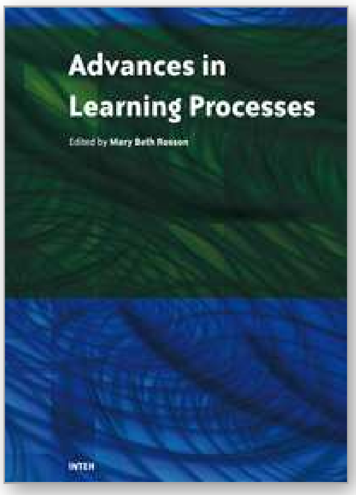
van Merriënboer, G.; Clark, E. & de Croock, M. (2002). Blueprints for complex learning: The 4C/ID-model, Educational Technology Research and Development, Vol. 50, No.2, (June 2002) 39-64, ISSN 1042-1629

Werner, H. (1948). Comparative Psychology of Mental Development, International Universities Press, ISBN-10 082368024X, New York

Wilson, G. (1997). Thoughts on Theory in Educational Technology. Educational Technology, Vol. 37, No.1, (January-February 1997) 22-27, ISSN 0013-1962

Winn, W. (1997). Advantages of a Theory-based Curriculum in Instructional Technology. Educational Technology, Vol. 37, No.1, (January-February 1997) 34-41, ISSN 0013-1962

Zadeh, L. (1965). Fuzzy Sets. Information and Control, Vol. 8, 338-353



Advances in Learning Processes

Edited by Mary Beth Rosson

ISBN 978-953-7619-56-5
Hard cover, 284 pages
Publisher InTech
Published online 01, January, 2010
Published in print edition January, 2010

Readers will find several papers that address high-level issues in the use of technology in education, for example architecture and design frameworks for building online education materials or tools. Several other chapters report novel approaches to intelligent tutors or adaptive systems in educational settings. A number of chapters consider many roles for social computing in education, from simple computer-mediated communication support to more extensive community-building frameworks and tools. Finally, several chapters report state-of-the-art results in tools that can be used to assist educators in critical tasks such as content presentation and grading.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821