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Special issue Dialogical Approach in Virtual Communities: Theories and Methods

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Group dynamics in virtual communities: Reformulation process as a dialogical device

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Abstract

This paper presents a methodological reflection on the study of virtual and blended communities. By adopting a dialogical approach, the paper proposes the analysis of reformulations to explore psychosocial group processes within blended communities, characterized by the mixture of online and offline interactions. The method represents an innovative use of reformulation analysis, traditionally used in dyadic interactions of clinical settings. The study illustrates the potential of this methodological innovation, which involves an extended range of categories. Examples from an empirical study of a learning community of university students in a blended course are presented to illustrate the categories.

Keywords: reformulation process, group dynamics, dialogism, virtual context.

Introduction

The development of group dynamics in virtual communities is of growing interest as a research subject, mainly because of rapid expan-

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sion of the internet use. Online communities are increasing above all in learning contexts where the virtual dimension is often intertwined with face-to-face processes, producing blended communities. Previous research shows the need to explore methods that fit the study of group dynamics in virtual environments (Daniel, 2011; Hardin, Fullen & Valacich, 2006; Wellman, 1996). Our attempt is to address a methodological approach specifically for blended communities. Our method enables us to explore what happens when group members are involved in both online and offline interactions.

This study adopts a dialogical approach and takes on the cultural definition of a group following Wenger's (1998) construct of "communities of practice". From these perspectives groups are composed of people engaged in co-construction of social practices through discursive practices (ibid, 1998). Communities of practice are based on negotiation processes as all group features – aims, engagement, artefacts, roles, norms, repertory – are continuously co-constructed by discursive activities of members. In this sense, group dynamics are the outcome of multiple negotiations in which group members are involved; therefore, they are constructed through discursive practices that are the symbolic representation of negotiation processes.

Dialogism and discursive practices

Discursive practices are the result of coordination among different interlocutors that dialogically co-construct meanings. Meaning, from this perspective, does not belong to the message itself, but to the position it occupies between speakers (Voloshinov, 1973). Both the sender and recipient of the message contribute to define its meaning. Bakhtin (1981) maintains that dialogue can be defined as a dialogical tension among divergent points of view. This also occurs in situations of dialogue with ourselves, as the perspective of the Other is taken in account even when the 'other' is silent or absent. Indeed, Bakhtin's (1981) concept of "responsive understanding" clearly refers to the unavoidable presence of an interlocutor in our speeches, which are always addressed to someone even if they are physically absent. According to this dialogical perspective, we live in a world created by words, by words uttered by others (Bakhtin, 1986). The Self is incomplete in itself and the Other with which it interacts gives it shape and meaning through the dialogue. Therefore, to take a dialogical perspective means to recognize that the foundation of every psychological process is the dialogue; the discourse of each individual is based on the discourses of others.

In Bakhtin's view (1981), dialogism is an internal characteristic of the language: every speech contains traces of previous speeches, it is composed of different genres and invokes discourses (or voices) expressed by other people in different places and times. In this sense, the discourse is heterogeneous and characterized by "social heteroglossia" (Bakhtin, 1981). According to Marková (2003), dialogism is not only a feature of language, but it is also and above all an epistemological and ontological position: "the capacity of the human mind to conceive, create, and communicate about realities in terms of the "Alter" (p. 85).

Literature about dialogism is variegated (Linell, 2009), therefore talking of a single "dialogical approach" is misleading (Grossen, 2010). Different fields of psychology have adopted the dialogical approach. Yet despite differences, all fields converge on the social nature of human actions whose meanings are interactively and discursively constructed in social practices shared with other individuals in a context of intersubjectivity.

Hence, the social nature of human action requires the adoption of a dialogical perspective even in the study of psychological group processes. A way to dialogically analyse psychosocial dynamics of specific communities is to focus on their discursive practices through discourse analysis. Discursive interactions illustrate how participants coordinate their contributions and negotiate shared meanings through the interpretation of others' speech in the cooperative construction of the text (Gulich & Kotschi, 1983, 1987).

Reformulation process: A dialogical device

The mechanism of reformulations is a useful tool to study the dialogical nature of group dynamics. Reformulation process is one of the main interpretative movements in discourse activities (Salazar Orvig, 2002), it allows the joint construction of discourse. Anchoring the interlocutor's speeches to other speakers' talks, it represents a dynamic activity implying the actor's positioning about what has been expressed by others (Bakhtin,1984). It is much more than a textual repetition of other's discourse, as it involves a dialogical revision of the evocated voices: it tries to give a new sense to the recalled discourse (Gruning & Gruning, 1985). Repetitions and reformulations are two different kinds of dialogic movements in discourse; they differ in the distance between the interpretative utterance and its discursive source. Repetitions are characterized by a minimum distance between interpretative utterance and source; they represent a full support to other's discourse (the source). In contrast, reformulations are characterized by a greater distance between the interpretative utterance and source; they try to give a new meaning to other's discourse (the source) through integration, understanding and interpretation (Salazar Orvig, 2002). In short, a reformulation entails a repositioning of the speaker that can represent also a divergent position from the source (Salazar Orvig, 2002).

The literature about reformulations (Grossen & Apotheloz, 1996; Gulich & Kotschi, 1983; Traetta & Annese, 2012) identifies different kinds of reformulations. The presence of connectors ("so", "therefore", "in other words", "for example", "thus") that mark the activity of reformulation itself, characterizes paraphrastic reformulations (Gulich & Kotschi, 1983). They show a high degree of semantic equivalence and a local nature, as it immediately follows the reformulated source, like in face-to-face discussions. On the contrary, not-paraphrastic reformulations entail a great distance from the authorship of the reformulated source. In this case the connector is replaced by a "metadiscursive clause" (Grossen & Apotheloz, 1996) that marks the discursive activity of the source's author ("as you said", she explained that", etc.). This kind of reformulation is recurrent in clinical contexts (Apotheloz & Grossen, 1996) where it constitutes a useful strategy for the therapist. In general, the dyadic conversation of clinical interaction represents the traditional setting of reformulation analysis. In this kind of studies (Apotheloz & Grossen, 1996; Grossen & Apotheloz, 1996) reformulations are used to reshape the discourse of a specific author, the patient. In clinical settings, researchers treat individual reformulations introduced by metadiscursive clauses. Furthermore, this kind of reformulations is contextual, as the whole process of reformulation – source and reformulated discourse included – occur in the same discussion.

Reformulation process in blended contexts: A methodological innovation

Aims and context

In this paper we make the claim that reformulation analysis is a helpful device in other contexts, in particular for observing the dialogical dynamics in blended communities. Specifically, not-paraphrastic reformulations, characterized by metadiscursive clauses that mark the presence of a reformulation process, allow us to retrieve discursive sources even when they are distant in time and space, expressed in previous sections of the discussion or in another discussion. For this reason they suit the aims of our research, which is to study the psychosocial dynamics in blended learning communities combining face-toface with online interactions.

We explore not only the specificities of group dynamics in virtual context, but also their integration with the face-to-face features.

The dialogical analysis of reformulations in blended interactions of learning communities can prove very helpful for understanding and improving learning process in blended courses.

The study presented here features the blended course of E-Learning Psychology at University of Bari (Italy).

The course, exhaustively described in the editorial note, consisted of didactic modules, including weekly offline and online activities and group discussions. During every module, students interacted first in small groups discussions and subsequently in plenary discussions involving the whole community, both online and offline. Students were divided into three small groups to which they assigned a name. Moreover, students played several roles such as e-tutor, discussion summarizer and critical friend; all these roles are aimed at enhancing study competences, group work skills and e-learning expertise. More details about roles are discussed in the editorial note.

Offline and online students' interactions were examined at three different stages – in the beginning, the middle and the end of the course – in order to outline the diachronic development of group dynamics.

The reformulation analysis as applied to blended learning communities entails a methodological innovation. It takes into account the group context in the learning environment, a departure from its traditional dyadic clinical setting. This application has made necessary an extension of categories. Briefly, we introduced three kinds of categories: collective reformulation. These are in addiction to the traditional types recurring in clinical settings (Apotheloz & Grossen, 1996; Grossen & Apotheloz, 1996): individual reformulations, discursive reformulations and contextual reformulations.

In the following paragraphs we will explain the innovations in detail, providing some examples for each category. Moreover, every example will be described through a table reporting specific dimensions of the analyzed category.

Individual and collective reformulations

The primary methodological innovation presents the distinction between individual and collective reformulations. It is based on the specification of the reformulated source's author. Indeed, differently from the traditional dyadic setting, in the group context it is possible to find reformulations of a collective discourse (made by some individuals maintaining the same position or even by the whole group) in addition to reformulations of an individual discourse, pronounced or written by a single participant.

The traditional individual reformulations are characterized by a metadiscursive clause introducing the reformulated discourse (see example 1; Tab. 1):

Example 1: 1st online plenary discussion Serena: "As Arianna says, physical proximity is another matter..."

Tab. 1. Metadiscursive clauses

Metadiscursive clause	"As Arianna says"
Speaker	Serena
Source's author	Arianna
Reformulation	"physical proximity is another matter"

In this example the source's author is a single person (Arianna) quoted by the speaker (Serena) through a metadiscursive clause.

A specific quotation such as the one in the above example is difficult when the author of the reformulated discourse is not a single individual, but a collective agent. A collective agent is a very frequent author in reformulations occurring in group context. In this case the source is indefinite as it refers to a general discourse rather than to a specific part of the text. Therefore, the reformulation represents a summary or a commentary of similar voices expressed in the discussion. This is the reason why we created a new category of reformulations characterized by a "metadiscursive comment" (see example 2; Tab. 2), a general commentary of the quoted voices:

Example 2: 1st online discussion – small group "The ignorant fairies"

Romina: "As we said yesterday, technology is useful to connect remote universities..."

Reformulation	"technology is useful to connect remote universities"
Source's author	Indefinite (the whole community)
Speaker	Romina
Metadiscursive comment	"As we said yesterday"

Tab. 2. Metadiscursive comments

In this example, the speaker (Romina) makes a comment about a plenary discussion engaging the whole community rather than a single participant. Thus, the source author is indefinite and the reformulation expresses a supposed collective point of view.

The methodological extension to the collective reformulations, produced by the group context, is useful for exploring the intertwining of individual and collective voices in the intersubjective plot of community. Often participants reformulate the voice of the whole community in order to support and reinforce their personal opinion.

Discursive and cognitive reformulations

As interactions within a learning community are aimed at the knowledge creation (Scardamalia & Bereiter, 2006) it was necessary another methodological innovation focused on this specific feature of the group context. In this kind of community, we observed recurrent textual reformulations of cognitive processes, in addition to the usual reformulations of discursive processes. This evidence led us to distinguish between discursive and cognitive reformulations. If the former ones were marked by a metadiscursive clause, the latter ones are marked by a metacognitive clause showing a single individual as the source's author of the cognitive process (see example 3; Tab. 3):

Example 3: 1st online plenary discussion

Gianmarco: "Tuesday I felt that something changed in offline and online participation in our classroom"

Metacognitive clause	"I felt that"
Speaker	Gianmarco
Source	Cognitive process
Source's author	Gianmarco
Reformulation	"something changed in offline and online participation"

Tab. 3. Metacognitive clauses

In this example, Gianmarco reformulates his own cognitive process; so that, the source's author is individual and definite, therefore the reformulation is introduced by a metacognitive clause.

On the contrary, cognitive reformulations can be marked also by a metacognitive comment when the source's author of the cognitive process is a collective agent (see example 4; Tab. 4):

Example 4: 1st online plenary discussion

Arianna: "We conceived online learning as an opportunity for old people..."

Metacognitive comment	"We conceived"
Speaker	Arianna
Source	Community cognitive process
Source's author	Indefinite (the whole community)
Reformulation	<i>"online learning as an opportunity chance for old people"</i>

Tab. 4. Metacognitive comments

In this example, the reformulation recalls a collective cognitive process whose author is indefinite, therefore it is introduced by a metacognitive comment that summarizes a community's thought, emerged as a collective voice.

The category of metacognitive comment seems to be a peculiarity of learning communities in that as it acts as a textual device to represent the appropriation process of course's contents by each member. Thus, the individual appropriation of collective cognitions represents those processes of collaborative knowledge building the blended community analyzed here was aimed at.

Contextual and blended reformulations

The last methodological innovation emerged as a natural need for the blended nature of the analyzed community. Indeed, the mixture of

two interaction environments – online and offline – produced both discrimination between contextual and blended reformulations, and reformulations belonging to the same context and reformulations belonging to different contexts.

In contextual ones, source and reformulation occur in the same environment or, often, in the same discussion (see example 5; Tab. 5)

Example 5: 1st online plenary discussion

Valentina: "As you say, we know each other".

Reformulation	"we know each other"
Speaker	Valentina
Reformulation's context	1 st online plenary discussion
Source	"being university colleagues, we know how to work"
Source's author	Serena
Source's context	1 st online plenary discussion

Tab. 5. Contextual reformulations

In this example the speaker – Valentina – reformulates an utterance expressed by Serena during the same discussion, taking place always online.

On the contrary, in blended reformulations, source and reformulation occur in different discussions and in diverse environments. This kind of reformulation is new in the reformulations' literature as it stems from the distinctiveness of blended setting that intertwines multiple online and offline discourses. In example 6 (Tab. 6), it is clear the diversity of context in which source and reformulation take place:

Example 6: 1st online plenary discussion

Arianna: "I think there are conditions requiring asynchronous communication, as I said during the classroom lesson".

Source's context	1 st offline plenary discussion
Source's author	Arianna
Source	"Under some conditions asynchronous communication is required"
Reformulation's context	1 st online plenary discussion
Speaker	Arianna
Reformulation	"I think there are conditions requiring asynchronous communication"

Tab. 6. Blended reformulations

In this example, during an online discussion, Arianna recalls her own discourse pronounced in an offline discussion. This kind of reformulation, merging discourses of multiple discussions and contexts, is useful for underlining the combination of online and offline dynamics in blended communities.

Tab. 7 summarizes the categories of reformulation we defined and how they can be intersected obtaining four kinds of reformulation.

Tab. 7. Categories' range

	Discursive reformulations	Cognitive reformulations	
Individual reformulations	Metadiscursive clauses	Metacognitive clauses	
Collective reformulations	Metadiscursive comments	Metacognitive comments	

In addition, there are other two categories – "contextual reformulations" and "blended reformulations" – that cannot be intersected because they refer to the context where reformulations occur and can fit all four types of reformulation shown through tab. 7.

By performing this expanded reformulation analysis in blended communities, it was possible to focus on specific psychosocial processes: first, all distinctive groups dynamics in online and offline setting; second, blended group dynamics (through relations between online and offline discourses and across different discussions in the same environment); and finally, leadership processes.

Reformulation dynamics in blended communities: An application

This reformulation analysis, improved according to the peculiar traits of blended interactions in a group context, was performed to observe the blended community of students attending the course of E-Learning Psychology in the academic year 2008/2009.

The data analysis was implemented through two steps. The first step performed by using the Social Network Analysis (SNA) (Scott, 1997; Wasserman & Faust, 1994), aimed at providing a general and static representation of the community architecture through aggregation and cohesion indices of community network and through each member's centrality analysis. The second step, conducted by the reformulation analysis, produced a specific and dynamic evaluation of the SNA representation by investigating in-depth the community's dynamics as it evolved.

In this paper, we focus on the latter step – as far as it concerns methodological application – with some references to SNA outcomes (Annese, Traetta & Spadaro, 2010; Annese & Traetta, 2011). In particular, we illustrate the reformulation analysis' results through explanatory examples that prove our methodological proposal for studying group dynamics in blended communities.

Reformulation analysis starts from the reading of online and offline discussions. In online discussions data are represented by web forum posts; in offline discussions they are conversational exchanges of classroom lessons. Offline data were transcribed according to Jefferson transcription system (Jefferson, 1984). The next step of reformulation analysis was to identify all the reformulations occurring in the analyzed discussions and we totally detected 1266 reformulations. Then two independent researchers coded every reformulation, according to the appositely created categories' grid. The double coding was performed on 30% of data, achieving an inter-reliability rate of 83%.

The first results of reformulation analysis remark a distinctiveness for each context and a "blending" between online and offline features, yet emerged through the SNA outcomes. Indeed, SNA indices have shown a specific participation pattern for each context: uniform and cohesive in online context, irregular and discontinuous in offline context. At the same time, the results have shown some similarities between offline and online contexts, as for example similar participation trajectories followed by some members in the two different contexts. The reformulation analysis validates and deepens these results, showing some distinctive elements in both environments and, at the same time, some indices of a "blending" between online and offline.

A peculiar aspect of online environment is the dominance of contextual and discursive reformulations (see Tab. 8).

		Blended	Contextual	Tot.	Tot. discursive/ cognitive
ONLINE	Metadiscursive clauses	3.85%	68.08%	71.93%	90.78 %
	Metadiscursive comments	0.77%	18.08%	18.85%	
	Metacognitive clauses	0.77%	5.38%	6.15%	9.22%
	Metacognitive comments	0.38%	2.69%	3.07%	
	ТОТ.	5.77%	94.23%	100%	100%

Tab. 8. Occurrence of online reformulations

The dominance of contextual and discursive reformulations shows how students negotiate in every online discussion the focus and the aims of their interactions by recalling contents of the same context and reformulating their own discursive processes (see example 7):

Example 7: 3rd online discussion – small group "Mosquitoes"

Valentina: "Between these two models I probably choose the learnercentered one you mentioned at the beginning".

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In this example, the specific task of discussion for students is the identification of helpful indicators to be included in a grid of analysis for online courses. Students are discussing learning models and, specifically, they have to choose between the learner-centered model and the information transfer model. To make a choice they recall contents of the same contextual discussion by making reformulations of their previous discursive processes.

Offline context shows also some peculiarities (see Tab. 9); like the online environment, it is characterized by the high presence of discursive and contextual reformulations. In contrast to the online environment, these kinds of reformulations are not strongly prevalent as there is a great use of blended reformulations and a moderate use of cognitive reformulations.

		Blended	Contextual	Tot.	Tot. discursive/ cognitive
OFFLINE	Metadiscursive clauses	12.33%	33.04%	45.37%	77.53%
	Metadiscursive comments	17.62%	14.54%	32.16%	
	Metacognitive clauses	7.93%	6.17%	14.1%	22.47%
	Metacognitive comments	4.85%	3.52%	8.37%	
	ТОТ.	42.73%	57.27%	100%	100%

Tuble 5. Occurrence of onnine reformulations	Tab.	9.	Occurrence	of	offline	reformu	lations
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The greater use of blended reformulations in offline context in comparison with online discussions shows how negotiation processes in blended communities are exported from one environment to another one and then distributed between virtual and face-to-face discussions. Additionally, offline context seems to be a suitable setting for promoting distributed discursive and cognitive processes even among activities, actors, tasks and settings (see example 8):

Example 8: 3rd offline plenary discussion

Maurizio: "During online activities, we thought that 'hybrid' meant the idea that courses would never have completely matched the constructivist perspective".

In this example, Maurizio tries to explain, during an offline discussion, a collective cognitive process, occurred during online activities, underlying the group decision to choose the label "hybrid" for the grid of analysis. The offline context becomes the ideal setting for collectively sense making of the blended experience, for strengthening the shared repertory co-constructed online.

Summarizing we can say that reformulation analysis describes SNA outcomes through a dynamic perspective and is able to explore both the blended dynamics and the peculiar processes of online and offline contexts in blended communities.

A further application of reformulation analysis deals with leadership. It explores leadership dynamics by investigating the occurrence of produced and received reformulations for each participant. In this way, we could identify the presence of central members, leaders or counter-leaders. Leaders are characterized by a great number of both produced and received reformulations, so they are active participants, but above all they are popular for other members. Counter-leaders are characterized only by a great number of produced reformulations, so they are merely active participants without being popular for other members.

With regard to leadership process, SNA showed two different results for leadership process in online and offline contexts. The former one is characterized by a distributed leadership as participation strategies are homogeneous for all members; the latter one is characterized by leadership of a few central members as participation strategies are irregular.

Reformulation analysis is a helpful tool to confirm SNA outcomes even for leadership dynamics, indeed it detects a discrimination between the two contexts. Online interaction allows a distributed leadership process because the whole community is more reformulated than individual participants are, so the source of reformulation is represented by community members who are all equally central. Offline interaction centralizes leadership dynamics in a few members, those considered as source of reformulation. Initially these few central members are chosen by an external attribution as they are assigned by the teacher to formal roles (i.e. leader e-tutor). Gradually, other few members become leaders by an internal attribution as they are assigned by a community negotiation to informal roles (i.e. spontaneous leader and not because the teacher assigned a role) (see example 9):

Example 9: 3rd offline discussion - small group "Butterfly"

Arianna: "Tutor, would you please start up the discussion!" Marina: "All responsibility to her..." Serena (tutor): "So guys what do you think? ((she laughs)), oh well: (0.3). well, I have: that is, if we hand out the grid now maybe: " Marina: yes we do Serena (tutor): the final grid, do you have it? Arianna: Ours? [yes, I have it. Marina: [yes, she has it. She has both versions of grid. Serena (tutor): you are great! Arianna: "Let's begin! Everything is ok for the first one: for the learning models' module and: we had no troubles. We made it quickly because

models' module and: we had no troubles. We made it quickly because <we had to ask the distinction> this first module: <gave us the pattern> it gave us the start and guided us".

In this example, the student who played the formal role of online tutor – Serena – is explicitly requested to start the offline discussion by another participant – Arianna – at her turn supported by a further member – Marina. This conversational exchange makes clear that the student assigned to the online tutor's role is requested even to manage offline interaction. Group members' expectations about online tutor assumes an ability of shifting tutor's tasks and responsibilities from online to offline context, so tutoring the whole process of blended interaction. However, as the tutor (Serena) is not able to meet the group expectations; she is not able to guide the debate in another setting. So, after some inefficacious turns, Arianna benefits from her hesitation and takes control of the offline interaction by informally replacing the tutor's role through the group consent. If the tutor is inadequate, other members act in a complementary way by bridging his/her gaps in a negotiation process that produces an internal attribution of the group leadership.

This example clearly shows that the leadership dynamics, initially affected by the formal roles' system, are essentially intersubjective processes continuously negotiated among group members choosing a leader whose characteristics and skills would fit community goals (Speltini & Palmonari, 1999).

The community's members negotiate not only the attribution of leadership (external/internal), and the leadership style, but also different types of roles that can be formal (i.e. e-tutor, critical friend, summarizer) or informal (i.e. counter-leader). In this sense negotiation process is the core of communities of practices as all group dynamics – leadership, aims, roles, norms, etc. – are negotiated and co-constructed by the community's members. As we have shown, reformulation process represents a valid tool for capturing the dynamic nature of negotiation process.

Conclusion

In this paper, we describe how the reformulation process provides a methodological device that is able to explore the dialogical construction of group dynamics in blended communities, where online and offline interactions are interlaced.

The methodological innovation offered by the extension of categories' range proved to be very suitable for studying blended contexts as it accomplishes two research goals. Regarding the first goal, it focuses on specific features of single environments. In terms of the second goal, it is able to single out the links between environments and the construction of the intersubjective connections (Traetta & Annese, 2012); the composite plot of online and offline activities, central and peripheral participants, discursive and cognitive processes; and in short, it is able to single out the blended community architecture. Furthermore, reformulation analysis allows understanding both of the polyphonic component of reformulated messages and the interactional contexts where they occurred. In this study, the examples of reformulation analysis show how it works to detect the negotiation of all community features (aims, repertory, roles, leaders, etc.) through discursive practices. In this sense, reformulation methodology effectively works to support our research conceptual framework, as it is able to describe group dynamics developing in the negotiation process of community practices (Wenger, 1998).

In our research, this methodological tool also effectively works for its pragmatic outcomes. The investigation of psychosocial dynamics building community architecture allows us to refine the courses' organization to improve some features or to subsequently design new blended courses in light of research findings.

The findings from this study suggest that the proposed device worked effectively in our study. Despite its promisingness, the methodology could be further improved by reassessing the categories' range in order to examine other social processes such as identity dynamics (Hermans, 2001; Hermans & Gieser, 2012). Considering new categories would be interesting in investigating the functions of reformulations in the specificity of group context, so different from the clinical setting in which the reformulations were traditionally studied. The study of reformulations' functions could be helpful for observing how community members activate reformulation process to position themselves in social interactions in order to dialogically construct their identity.

Moreover, the use of this methodological tool could be extended to other fields, such as the organizational contexts where a further innovation of categories' range could be expected in relation to the specificity of the setting. Of course, the reassessment of the methodological innovation could require the involvement of different disciplinary expertise, for example a collaboration between linguistics and psychology. The expertise in textual devices would complement the psychological investigation of peculiar contexts' dynamics.

In conclusion, textual evidences of reformulation analysis can enrich in a dynamic perspective the static observation of psychosocial processes performed by other quantitative research tools. It represents an in-depth methodological device, essential in integrating the compressed representation of quantitative results in research works.

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