Distributed Educational Influence and Computer-Supported Collaborative Learning

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Abstract

This article introduces a line of research on distributed educational influence (DEI) that has recently been developed by the research group to which the authors belong. The main hypothesis is that in computer-supported collaborative learning contexts, all participants are potential sources of educational influence (EI). According to this hypothesis, the success of collaboration and its outcomes depend on the extent to which participants take responsibility for being both providers and recipients of aid, such that EI becomes adequately distributed among the group as a whole. The paper is organized into four sections that deal respectively with: (1) the concept of DEI, its origin and its characteristics, with special attention being paid to the demands inherent to the exercising of EI in online collaborative learning; (2) an empirical approach to the study of DEI, based on case studies and a multimethod perspective that combines structural analysis of participants' activity with content analysis of their contributions; (3) a review of some interesting results obtained so far and some questions that remain open; and (4) proposals for how the study of DEI could help to enrich research on online collaborative learning.

Key words

Computer-supported; Collaborative learning; Content analysis; Distributed educational influence; Educational influence; Multimethod approach; Structural analysis.

I. Introduction

The purpose of this article is to introduce a line of research on computer-supported collaborative learning that has been developed over the last decade by our research group working on interaction and educational influence (GRINTIE, *Grup de Recerca en Interacció e Influència Educativa*: http://wwwpsyed.edu.es/grintie). The main hypothesis driving this line of work is that collaborative learning processes are characterized by the fact that all participants are, in theory, both providers and receivers of aid when carrying out their tasks and activities. Thus, all those involved in a collaborative learning context are a potential source of educational influence. According to this hypothesis, the success of collaboration and its outcomes depend on the extent to which participants take responsibility for being both providers and recipients of aid, such that educational influence becomes adequately distributed among the group as a whole.

A key concept in this framework is what we refer to as distributed educational influence. In what follows we will describe this concept in greater detail and set out an empirical approach to its study. We will also discuss its scope and relevance to the study and understanding of collaborative learning processes, especially those that take place in computer-supported environments. To this end the article is organized into four sections. The first explores the link between two concepts: the concept of educational influence (EI), as developed by members of our research group (GRINTIE) in a series of previous papers that analysed educational practice in face-to-face settings (Coll, Onrubia & Mauri, 2008), and the concept of distributed educational influence (DEI), which is the focus of the present paper. It will be seen that the development of the concept of DEI has had two consequences. The first is that it has opened up the concept of EI in two directions: one concerns the aspects or domains with respect to which EI should be exercised in collaborative learning contexts, while the other involves the conditions or requirements of participation that need to be fulfilled by participants in order to exercise EI in these contexts. The second consequence is that with regard to the distribution of EI, a distinction can now be made between the level of distribution (i.e. how many participants actually exercise EI) and the way in which EI is exercised (i.e. the distribution among participants of different ways of exercising EI). The second section of the paper has a clear methodological focus and outlines the key features of our empirical approach to the study of DEI, including procedures for collecting data and the analytical model on which our approach is based. The third section briefly discusses some results that, despite being preliminary, support, in our view, the relevance of this line of research in terms of improving our understanding of online collaborative learning processes. Finally, the fourth section discusses a number of developments that illustrate how the concept of DEI could help to enrich the theoretical and empirical approach to certain key questions within contemporary research on online collaborative learning, for example, the use of scripts or the characteristics and functions of formative feedback.

II. From educational influence to distributed educational influence

Our interest in the processes and mechanisms of EI dates back to the 1980s and it has its roots in a constructivist and sociocultural perspective on teaching and learning in formal and school-based educational contexts (Coll, 1990; 1999). From this theoretical perspective, learning is understood as the process through which a student attributes meaning to and constructs meanings around a body of cultural knowledge that is incorporated into the school curriculum in the form of learning

content. It is also assumed that this process relies considerably on the mediating and supportive function of the teacher, who is responsible for encouraging, advising on and guiding the learning process in the direction of culturally constructed and accepted meanings. Understood in this way, learning is the result of a process of construction that is simultaneously cultural, social and individual: cultural, because the learning content consists of historically constructed and culturally organized knowledge; social, because the process and its outcomes depend to a large extent on the support, advice and guidance of an educational agent who can act as a mediator between the student and the learning content; and individual because it is the student who is ultimately responsible for his or her own learning, and nobody else can fulfil this task.

EI refers to the inter-individual processes through which teachers, or other educational agents, help learners to construct progressively richer, more complex and more valid meanings in relation to situations, phenomena, or physical or symbolic objects. In order to fulfil its function and to be effective, aid of this kind must be adapted to the student's own process of construction, such that how much and what kind of help is offered must be varied according to the vicissitudes of the constructive process. This means that adapted educational aid can take several forms, may be offered in various ways and may be manifested in a variety of teaching strategies and resources. Within such a framework, processes of EI constitute a link between the more individual and internal domain of learning (i.e. the processes through which the student constructs meanings and attributes meaning to the learning content) and the more social and cultural domains (i.e. the student's appropriation and reconstruction of existing cultural knowledge through the help of educational agents).

Processes of EI are closely related to the way in which both teachers and students organize their activity, in other words, the way in which their actions, interactions and communicative exchanges are articulated around educational content and tasks. Indeed, it is through joint activity that teachers can offer help to students and adapt it to their needs at the time, and, likewise, that students can receive such help, link it to their activity and apply it so as to progress with their learning. Note, however, that the fact that this joint activity may be organized in a variety of ways means that there are also numerous possibilities in terms not only of the intensity, diversity and characteristics of the help offered by teachers, but also of the ease with which such help can be adapted to students' needs and the opportunities that students have to take advantage of it. Furthermore, the organization of joint activity is continually subject to a process of negotiation and review by those involved, such that the forms it takes, and therefore the opportunities for help that it enables, usually evolve during the learning and teaching activities which are being engaged in. In summary, processes of EI operate within the framework of joint activity which, in turn, is the result not only of a process of construction involving teacher and student, but also of the context in which both parties construct meanings and attribute meaning to learning content.

This way of understanding EI corresponds primarily to face-to-face teaching and learning in schools, and it has given rise to a series of studies which have enabled researchers to identify and describe certain mechanisms and forms of EI that commonly operate in such settings, and also to develop a theoretical and methodological model for analysing joint activity and processes of EI[1]. Given its very nature, however, EI is a situated phenomenon, such that studying it in collaborative

[1] See Coll, Onrubia & Mauri (2008) for a review of studies on EI in relation to classroom-based learning in schools.

learning environments poses considerable theoretical and methodological challenges, and obliges us to revise the analytic model that has been developed solely in relation to face-to-face teaching and learning in schools. In our view, there are two features of computer-supported collaborative learning environments that are important in this respect.

First, although our constructivist and sociocultural perspective on learning means that EI is present within both guided and collaborative processes of knowledge building (Mercer, 1995), the responsibilities of those involved differ appreciably between the two. In guided processes the teacher is expected to be the primary source of aid, even though other students may, and often do, constitute an important source of EI. In collaborative processes, however, each participant is a potential source of aid for the rest, without this negating the specific responsibility of the teacher (Coll, Bustos & Engel, 2011). In this sense, the notion of DEI refers to the fact that in collaborative learning scenarios it is not merely that all participants may be a source of EI but, rather, that they are expected to act as such. To put it another way, the process of guided knowledge building is based on the principle that the teacher is the main source of EI, it being assumed that outcomes depend to a large extent on his or her ability to fulfil this role. Likewise, collaborative learning scenarios are based on the principle that all participants are sources of EI, it being assumed that outcomes depend heavily on the extent to which they actually take on this responsibility and exercise it appropriately.

The second point we wish to make relates to the fact that the kind of collaborative learning we are concerned with here takes place in computer-supported environments, either totally or partially online, and this introduces a number of important new features in terms of how joint activity is organized. These new features concern not only the process by which participants negotiate, adopt and revise certain forms of organization (through which they will exercise EI), but also the restrictions imposed by the fact that the actions, interactions and contributions of participants rely fundamentally on written communication that is almost always asynchronous and without direct visual contact. These restrictions impose certain demands on the exercising of EI which are different to those associated with face-to-face interaction, the latter being a situation in which spoken language is the fundamental medium of communication, and where participants can also make use of paralinguistic and non-verbal resources, especially body language and gestures.

In computer-supported environments the negotiation and revision of the different ways in which joint activity may be organized, and consequently the possibility of providing and receiving help, depends on the fulfilment of certain requirements regarding participation. For example, participants need to log in to the environment relatively often and regularly, this being an obvious prerequisite to providing or receiving help. However, they also need to read the contributions of other participants and make their own with a certain frequency and regularity, as otherwise their own contributions will not be available as a potential aid to others, and they will be unable to take advantage of others' ideas in order to progress with their own learning. Participants who fail to fulfil these and other requirements of participation imposed by the nature of computer-supported environments will be unlikely to be in a position to exercise EI and contribute to the development of collaborative learning processes.

If participants' contributions are to foster the process of collaboration and collaborative learning, however, those involved must do more than simply fulfil the basic requirements of participation. Indeed, their input must also be relevant, that is, it must genuinely help to establish ways of organizing the joint activity that enable both individuals and the group as a whole to construct

meanings and give meaning to the learning content. Here, it is once again important to bear in mind the restrictions of computer-supported environments. In the context of face-to-face learning and teaching, the joint activity often takes forms that do not need to be spelled out, at least not in detail, as they are obvious to all those involved merely by being present. Indeed, it is only when somebody does or says something unexpected or which contradicts the way in which the joint activity has been organized that the rules governing the activity — which until that point have been largely implicit — will be made explicit. Even then, very little time is generally required to point out and admonish the unexpected actions, reminding participants of what is required of them. This is because face-to-face settings have a number of inherent features, notably the availability of certain communicative resources, shared physical and symbolic reference points, and the fact that any action taken can have an immediate effect. The exception to this would be when a serious misunderstanding or disagreement has occurred among participants with regard to how the joint activity should be organized, such that an open conflict emerges.

By contrast, the interaction in most computer-supported collaborative learning environments is based on asynchronous written communication without direct visual contact, and this means that adopting certain ways of organizing the joint activity and respecting the rules that govern it generally requires greater attention and effort on the part of participants. In order to co-construct progressively more detailed, more complex and more shared meanings in relation to the learning content, participants must reach an agreement about what they are going to do and how they are going to do it, as well as deciding who will do what and in what order, how their different actions will be coordinated, what products or outcomes they are going to generate, what requirements these products must fulfil, and how they are going to ensure that the process unfolds as planned. In other words, contrary to what occurs in face-to-face interactions the way in which joint activity is organized in computer-supported environments is not generally apparent to participants at the outset. Indeed, the way in which the activity will be organized usually has to be spelled out, with considerable effort being required to ensure that participants understand the obligations and demands that result from this, and also to identify and admonish those actions which fail to meet these requirements, including reminding all those involved of what is expected of them.

These considerations have led us to propose an empirical approach to the study of DEI in computer-supported collaborative learning environments that takes into account the three dimensions or domains of activity that need to be managed in such contexts, and in which, therefore, EI has to be exercised in order to ensure that the collaborative process unfolds in an adequate way. We refer to these three domains as follows: the management of social participation, management of the academic task and the management of meanings.

The *management of social participation* refers to actions, contributions and communicative exchanges related to the establishment of rules or instructions regarding who can or should do what, how, when, with whom and how often. *Management of the academic task* refers to actions, contributions and communicative exchanges related to the establishment of rules or instructions about what has to be done, how it should be done and by what procedures, as well as what final products must be created and what characteristics these products should have. Both these domains are essential for analysing and understanding how participants organize their joint activity, such that they create a context in which it is possible to construct and share meanings in relation to the learning content. The third domain concerns the *management of meanings* produced

by participants in this context of joint activity, and it refers to the actions, contributions and communicative exchanges that are directly linked to this content.

III. An empirical approach to the study of distributed educational influence

Our empirical approach to the study of DEI has two facets, namely case study and a multimethod perspective. The analysis of cases is a useful strategy when one wishes to understand complex and dynamic social phenomena in naturalistic contexts without altering the variables to be studied (Yin, 1989). Hence, it is particularly appropriate for exploring how participants help one another over relatively long periods of time while engaged in collaborative learning. The case study approach has a long tradition in research on online computer-supported environments (see, for example, Schrire, 2006; Stahl, Koschmann & Suthers, 2006) and it has been repeatedly used in our previous studies of educational interaction in face-to-face teaching and learning contexts (Coll, Onrubia & Mauri, 2008).

The second facet of our empirical approach involves a multimethod perspective that is specifically geared toward the analysis of DEI. The mixed methods approach, one that combines different levels of analysis (de Wever, Van Keer, Schellens & Valcke, 2007; Veldhuis-Diermanse, 2002), individual and group measures and indicators (Arvaja, Salovaara, Häkkinen & Järvelä, 2007), or quantitative and qualitative approaches (Häkkinen, Järvelä & Mäkitalo, 2003; Hmelo-Silver, 2003; Strijbos, Martens, Jochems & Broers, 2004), has become a well-established trend within psychoeducational research as investigators have searched for research designs that enable a more holistic and more detailed understanding of learning processes in computer-supported environments (Suthers, 2006).

a. Observed scenarios

All the cases studied involve teaching sequences, in other words, processes that, regardless of their duration, include the typical components of any teaching and learning process (i.e. objectives, content, teaching and learning activities, and their evaluation) and in which a beginning, a period of development and an end can be clearly distinguished (Coll, Colomina, Onrubia & Rochera, 1992). This decision was directly related to the need to make the actions of participants during their joint activity a key aspect when it came to identifying and understanding the kinds of help they provided to one another. The strategy adopted involved recording and analysing in depth a series of real teaching and learning scenarios in a higher education setting, scenarios that involved essentially conversational forms of learning and educational practices that were, a priori, of sufficient quality. When selecting the cases we took into account factors that could potentially influence the exercising of EI, such that overall the cases covered a variety of online collaborative learning scenarios and activities and enabled us to study a wide range of processes and forms of DEI. Thus, we examined cases that differed in terms of the number of students involved (small groups of 4-6 participants or large groups of 15-30 participants), the nature of the proposed teaching and learning activities (online debates that varied in terms of the extent to which they were structured or how open the written product could be) and the computer-supported tools used

to carry out the activities (different types of forum, such as Moodle or Knowledge Forum, and wikis).

b. Data collection procedure

The data collection procedure was basically the same in all cases and was determined by the need to record in as much detail as possible the development of participants' joint activity across the teaching sequence. This general procedure was organized into three stages and involved the systematic collection of information about the following aspects:

Information available prior to the beginning of the activity:

- documentation relating to planning the activity, including, where appropriate, the curricular and reference material available to students and the material prepared by the teacher;
- the expectations of participants (students and teacher) regarding the objectives, development and potential outcomes of the activity.

Information produced during the activity:

- contributions made by participants (students and teacher) while carrying out the activity;
- documents (both draft and final versions) produced by participants (students and teacher) while carrying out the activity;
- activity registers (logs) generated automatically by the computer-supported environment;
- views of participants (students and teacher) regarding the development of the activity.

Information available at the end of the activity:

- procedures and instruments used to assess students' learning at the end of the activity (in the event that such assessment was carried out), and the results obtained;
- views of participants (students and teacher) upon completion of the activity regarding how the process has gone, the extent to which objectives have been met and the learning that has been achieved.

The instruments used to collect information about these aspects were interviews, self-reports, questionnaires, the logs of the contributions made by teachers and students, and the automatic registers of the activity carried out in the computer-supported environment.

The contributions of participants (messages and documents) and the registers of their activity in the computer-supported environment constitute the core of the information used to analyse DEI (profiles, forms in which EI appeared and the degree of distribution) and its impact on the process

and outcomes of collaborative knowledge building. The main purpose of the other kinds of information was to enable the triangulation of results and to provide complementary elements that would help to interpret them.

c. The model for analysing DEI

Our multimethod approach to the study of DEI includes two complementary types of analysis: structural analysis of participants' activity in the computer-supported environment and content analysis of their contributions. The goal of the former is to identify individual activity profiles that are potentially associated with the exercising of EI, whereas the purpose of the latter is to establish the actual extent to which participants exercise EI and the ways in which they do so.

The *structural analysis of participants' activity* includes a set of indicators and indices that are calculated both for individual participants and for the group as a whole. More specifically, the structural analysis considers indicators and indices regarding presence and participation, on the one hand, and connectivity, on the other. The premise underlying both types of indicators and indices is that the nature and intensity of the help that is offered among participants is determined by the degree to which they participate and become involved in the joint activity, as well as by the communicative exchanges that take place between them across the whole of the learning and teaching process.

Among the indices of presence and participation, mention should be made of those that refer to *logging in* to the computer-supported environment and those that concern *participation*, in the strictest sense, in the activities performed within it. Thus, the *individual log-in index* indicates how often participants have logged in to the environment, whereas the *individual log-in pattern* takes into account the periodicity as well as the frequency of log-ins. As regards participation, the *individual reading index* corresponds to the number of times each participant has read the contributions of others, while the *individual contributions index* indicates the number of contributions made by each participant in relation to the number of contributions required according to the task instructions. For each of these indices we also established a cut-off or threshold value, above which the presence of participants would, in theory and for the aspect or domain in question, favour the exercising of EI. By simultaneously considering indices of both presence and participation it is possible to establish activity profiles that can be evaluated in terms of the extent to which they correspond to the theoretically ideal profile for the exercising of EI. It should also be noted that the individual indices of log-ins, readings and contributions have their group correlates which provide information about the extent to which the group as a whole may favour, through its structural characteristics, a broad distribution of EI.

The indicators and indices of *connectivity* are inspired by social network analysis (see, for example, Scott, 1991; Wasserman & Faust, 1997) and provide information about communicative relationships in terms of the direct responses made by participants to the previous contributions of others. Of particular interest for the study of DEI are reciprocal and responsive relationships as indicators of the level of interpersonal communication that is required to provide and receive help in what is essentially a conversational learning context. Thus, the group indices used in our model for analysing DEI include *density*, a measure that refers to the number of ties or links that are created among participants as a result of the contributions that make in relation to one another,

and *centralization*, an indicator referring to the degree to which the group's functioning depends on the activity of certain participants. As for the individual indices, the model includes 1) the degree of *centrality in the emission of responses*, which indicates how central or peripheral a given participant is within the group on the basis of the contributions he or she makes in relation to the other participants; and 2) the degree of *centrality in the reception of responses*, which refers to the position occupied by a given participant in terms of the contributions that are directed at him or her by the other participants[2]. The information provided by the indices of connectivity enable a more nuanced interpretation of the activity profiles that are established on the basis of the indices of presence and participation, as well as of the evaluation of the degree to which the latter two aspects are likely to favour the exercising of EI.

The *content analysis of contributions* serves to identify the extent and form of EI that is actually exercised by participants. This analysis focuses on identifying the contributions or fragments of contributions concerning the three domains of joint activity that we defined earlier: the management of social participation, management of the academic task and the management of meanings in relation to the teaching and learning content. By moving back and forth between the original theoretical model of DEI and the data obtained from the cases analysed, we have established a category system for each of these three domains.

The categories associated with *social participation* refer to the actions, contributions and communicative exchanges that participants produce in relation to the rules or instructions regarding who can or should do what, how, when, with whom and how often. Examples of these categories include the formulation or reiteration of the rules for participating in the activity, the request for clarification of these rules, appraisals of the extent to which the rules have been respected by participants, and proposals for revising or reformulating the rules.

The categories associated with the *academic task* refer to the actions, contributions and communicative exchanges that participants produce in relation to the establishment of rules or instructions regarding what has to be done, how it should be done and by what procedures, as well as what final products must be created and what characteristics these products should have. Examples of these categories include reminders of the nature of the task or of the demands of the expected product or outcome, the request for clarification about these characteristics and demands, proposals for reformulating them, and appraisals of the degree to which they have been fulfilled by participants.

Finally, the categories associated with the *management of meanings* have to do with what and how participants contribute to the process of constructing progressively more detailed and more shared systems of meaning in relation to the learning tasks and content. The actions, contributions and communicative exchanges that are characteristic of this dimension include the presentation of information, the formulation of queries, the request for clarification, synthesis and recap, favourable or unfavourable evaluations of the contributions made by other participants, the

[2] For a more detailed description of these indicators and indices, and of the procedure used to calculate them, see Coll, Engel & Bustos (2009), Coll, Bustos & Engel (2011), and Engel, Coll & Bustos (2013).

identification and correction of errors, and expressions of agreement or disagreement, etc. in relation to the learning tasks and content[3].

In the next section we will show how the combined application to the same set of data of a structural analysis of activity and a content analysis of participants' contributions has proved to be an effective way of identifying the extent and forms of EI that are actually exercised by each participant, as well as the degree to which EI is distributed among participants as a whole.

IV. Some results of interest and questions that remain open

The application of this analytic model to the cases studied to date has yielded a series of results which suggest that the construct of DEI, and its associated theoretical framework, can play an important role in improving our understanding of online collaborative learning processes. In our view, there are three sets of results that are of particular interest: the identification of individual activity profiles that would potentially favour the exercising of EI and the frequency with which they appear in the groups engaged in collaborative learning tasks; the existence of different ways of exercising EI, their distribution and their complementarity during processes of collaborative learning; and the possibility of using the indices and categories employed in the analytic model to assess the quality of collaborative processes and online collaborative learning.

a. Activity profiles that would potentially favour the exercising of EI

As noted earlier, the structural analysis of participants' activity enables us to identify profiles that can be evaluated in terms of the extent to which they correspond to the theoretically ideal profile for the exercising of EI. Activity profiles are based on the log-in, reading and contribution indices, as well as on the patterns of log-ins and contributions. The extent to which they correspond to the theoretically ideal profile for the exercising of EI is assessed in relation to the threshold value established for each index (i.e. log-ins, readings and contributions), with values above the corresponding threshold being regarded as favouring the exercising of EI. This means that in an ideal profile the values of all these indices will be above the threshold, whereas a profile in which all values are sub-threshold would be regarded as falling short of the ideal.

In the cases studied to date (Bustos, 2011; Bustos, Coll & Engel, 2011; Coll, Bustos & Engel, 2007, 2010, 2011; Coll, Bustos, Engel, de Gispert & Rochera, 2008; Coll, Engel & Bustos, 2009) we have been able to identify groups of participants with activity profiles in which all index values are above the corresponding threshold, suggesting that the profile would potentially favour the exercising of EI. Conversely, some groups of participants present activity profiles in which most or all of the index values are sub-threshold, indicating that these profiles are ill-suited to the exercising of EI.

[3] For a detailed description of the procedure for categorizing contributions and the procedures used to ensure the reliability and consistency of the content analysis, see Bustos, Coll & Engel (2009) and Coll, Bustos & Engel (2011).

If, on the basis of the structural analysis of activity, we define the distribution of EI as the proportion of participants whose profile would potentially favour the exercising of EI, then most of the cases studied show a distribution of between 20% and 50%. The results also show that, in the cases studied, the structural analysis of activity can identify not only the level of distribution of EI but also those participants who play a key role in the collaborative process by providing help to others. In this regard, our findings also suggest the potential value of implementing strategies that might encourage participants to be more proactive in the collaborative process, such that they assume responsibility as providers of help to others. If the aim here is to increase the level of distribution of EI and improve the collaborative process, then one particularly promising avenue for future research would, in our view, be to examine the possibility of offering participants precise and detailed real-time information about certain key aspects of the activity (log-ins, readings, contributions) at both the individual and group level (Bustos, Coll & Engel, 2011).

By its very nature, however, the structural analysis of activity — no matter how much it may be enriched and improved, and no doubt our model still requires substantial input of this kind — cannot provide relevant information about the content, dynamics and effects of exercising EI. It is here that it needs to be complemented by a content analysis of participants' contributions that can tell us something not only about the extent to which they actually — not just potentially — exercise EI, but also about the different ways in which this influence is exercised, how it is distributed and its complementarity during the process of collaborative learning.

b. Ways of exercising EI and the development of collaborative learning processes

By considering the three domains of shared activity that are used to analyse participants' contributions it is possible to identify different ways of exercising EI according to the domain or domains in which it is exercised. On this basis, and given the importance of the temporal dimension to our approach, the identification of different ways of exercising EI takes into account the following two aspects (Bustos, 2011): 1) who contributes, how much and when in each of the three domains; in other words, which participants contribute through their input to the management of social participation, of the academic task and of meanings, to what extent do they contribute and at what point during the teaching sequence do they do so; and 2) to what categories (reminders, task requirements, evaluations, queries, provision of information, synthesis, recap, etc.) do participants' contributions in each of the three domains correspond.

The results of this analysis indicate that, in general, participants whose activity profile is closer to the ideal for exercising EI are also those who are most active in terms of the real extent to which such influence is exercised. However, this influence can take different forms, in that it may be concentrated in one or other of the three domains, or be spread, evenly or otherwise, across two or three of them. In the cases studied to date we have identified as many as seven different ways of exercising EI that can be grouped into three categories: 1) *total exercising of EI*, in which it is exercised in all three domains of joint activity (participation, task and meanings); 2) *partial mixed exercising of EI*, in which it is exercised in two of the three domains (meanings + task, meanings + participation, or task + participation); and 3) *focused exercising of EI*, in which it is exercised in just one domain of joint activity (participation, task or meanings).

In terms of the role that EI plays in collaborative learning processes these results suggest that it is important to identify not simply how many participants actually exercise such an influence but also the ways in which they do so and how the different ways are distributed among them. For our theoretical perspective both these aspects are equally important for understanding how and why a given collaborative process is effective and productive while another is not. In the cases studied to date the exercising of EI has not been the exclusive preserve of the teacher but, rather, has been distributed in different ways and to varying degrees among all participants. Furthermore, no clear association has emerged between the different ways of exercising EI and the role of student or teacher. Indeed, we have documented examples of both 'total' and 'partial mixed' exercising of EI among both teachers and students.

Although the procedure used to identify and analyse the different ways of exercising EI is still being developed, and while acknowledging that the results obtained so far need to be interpreted with caution, we believe that the notion of *ways of exercising EI* opens up new avenues for research on collaborative processes in online environments. In such contexts the exercising of EI may be distributed to varying degrees among participants, but what really matters is that, overall, the joint activity is managed in such a way as to foster collaborative group dynamics in relation to the three domains: participation, the academic task and meanings. It should be emphasized, however, that although our results regarding the different ways of exercising EI are encouraging, the studies conducted to date have a number of important limitations. Notably, the methodological approach used so far is unable to analyse the data in terms of the extent to which the educational aid offered is appropriately adapted to its target, and this is clearly a considerable limitation when it comes to studying processes of collaborative knowledge building in terms of EI and DEI.

c. The analysis of DEI and the quality of collaborative processes and online collaborative learning

As we have already noted, our research clearly shows that in online collaborative learning scenarios the exercising of EI is distributed in different ways and to varying degrees among those involved. However, the results do not tell us whether or not, or to what extent, the distribution of EI may actually promote participants' learning. Clearly, then, one way in which research on DEI needs to progress is through the development of a system of indicators for assessing the quality of online collaborative learning processes. In developing such a system one would need to address at least the following three requirements. First, it would be necessary to have a set of indicators that provide adequate (i.e. valid and reliable) information regarding the exercising of EI, the ways in which this is done and how such influence is distributed among participants. Second, one would need a similar set of indicators that could tell us something about the quality of collaboration and the outcomes of collaborative learning at both the individual and group levels. And third, it would be necessary to check that there was a consistent relationship between these two sets of indicators.

In our view, the indicators and indices used in the structural analysis of participants' activity provide a platform from which to address the first of these requirements. This is because, in the cases studied, those participants whose activity profile was closer to the ideal for exercising EI were also those who were most active in terms of the real extent to which such influence was

exercised. Of course, the coherence of this finding does not mean that the procedure used to develop the activity profiles should not be further improved.

In fact, there are both theoretical and empirical reasons why it would seem advisable to review our decision to assign the same weight to the five indices used to develop activity profiles (i.e. log-ins, patterns of log-ins, readings, contributions, patterns of contribution). From the theoretical point of view, frequent or relatively frequent log-ins and a regular or relatively regular pattern of log-ins are necessary conditions for the exercising of EI, but they are in no way sufficient conditions. Indeed, in order to take advantage of the help provided by other participants and to offer them help in return, participants need to do more than simply log in to the environment with a certain frequency and regularity. Rather, they need also to read the contributions made by others and make their own contributions with a similar frequency and regularity. In other words, the indices of presence (log-ins and patterns of log-ins) and participation (readings, contributions and patterns of contribution) as components of an activity profile that may or may not favour the exercising of EI do not have the same value and, consequently, they should not be given the same weight when drawing up such profiles; of course, this proposal is contrary to the procedure that we have used in our research to date.

From the empirical point of view it is important to note that in the cases studied we have observed a difference between two kinds of participant, namely those whose activity profiles have values close to those of the ideal for exercising EI on the participation indices (readings, contributions and patterns of contribution) but not on the indices of presence (log-ins and patterns of log-ins), and those whose activity profiles have values close to those of the ideal profile on the indices of presence but not on those for participation. The difference becomes apparent when one analyses the content of the contributions made by these two kinds of participant, since the former group are more active in terms of the real extent to which EI is exercised. This is an additional argument in favour of revising the procedure used to draw up the activity profiles, along the lines suggested in the previous paragraph.

There are no doubt other aspects of the procedure used to produce activity profiles that could be improved and refined. Nevertheless, the points made so far are sufficient to illustrate the relevance and feasibility of attempting to develop a system of indicators of the quality of online collaborative learning processes that incorporates the approach and contributions of research on DEI. The potential interest of such a development is reinforced by the fact that the majority of existing computer-supported environments produce activity registers that include the information required to calculate the indices on which our profiles are based, and they can also process this information automatically such that the corresponding profiles would be produced practically in real time.

V. Other areas of research related to DEI

The theoretical and methodological developments produced within the framework of research on DEI in computer-supported environments, as well as the results obtained to date, offer a perspective that could help to extend and enrich other topics that are currently being studied in relation to online collaborative learning. In what follows, we will briefly discuss how the concepts of EI and DEI, and above all the analytic model developed to study them (which combines the structural analysis of activity with the content analysis of participants' contributions), may usefully

contribute to research in four areas: personal learning environments, e-feedback, the use of scripts in collaborative processes and the application of learning analytics to improve collaborative learning processes.

a. DEI and personal learning environments

According to Adell and Castañeda (2010, p. 23), a personal learning environment (PLE) is "… the set of tools, sources of information, connections and activities that a person regularly uses in order to learn". Although one might conclude from this definition that we as individuals have always had a personal learning environment, the concept as such, its rapid diffusion, and its growing popularity and acceptance can be traced more immediately to the development of Web 2.0 and the ubiquitous wireless and mobile technologies that have given rise to new learning scenarios and which have transformed traditional contexts of socialization and training. Within this framework, some educational institutions, mainly those in the higher education sector, have sought to establish computer-supported environments that offer students the possibility of organizing, according to their interests and objectives, their own PLE including learning resources, applications and tools, as well as their own network of people with whom they will engage in learning activities and processes.

From the perspective of EI and DEI, one of the defining features of PLE is that at the same time as offering students the opportunity to organize their own learning processes and environments, they also offer them multiple opportunities and resources for acting as providers and recipients of help. Depending on the components involved (resources, tools, applications, sources of information, contact network, etc.), and especially on how these are used, students may construct their own particular learning pathways, into which they can incorporate different types and sources of help and support. By their very nature, PLE enable learners, at least in theory, to extend and diversify their sources of EI to an extraordinary extent, and what is perhaps even more important, such environments allow them to search actively for new sources and types of help and to choose between them.

However, the results of studies that have examined the use of PLE in formal educational contexts suggest that students generally do not take full advantage of these possibilities and opportunities (see, for example, Johnson & Sherlock, in press; Valtonen *et al*., 2012). Although it is not within the scope of this paper to review and analyse the many and diverse reasons for this, there are two aspects that are worth mentioning here: the first concerns the lack of guidance, advice or help on the part of teachers as regards how students might capitalize on the characteristics of technological environments and use them as PLE; the second has to do with the nature and characteristics of learning activities and tasks and the extent to which a student's involvement in them may or may not encourage him or her to explore the possibility of using technological environments as PLE. Thus, the fact that an environment could be used by students as a PLE is not in itself enough, since the activities that are proposed and promoted within it must also invite and encourage students to use it in this way. From an educational point of view, therefore, the key lies not in offering students technological environments that would enable them to construct their own PLE, but in designing activities that guide them toward and support them in constructing their own learning pathways.

In sum, regardless of whether we focus our attention on 1) how learners set up their PLE or 2) on how they use them, an approach based on the concepts of EI and DEI can help to extend and enrich research on PLE. With respect to the former question, the contribution of an EI/DEI perspective would be to consider the types, characteristics and sources of help that learners incorporate into their PLE, as well as the strategies they use to seek and ask for help, and to choose among what is made available. As regards the second question, an EI/DEI approach serves to remind us that the characteristics and demands of learning activities are a key aspect to consider in terms of the extent to which a technological environment may or may not be utilized as a space for learning.

b. DEI and formative e-feedback

Another important area of current research on collaborative learning in computer-supported environments that could be enriched through incorporation of the DEI perspective concerns formative e-feedback. This term is commonly used in specialist publications to refer to the information that is offered to learners in online computer-supported environments with the aim of appraising their progress and guiding them towards the learning objectives (see, for example, Narciss, 2008). In a recent study of e-feedback and its role in supporting online collaborative learning in small groups (Coll, Rochera, de Gispert & Díaz Barriga, 2013) we examined this issue from the perspective of DEI. Two main arguments were put forward. First, that in such contexts all participants, both students and teachers, can offer help in the form of feedback on the knowledge building process. And second, in order for collaboration to be fluid and for learners to progress towards the established goals, feedback must be targeted not only at the learning content but also at the characteristics and demands of the task and the social organization required to perform it. The results of this study supported both these arguments. Indeed, we found that both the teacher and some students offered feedback to other participants at certain stages of the activity and in relation to all three domains (social participation, academic task and meanings), although they did so to varying degrees and at different points in the process.

Aside from the specific findings of this study, what we wish to emphasize here is the advantage of considering the three domains included in the model for analysing DEI (i.e. social participation, academic task and meanings) as a reference point for identifying the areas in which feedback may be offered and for studying its distribution among participants throughout the learning process. As in the case of PLE, studying e-feedback from the perspective of DEI opens up new lines of research and raises a series of key questions, for example: What is the optimal level of e-feedback distribution among participants? Is it necessary to consider different ways of providing e-feedback, just as we have done with respect to El, and to examine the domain or domains (i.e. social participation, academic task and meanings) on which they are focused? What distinguishes, if anything, the teacher's feedback from that provided by students?

c. DEI and collaborative scripts

Research conducted over the last two decades on online collaborative learning has repeatedly highlighted how students often find it difficult to enter into the dynamic of collaborative knowledge

building and, therefore, to achieve their learning goals in such contexts (see, for example, the reviews by Dillenbourg, Järvelä & Fisher, 2009; and by Gress, Fior, Hadwin & Winne, 2010). This has led some authors to propose the use of scripts that would serve to structure the collaborative process and encourage students to interact in ways that would foster collaborative knowledge building (Dillenbourg & Jermann, 2006; Weinberger, Fischer & Mandl, 2005; Weinberger, 2011). Recent years have witnessed an explosion of research interest in the use of collaborative scripts, and this has given rise to a wide range of proposals that vary in terms of the degree of detail and specificity of the advice given, the flexibility with which the script may be applied and, above all, the aspects of the learning task and the kinds of interactions among learners that are targeted or prescribed. In our view, it is precisely in this aspect that the DEI perspective is of particular interest to research on collaborative scripts.

If, as Dillenbourg and Tchounikine (2007) state, a collaborative script is essentially a set of instructions regarding how students should form groups, interact with one another, collaborate and use the resources made available by the environment to tackle the learning tasks in a collaborative way, then the key lies in the point of reference that is chosen when formulating these instructions, such that they fulfil their purpose as effectively as possible. In this regard, our proposal is to use the theoretical formulations and analytic model associated with DEI as a platform from which to build scripts that could guide and advise learners in contexts of this kind, while simultaneously facilitating and fostering a collaborative working dynamic. From this perspective a script that seeks to promote collaborative work would need to pay special attention to the following aspects, among others. First, given that the collaborative process is closely linked to the exercising of EI, the script should be geared toward promoting the real exercising of EI among all participants, in other words, promoting a broad distribution of EI. Second, because the collaborative process will only be fluid and effective if social participation, the academic task and meanings about the learning content are all adequately managed, the script must include advice regarding these three aspects of joint activity, such that the total set of interventions made by participants ensures proper management of this kind. Finally, insofar as the possibility of providing and receiving help, and therefore of exercising EI, depends on participants having a certain degree of presence and involvement in the learning tasks, the script must clearly set out what is required of participants in this regard and draw their attention to the importance of fulfilling these requirements.

d. DEI and learning analytics

The fourth and final area of current research on online collaborative learning that, in our view, could be enriched through the findings of studies that have examined EI concerns what is known as learning analytics. Here the term 'analytics' refers to the application of statistical analysis and explanatory and predictive models to large amounts of data so as to gain a better understanding of complex phenomena and be able to act on them. Thus, learning analytics can be defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Brown, 2012, p. 1). This line of research has attracted considerable attention in the last four or five years as a result of two developments: first, the growing trend among educationalists to move towards personalized learning, coupled with the search for procedures and techniques that could gather and analyse information about students' learning so that teaching input can be tailored

accordingly; and second, the increasing ability of learning environments to gather, analyse and present this information about the activity of learners not just automatically but often immediately. In the 2013 NMC Horizon reports on basic (New Media Consortium, 2013a) and higher education (New Media Consortium, 2013b) learning analytics are mentioned as one of the emerging technologies that, in the opinion of the specialists consulted, will enter mainstream use within the next two to three years.

In our view, combining the study of DEI in computer-supported environments with learning analytics could lead to the enrichment of both lines of research. On the one hand, the development of tools, procedures and techniques that can automatically gather and process the information required to produce activity profiles, assess the extent to which they are well suited to the exercising of EI, and report the results in a simple format opens up new perspectives for research on EI and DEI. One only has to think, for example, about the possibility of making this information available to students so that they can use it to become better providers of EI, thereby broadening the distribution of EI among participants as a whole and improving the process of collaboration. Alternatively, such information might be used by teachers to reinforce, annul or redirect, as necessary, certain interventions, whether their own or those of students, that promote, restrict or block the exercising of EI and the scope of its distribution, as well as collaborative processes in general.

However, the potential benefits may also operate in the other direction. As Brown notes, in the paper cited above, it is helpful to distinguish between the technological and statistical components of learning analytics and their respective purposes. Developing learning analytics that can make a decisive contribution to the improvement of online collaborative learning requires both suitable technology and statistical techniques capable of processing the information that is collected about learners' activity and their learning context. However, there is also a need for powerful theoretical models that can help decide which information it is most important to collect and process, how it should be interpreted and how to develop, on the basis of the results obtained, strategies that could improve collaborative learning processes and outcomes. In this regard, the approach and contributions of research on DEI provide a platform from which to develop learning analytics geared toward the collection, processing and interpretation of information about those aspects and domains of learners' activity that are associated with the exercising of EI and its distribution among participants. With respect to a point made at the beginning of this article, learning analytics of this kind would link the success of collaboration and its outcomes to the extent to which learners take responsibility for being both providers and recipients of aid, such that EI becomes adequately distributed among the group as a whole.

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