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To cite this article: Grace Morales, Gérard Sensevy & Dominique Forest (2017) About cooperative engineering: theory and emblematic examples, Educational Action Research, 25:1, 128-139, DOI: 10.1080/09650792.2016.1154885

To link to this article: http://dx.doi.org/10.1080/09650792.2016.1154885

Published online: 08 Feb 2017.
About cooperative engineering: theory and emblematic examples

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1. Introduction

In this article we present a particular type of research, cooperative engineering (Sensevy et al. 2013), which one may see as offering family resemblances with various kinds of research: action research, activist research, design-based research, lesson studies. This presentation is an attempt to show the specifics of this endeavour, notably by focusing on the way an enduring ‘engineering dialogue’ between teachers and researchers enables them to reconsider the relationships between the concrete and the abstract, while grounding the research activity in a new epistemology.

2. Cooperative engineering: a brief presentation

In this first section, we would like to give the general structure of what we call cooperative engineering. Some of the assertions that we make will be concretely illustrated in the following case study.
2.1. Beyond dualistic thinking

We argue that one of the main loci of enduring dualisms in educational science is the usual way of considering teachers and researchers. According to this dualism, teachers are viewed as ‘practitioners’ trapped in a practical relationship to their work, while researchers hold a theoretical stance. Within this division of labour, educational research has to be either applied research (in which practitioners have to apply the ‘scientific results’ to their practice) or a certain kind of ‘practical research’ (in which practitioners on their own try to implement some pedagogical devices they think particularly relevant). This first dualism (‘Theory’ and ‘Practice’) is entangled in a second, that of ‘Ends’ and ‘Means’ (Dewey 2004). If they have to work together, the division of labour between teachers and researchers often entails that researchers tend to define the ends of the research (its fundamental purposes and goals), while the teachers have to find the concrete means to achieve these ends.

The cooperative engineering process proposes another way of considering research, which rests on the following principles:

- A principle of symmetry, which one can conceive of as a kind of Kantian regulative idea, a device for guiding enquiry. Teachers and researchers are both practitioners, but practitioners of different kinds. The idea is that in order to improve an educational process, teachers and researchers are viewed a priori as equally able to propose adequate manners of acting or relevant ways of conceptualizing practice in the elaborated design.
- The necessity of acknowledging differences. Cooperative engineering requires that every agent plays ‘her game’; that is, proposes to the collective her first-hand point of view, what she ‘sees’ and what she ‘knows’ from her position, a point of view which is irreducible to any other one. Irreducible, but not incommensurable. It is a fundamental purpose of cooperative engineering to foster an enduring dialogue which one may conceive of as a progressive sharing of ‘seeing as’ (Wittgenstein 2009), a progressive shaping of a common thought style (Fleck 1981). Indeed, this dialogue can be seen as the joint construction of a common reference, a common background (Wittgenstein 1972), gradually shared by all the participants.
- The necessity of building a common reasoning about ends and means, and thus the potentiality to play both as a collective and as an individual the game of giving and asking for reasons (Brandom 1998). In such a game, each participant becomes able to give the rationale of the elaborated structures, is able to understand and build a first-hand relationship to this design rationale, beyond any division of labour. Moreover, each participant becomes able to raise some questions, whether it be ‘practical’ or ‘theoretical’, relating to the elaborated design.
- It is worth noticing that cooperative engineering may foster what we have termed a local practical indistinguishability between the teacher and the researcher. At some moments of practice, both of them share an engineer stance, which means theoretical and concrete ways to respond to a problem of the teaching practice. This principle has to be thought of in relation to the ‘differences principle’. Speaking of a ‘local practical indistinguishability’ between the teacher and the researcher does not mean that they melt together within an unlikely fuzzy stance. It does not erase the differences between the two professions, but it temporally and locally reunites them together under an engineer stance, which enables them to share not only the rationale of a given design,
but also the knowing of a common range of possible strategies that are relevant to enact for the ‘good functioning’ of this design.

2.2. Some epistemological remarks: the concrete and the abstract

From an epistemological viewpoint, the preceding principles rest on the following body of hypotheses.

- Sciences of culture are sciences of contexts (Passeron 2013).
- The assertions produced within the sciences of culture need to be systematically referred to the contexts they denote.
- A good manner in which to build such a reference consists of instituting some contexts as exemplars (Kuhn 1979), and these exemplars then function as paradigms (sense 2 for Kuhn\(^1\)). We may hypothesize that a given example of practice has to be considered first as an ‘emblematic example’ within a peculiar research endeavour, which further needs to pertain to the common knowledge of a research community to become an exemplar in this research community.
- These exemplars/paradigms can be described from an abstract formula (Deleuze 1988), which enables one to understand them in their main structural features, and which organizes a network of related exemplars, gathered by the family resemblance that the abstract formula allows one to recognize.
- The scientific inquiry thus spreads out in the construction of a paradigmatic system, a constellation of exemplars, linked by a paradigmatic analogy. The inquiry requires building a paradigmatic system, related to a particular concept, and then to browse this system in order to compare and to relate the different exemplars it encompasses. The browsing of the paradigmatic system – that is to say, the work of each of the exemplars it contains and their relationships – asks for an ‘organized plurality of systems of descriptions’ (Descombes 1998, 53). In particular, such work needs to hold together thin and thick descriptions, in Gilbert Ryle’s (2009) sense, the ‘plurality of descriptions’ being given by the different densities of each of them (Descombes 1998), each of them enabling the researcher to document aspects of the exemplar that the others cannot account for. Such an inquiry radically turns upside down the usual relations between the concrete and the abstract, in which the abstract is conceived of as the common part shared by some concrete elements. It rests on a Marxian dialectical vision of these relations, in the sense that scientific activity allows the ‘ascent’ from the abstract to the concrete (Engeström, Nummijoki, and Sannino 2012; Ilyenkov 1982; Kosík 1976; Marx 2012). In the process we have previously described, such an ascent takes place in the comparison of different exemplars of the paradigmatic system, based on the abstract formula, which allows a first apprehension of each of them.

According to this epistemology, cooperative engineering can be seen as a deliberate attempt to give a fundamental priority to the concrete of practice over the abstract ideas that may describe it. In building designs, the cooperative engineers meet some pieces of practice they institute as emblematic examples of practice, which enable them both to illustrate and to understand some crucial dimensions of the teaching–learning process. In the following case-study section we will provide such an emblematic example.
2.3. Cooperative engineering: what kind of research?

In cooperative engineering, the goals of designing teaching–learning environments and developing theories of teaching and learning are intertwined. In that way, cooperative engineering first refers to fundamental research, within an anthropological approach (Chevallard and Sensevy 2014) whose fundamental object is the ‘Didactic Human Fact’ (Cloud 2015); that is, human being learning and human being teaching. But this human fact is always becoming, is always virtually other than it is; always in a state of development, never final. Thus this fundamental anthropological research rests on the creation of a specific instrumentation for the science of culture, in which the transformation of practice and background values enables both the reconstruction of designs more fitted to agents’ needs and desires, and the progress of scientific knowledge. With this respect, cooperative engineering may contribute to the building of a new paradigm; that is, both an anthropological paradigm (in that it aims to contribute to a theory of practice) and an engineering paradigm (in that it aims to contribute to better educational designs).

It is worth noticing that this new paradigm meets the endeavour of clinical research (Bulterman-Bos 2008) as it has been described by Foucault (1976). As A.M. Sheridan, the translator of Foucault’s book, points out, ‘when Foucault speaks of la clinique, he is thinking of both clinical medicine and the teaching hospital’ (Foucault 1976, VII). A clinical paradigm, in that way, relies on and fosters both the building of a theory and the designing of a training system. One may remark that the epistemology of paradigmatic analogy that we have already sketched is consistent with the epistemology of the clinic, which rests on the production of a ‘clinical picture’ that one may see as a network of examples (parts of ‘cases’) which represent the disease.

2.4. A general description of the process of elaboration of cooperative engineering

The general concrete process of building a teaching design in cooperative engineering shares many of its features with the lesson studies framework. In a nutshell, it can be described as follows:

1. Teachers’ and researchers’ common work.
2. Collective working out of the piece of knowledge at stake.
3. Building together a specific teaching design and thinking together of instructional strategies, both being shaped by the knowledge.
4. Implementing the learning sequences in the classroom.
5. Evaluating these sequences against the background of shared educational ends of various types.
6. Iterating the process.
7. Eventually providing a system of resources on which teachers and researchers may rely to enact another versions of the cooperative engineering.

2.5. Cooperative engineering and action research

According to us, this presentation of cooperative engineering deeply fits the action research paradigm, for example as it has been delineated by Taggard:
In short, we can say that action research is a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality, justice, coherence and satisfactoriness of (a) their own social practices, (b) their understanding of these practices, and (c) the institutions, programmes and ultimately the society in which these practices are carried out. (1994, 317; original emphasis)

In describing how an action research could be carried out, Taggart (1994) emphasizes the iterative triplet 'planning—observing—evaluating' which stands at the core of the cooperative engineering. Moreover, he shows as action research asks for redefining the respective stance and working of each participant:

The distinction between academics and workers must not be taken to imply a distinction between ‘theoreticians' and ‘practitioners' as if theory resided in one place and its implementation in another. Such a view is the antithesis of the commitment of participatory action research which seeks the development of theoretically informed practice for all parties involved. (Taggard 1994, 317)

It seems to us that a major attempt of cooperative engineering – whose general principles and epistemology rest on the establishing of new relationships between concrete and abstract – is to erase ancient distinctions in order to foster ‘theoretically informed practice for all parties involved', without recognizing old divisions of labour.

3. A case study

In this section, we try to illustrate the previous contentions by focusing on a case study.

3.1. A general presentation of the ‘Treasure Game’

Brousseau (1997) and his team designed the ‘Treasure Game' for kindergarten students at the beginning of the 1980s. This learning sequence takes place over several months and aims to have students build a system of graphical representations. Brousseau (2004) has presented a strong theorization of this research design, which he considered as a fundamental situation for the learning of the notion of a representation. The situation was re-implemented recently in some classes in Switzerland (Leutenegger and Ligozat 2009) and in France. It consists of producing a list of objects to be remembered and communicated. The game is organized in four stages, the rules changing as the game progresses.

In the first stage, the teacher presents two or three small new objects each day. These objects belong to the world of children and are passed from hand to hand. The teacher asks the students to name them, and she puts them in a box (the treasure chest). Then she asks: 'What's in my box?' A student then calls out the name of an object, the teacher pulls the object out of the box and places it in full view. Then she asks ‘Is my box empty?’ and if not, the game continues, and so on. Every two or three days, two or three new objects are presented by the teacher and are added to the previous ones. At the end of one month, the whole class can empty a box of 40 objects (thus being able to collectively memorise 40 objects). These objects can seem disparate but they were chosen carefully. One can look at some examples of objects in Figure 1, including ‘the lens’, ‘the pan’ and ‘the keys’.

When students (who cannot read or write properly) have to represent these objects, they will have to find some means to distinguish different objects within the same semantic category (the keys) or to make obvious differences between objects of ‘the same form’ (the lens and the pan) (see Figure 2).
This stage is played out with the entire group of students and focuses on the creation of a verbal system of reference for the objects inside the treasure chest.

Stage 2 proceeds with two memory games. Firstly the students have to play an individual memory game, as each pupil must individually remember three objects that are hidden daily in the treasure chest. But when all of the pupils have understood this memory game with three objects, the teacher introduces a crucial change, which we are going to study in this article: she asks each pupil to remember 10 hidden objects. This informational leap makes it impossible to win only with an ‘internal’ memory. The jump from three to 10 objects is intended to oblige pupils to produce individual graphical lists, in order to remember the specific objects and win the game.

We now present the last two stages of the Treasure Game, which we will not study in this article. Stage 3 aimed at communicating with lists. This new part of the game takes place in small groups of five pupils. Four object representations are written by a pupil, who is ‘the designer’, and these objects are hidden in the box. The other four pupils have to ‘read’ the graphic representations of the designer, and name each object to get it out of the box. This third stage gives pupils opportunities to debate; firstly in their small group, and secondly in the whole classroom during the fourth stage of the game.

In stage 4, the pupils are building a common code for the whole class. In the studies of this engineering, stages 3 and 4 are intertwined. Some changes in stage 3 prepare the debates in stage 4.

3.2. Dealing with the teaching problem: using a graphical list

3.2.1. The problem
In this case study we focus on a fundamental moment of Stage 2, the informational leap. What is the problem? The students are able to remember three objects by relying on their...
‘internal’ memory, and the teacher asks them to remember 10 objects. They cannot. Here, the learning objective lies in the necessity of appealing to the use of a graphic list.

This situation is an ‘adidactical’ one (Brousseau 1997) in that the students have to adapt themselves to the change in the situation (the passage from three objects to be remembered to 10 objects), without relying on the direct communication of relevant knowledge from the teacher. In this respect, Brousseau (2004, 256) says that ‘the teacher is impassive, notes the student failures, but is still encouraging’. It is the only ‘strategic advice’ given by the authors of the teaching design to the teachers who implement it.

But this ‘impassivity’ is not a natural behaviour for a teacher, who has to help students learn and have the didactic situation move forward. First, one may acknowledge that the teacher had to be confident enough to accept the fact that the students have a ‘failure experience’ in order to build by themselves the knowledge relevant to the problem. They have to actually experience the fact that their previous way of functioning (keeping in mind three objects) is not relevant. But above all, the issue is that of the teacher’s action. What can be the teacher’s action relating to the emerging of the graphic list? What rationale can be built in order to structure the strategies that the teacher may use to ensure this emerging process? In conclusion, the debates in the cooperative engineering team could be summarized in a core question that not only concerns this situation but reveals a general dimension of the teaching–learning process: What must the teacher express and what should she hide? In other words:

What should be told, and how? What should the teacher be (momentarily) silent about? It is important to note that such a question may be considered a fundamental question of the teaching practice. From a theoretical viewpoint, one could state that a teacher, when teaching a given piece of knowledge, has to express some meanings, and to be tacit about other ones. Within the joint action theory in didactics (Ligozat 2011; Sensevy 2014; Tiberghien and Malkoun 2009; Venturini and Amade-Escot 2013), we coined this strategic structure as a dialectics of reticence (to be silent and/or hiding) and expression (to say and/or showing) (Sensevy 2011, 2012, 2014, 2015; Sensevy, Gruson, and Forest 2015). This dialectics can be seen as a kind of abstract formula (in the sense of Section 2.2) that needs to be concretized in the actual practice in order to find some efficiency.

3.2.2. How did the graphic list idea emerge?

During the collective preparation of the first lesson of this second stage, teachers expressed concern about the actual students’ capacity to figure out the list solution, and they pointed out the possible discouragement of some students. This last point led the team to choose a small-group organization for this stage, giving the opportunity of a better sharing of emotions and stimulations. The collective discussion made the team more confident about the emergence of the graphic list, but the concrete problem of the strategic system that can be used remained unchanged.

While analysing the videotaped lesson of the first implementation, one of the researchers noticed that the teacher strongly oriented the students’ attention when they were searching for a solution in order to be able to remember the whole list of objects. In effect, the teacher relied on a student’s allusion to the lists available in the classroom to elicit the possibility of making a list as a means of remembering. We present now a brief description of the classroom session in which students confronted the necessity of making a graphic list.

During the first part of the session, students had tried to remember 10 objects several times, and they had failed. The teacher first went on by underlining the reality of the failure,
and its inescapability, by arguing that it was too difficult to ‘keep in mind 10 objects’. All of the students were convinced, and experienced the failure of the ‘mental method’.

At the same time, the teacher diffused the idea of a possible solution: ‘we should find a means’. She characterized this means as a ‘little means’, an easy means, a ‘familiar way of doing’, thus signifying that every student had the possibility to find a solution. Even though the teacher tried to help the students, they did not provide any solution. One could identify a kind of tiredness among the students. So the teacher decided to introduce in the discussion the ‘meaning of writing’ in the following way:

Student 1: and if you tell us? [A student asks the teacher for the solution of the problem.]

T: Oh, me, I won’t say anything [The teacher is reticent (i.e. she does not provide the students with the ‘graphic list’ solution).]

Student 2: Ah, ah, ah, she tell us nothing because it’s the Treasure Game [It is interesting to note here that the kindergarten students are deeply aware of the didactic contract (Brousseau 1997; Sensevy 2014) of the Treasure Game, in which the teacher is often reticent.]

T: yes indeed you are playing, but Ima, what did she … she wanted to do to remember in the evening? [After having insisted on the fact that the players are the students (‘you are playing’), the teacher enacts a specific strategy. At the beginning of the session, the student Ima proposed to use a list to keep a trace of the students’ plays in the Treasure Game. In the classroom life, the students are surrounded by many lists and Ima’s proposal was probably grounded on this fact. Nevertheless, it is important to note that Ima’s idea was not related to the problem at stake. It was the teacher, in this speech turn, who linked the previous Ima’s proposal to the current problem. Thus the teacher gave up her reticent stance to express herself in order to move the learning time forward.]

S3: Writing ! [The students respond adequately to the teacher’s suggestion.]

To sum up this episode, the teacher gave a clear incentive by focusing students’ attention on Ima’s word about the possibility of writing, and the students acknowledge this reminder. One may see how the teacher plays in various ways, on a few second interactions, the dialectic of the reticence and the expression.

It is interesting to consider the teacher’s analysis of these moves, while discussing with a researcher of the team, when she comments on turn 4 in the previous speech:

Here I am cheating, I am cheating, because what Ima wanted to do the morning was keep a trace of the students’ participation in the game to be sure they have participated. On my side, it meant keep a memory to remember …

The teacher critiques her own behaviour, but after having emphasized again her recognition of the difference between the student’s viewpoint and her own, she reconsiders her previous analysis:

After all, it’s sure that the idea of a list, the idea of ticking the students’ participation to be sure all the students have played, this idea is in the same spirit to keep a memory, it’s what I reactivate here. Even though they do not have this anticipation idea of keeping a trace as a representation to use it later on… So, it’s not really cheating, it’s, well, bridging the gap from my behaviour to a behaviour that they can adopt in their personal approach.

Following this analysis, the discussion in the research group concluded that this instructional strategy, even though it gave an important position to the teacher’s gesture, was a relevant one, according to the intended outcome of the engineering. At this stage of the teaching sequence, the main point lay in having students aware of the necessity of a graphic list as a solution of the problem. In this way, it appeared that the critical feature was not the fact that
students ‘spontaneously’ proposed to make a list. The crucial point referred to their grasp of consciousness that to make a list was a necessity. This viewpoint was deeply shared in the cooperative engineering group, and became a hinge meaning of their common background.

One year later, another teacher of the group undertook a second implementation of the same design, and she reported to the research group how satisfied she was when she carried out the situation at this Stage 2. Her concern for the emerging of the graphic list was replaced by a real confidence in the necessity to make students aware of the problem.

The learning session she managed was conducted in the same general way as the one we have already described. After the repeated failures of the ‘mental method’ to memorise the 10 objects, the teacher organized a whole class discussion. In this debate a student argued that there are ‘too many objects to remember’. The teacher agreed and encouraged the students to ‘find a means to do that’ and added ‘I know that you are all able to win, but you haven’t found the right means’. A student suggested drawing. One may think that the learning process had taken an important step, and this was the case, but it is very interesting to note that one of the students opposed the proposal of a ‘written strategy’ by saying it was ‘cheating’. When asked by the teacher to explain why, this student argued that by drawing, the students would now ‘in advance’ that ‘this is the good object’. It seems that this student felt the reduction of uncertainty that writing allows as a kind of ‘cheating the game’. The teacher reacted in asking the whole class whether drawing had to be forbidden, and the students answered that it did not, so that the teaching–learning process continued.

4. Considering the ‘graphic list example’ as an emblematic example

It seems to us that the case study about which we give some hints may help to acknowledge some features of the cooperative engineering, and to understand it as a specific form of action research.

4.1. The concrete and the abstract

In our example, the necessity of analysing a problem of practice brings the research team to the privileging of a particular ‘strategic system’ in order to deal with the problem of the making of a list, and beyond that to deal with both ethical and epistemic problems. In that way, the building of knowledge relates to the specific solving of a specific classroom problem. But the grounding of the research on a theory of practice enables the researcher to propose a new element of theorization, in this case relating to the teaching dialectic between reticence (hiding or remaining silent) and expression (showing or talking). To sum up, one can say that the studied practice is illuminated when it is analysed through this dialectic of reticence and expression. Indeed, the ‘abstract formula’ of this dialectic enabled the research team to deal with the didactic process. But in return, the abstract formula is brought to the concrete, and within this process the dialectical concept is transformed. In particular, the example we dealt with showed us a specific feature of the expression process, when the teacher argued that her incentive to rely on Ima’s allusion to the list could be seen as a way of ‘bridging the gap from my behaviour to a behaviour that they can adopt in their personal approach’. In this respect, the concrete example may provide a good opportunity to better understand the expression process from a theoretical viewpoint. Indeed, one may argue that such a process can be determined by the distance between the teacher’s way of thinking and the students’
way of thinking that the teacher acknowledges. This is to say that cooperative work is a way of progressively reshaping the intentional structure of action. We find here what seems to be a fundamental feature of action research, as Kemmis underlined while examining how action research restructures the relationship between sayings, doings and relatings:

In a ‘philosophical’ kind of action research, then, neither understandings nor practices nor the conditions that shape practices – sayings, doings and relatings – is logically prior to either of the others. They emerge and develop in relation to one another. Understandings may form intentions, but practice does not simply enact intentions – the doing is always something more than and different from what was intended. (Kemmis 2009, 465)

This entanglement of collective intentions and actual practice means that in this type of research the epistemological stance is of a particular kind. As we argued earlier, the inquiry rests on excerpts of practice that we try to institute as scientific exemplars (Kuhn 1979). In the common structuration of actions and intentions, exemplars and theories are tightly entangled, as well as the particular and the universal, the concrete and the abstract. The ‘list example’ on which we have elaborated in this article can be seen as an emblematic example, which could become an exemplar in the theory. Obviously, it is not possible to build a theory on a single example. The one we elaborate on in this article has to be considered as a node in a network, a constellation of exemplars analogically linked, and the concept of ‘the dialectic of reticence and expression’ could be seen as the emergent of this network, referring to this constellation.

4.2. The principle of symmetry, the acknowledging of differences, the local practical indistinguishability between the teacher and the researcher

The cooperative engineering process brings to the fore a principle of symmetry, which one may think of as the research of a symmetry, in the research team, between the teachers and the researcher. All of the participants intend to dilute the ancient dualisms. In the studied example, the teacher could hold a kind of superiority stance because she is the one who confronts the concrete of practice. The researcher could hold the same sort of stance because he is the one who has brought the initial teaching design to the team. Moreover, it is obvious, when one studies the teacher’s analysis of her practice, that she is able to concretize in a very fruitful way the theoretical dialectics of expression and reticence. In such a process, the main goal of the research team is to concretize the concept, and to conceptualize the concrete, and this back and forth movement cannot be achieved by maintaining some people ‘in the concrete’ and some others ‘in the concept’.

As we argued previously, researching symmetry between the teachers and the researchers does not mean erasing the differences between them. In our example, the teachers’ feeling relating to the way of guiding students played a fundamental role. A kind of anxiety towards the students’ feelings when confronting failure elicits the common inquiry, and a crucial criterion of the evaluation of the design lies in the feeling of ‘confidence into the situation’ that the design provides, after the team experienced the kind of strategy that teachers may use in order to elicit the writing of a graphic list.

Nevertheless, one can argue that this example shows a local practical indistinguishability between the teachers and the researchers. While experiencing together the whole process, they become able to describe a given piece of practice by using the same conceptual categories of analysis, and able to propose the same array of concrete strategies in order to deal with
the teaching problem encountered in this practice. It is true that the teachers actually teach, and that the researchers do not; that the researchers’ main activity lies in the production of academic knowledge, while this is not the case for the teachers. But in the precise situation that we depicted these differences are not active, to the extent that the fundamental goal of the engineering dialogue lies in the joint construction of a common reference.

We argue that it is this common focusing on the dialogue of the concrete and the concept that may contribute to foster a new paradigm for the science of culture, in which action research has to play a fundamental role. Indeed, one may contend that only ‘the participatory ideal of action research’ (Townsend 2013, 339) may achieve this entanglement of concrete and concept. In that way, the participatory ideal of action research is not only an ethical end, it represents an epistemological necessity.

Notes

1. Kuhn (1979) acknowledges two fundamental meanings to the notion of paradigm. The meaning that I term ‘sense 1’ refers to the notion of ‘disciplinary matrix’. Sense 2, the most important for Kuhn, refers to the exemplar.

2. In this transcript we briefly comment on each speech turn in order to give a first analysis of its meaning and to give some necessary background information to the reader.

Disclosure statement

No potential conflict of interest was reported by the authors.

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