



## Engaging discussion about climate change in a Quebec secondary school: A challenge for science teachers



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### ABSTRACT

The article analyzes the process of double stimulation in a two-year effort of two science teachers to create and implement a new approach in their teaching. Double stimulation was triggered by three types of conflicts of motives, the first one related to teaching strategies, the second one related to the concept of environment itself, and the third one related to values promoted at the school. The teachers constructed a second stimulus in the form of an open-ended teaching sequence to address the issue of climate change. This artifact enabled the teachers to take agentic actions and implement a novel instructional strategy in their classrooms. As the teaching sequence was progressively implemented and reformulated, pressures from the parents and the school management led to the emergence of new conflicts of motives.

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### 1. Introduction

There have been calls to reform curricula in Quebec, Canada, in order to promote environmental education (Barma, 2011). Since 2006, science teachers are expected to ask open-ended questions related to controversial environmental issues to foster learning science in context (MELS, 2007). Most teachers, however, are still struggling with the fact that they have to move away from a lecture-based teaching style (Barma, 2008). To actually implement such a practice in a classroom presents a challenge to the majority of teachers who focus on disciplinary content and evaluation (Barma, Power, & Daniel, 2010; Urgelli, 2008).

Two science teachers contacted our research team, asking for support at a time when new curricular prescriptions were being implemented and required important adjustments to their current practice. They appeared to be dealing with a conflictual situation at work. As we will document in the following sections, the science teachers were struggling with the way to implement an open-ended teaching approach, their conception of environmental issues and facing tensions coming from their school, where parents and the principal expected them to maintain tight control over their students.

Understanding the practice of science teachers is complex and at the heart of societal debates in Quebec (Conseil supérieur de l'éducation, 2013). Science teacher training in Quebec demands the acquisition of disciplinary knowledge as well as pedagogical skills. In our part of the world, there are two ways of obtaining a high-school teaching certificate. The most common is to enroll in a four-year university teacher-training program where students acquire competencies in their respective disciplinary fields and in pedagogy. The second possible avenue is to complete a strong disciplinary three-year university instruction and enrich it with courses in pedagogy. One of the participants, whom we will identify as Teacher A, did not yet obtain his teaching certificate but held a teaching position in a school; Teacher B, for her part, had just graduated and was fully qualified to teach.

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To put some of these elements in context, here is an excerpt of a conversation that took place at school in 2010. In the conversation, the researcher discussed with the two participants as they faced some difficulties in bringing forward environmental issues into their practice.

- Researcher: How would you define a controversial issue?
- Teacher A: Is it a question where there is no consensus to be found, on which there are opposing views? For example, shale gases, climate change. Do we have to do something about it? Are we responsible? Is it already too late?
- Researcher: Are you at ease talking about environmental issues?
- Teacher B: I am not at ease talking about politics... So far, I know there is interest in discussing the environment but unfortunately, I don't think there are projects available and ready to reach 36 students.

In the above, some conflictual issues were clearly spelled out by the participants. Although one of the goals is that teachers address environmental issues with their students, it seems that:

- Teacher A provided a definition of a controversial issue by asking a question himself and seemed unsure about his own conception of the definition;
- Teacher B was not at ease with discussing politics in a science class and was looking for some kind of a “fast track” teaching plan that she could use with her 36 students.

Both teachers were obviously not in their comfort zone when it came to defining controversial issues. “*I define myself as an environmentalist... no not true.*” Each of them was weighing opposing motives against each other as they hesitated about the way they could address the issue in their class: “*I am not sure I understand how, but I will do it anyway.*”

The teachers were also anxious regarding pressure from parents and the principal who wanted them to keep a tight control over their students:

- Teacher A: I would say that at the beginning of the year, when we talked about our project with the principal, we sensed that she was worried. We needed to reassure the principal about many aspects and especially on the issue of control. The vision of a teaching practice is a classic one, I would say, like making sure the students remain seated during the class.
- Teacher B: We have to make sure that we will not disturb the way things are done in this school. We must not bother students, or parents who will tell us that it is not the right way to teach their kids.

The impression we are left with after reading the excerpts is that both teachers felt that they were at the mercy of their work environment. At the beginning of the 2010 school year, the participants did not seem to know how to give meaning to the curriculum prescriptions. They had to address controversial issues, change their teaching approach in order to engage the students in open-ended questions and accept the principal's and parents' requests without knowing how to do so. Our first interactions with them led us to focus on a problematic situation emerging in the form of conflicts of motives they were facing at work trying to find out how they would break away from this problematic situation.

This paper presents how the principle of double stimulation, stemming from conflicts of motives, worked in the decision forming process and how a second stimulus was progressively redefined and reformulated over two years. That second stimulus would ultimately take form in a teaching sequence addressing the issue of climate change, meeting an educational challenge in environmental and science education. Interestingly enough, the resolution of the conflicts of motives they dealt with led to more acute ones at the end of the 2012 school year.

## 2. Conflicts of motives as key components of double stimulation

In addition to understanding the building of higher mental functions by means of two series of stimuli, Vygotsky's principle of double stimulation also refers to the way individuals may deal with a conflict of motives (Sannino, submitted for publication). The conflictual situation constitutes the first stimulus and is a necessary element to trigger transformative agency (Engeström & Sannino, 2013). For example, a teacher might employ a pedagogical strategy as a second stimulus, investing it with meaning in order to make and act on a conscious decision. As Vygotsky pointed out: “Duality is at the very foundation of the volitional act, and this duality becomes especially prominent and vivid whenever several motives, several opposing strivings, clash in our consciousness” (Vygotsky, 1997, p. 167–168). We borrow Engeström and Sannino's (2013) definition of transformative agency as a way of “dealing with contradictory motives by employing auxiliary cultural means to make conscious decisions and turn these decisions into action” (p. 3).

Building on Leont'ev's (2005) reflections on conflicts of motives, Sannino (submitted for publication) brings to our attention that engaging into volitional actions is more than just about choice and decision-making. These premises constitute a solid ground to investigate how agency emerges when teachers feel trapped in their practice as they address problematic issues at work and demonstrate a will to gain control over them. Amidst contradictory motives and choices to make, how do volitional actions take shape? How do individuals gain self-control over a difficult situation?

We will analyze our data following some key elements brought forward in Sannino's (submitted for publication) model of double stimulation as a mechanism of will formation. For example, a teacher could feel at the mercy of his or her working environment as he or she would not only be expected to have students discuss controversial issues and focus less on content but would also have to make sure that students perform at a mandatory certifying provincial exam assessing content only. Eventually, the teacher would engage in controlling his or her practice by resolving the conflicting motives for his or her own purposes, not yet knowing how he or she would

act, but being ready to make a decision. At this moment, the stimulus would have been converted into an auxiliary motive and make the implementation of the decision possible to begin.

### 3. Data and methods

#### 3.1. Methodological considerations

As discussed above, Vygotsky's principle of double stimulation can help us better understand how agency emerges when a person constructs a second stimulus in response to a problem involving a conflict of motives. A researcher can also make use of double stimulation as a means to elicit agency with participants (Virkkunen & Newnham, 2013). In this study, the research team adopted a developmental work research approach (DWR) premised on establishing a close collaboration with the two teachers as well as providing them with the results of the ongoing analysis in order to enable them to analyze and interpret their practice. We developed a collaborative relationship with the participants and intervened during and between some of their actions to get their practice moving in a new direction.

The three members of the research team played an active role in the formative intervention. With the approval of the principal, they moved around freely during two years in a high school with a student population of 600. Parents had been informed via the school bulletin that a new project was taking place and involved a research team. The majority of parents accepted to sign the consent forms. On a regular basis, the researchers prepared informal meetings, conducted sessions with the teachers and some of their 256 students. The three members of the research team attended lessons acting as co-teachers and co-evaluators. Even if this paper focuses on the formation of agency of the science teachers, we want to point out that students took an active part in the research. They accepted our interventions in their classes, joined focus groups and shared their work in progress.

#### 3.2. Data and analysis

To document the formation of agency in terms of resolution of conflicts of motives, 1003 speaking turns of four audio-recorded sessions with teachers were transcribed and analyzed over the two years. The criteria to select the units of meaning were the presence of opposing forces potentially revealing conflicts of motives in the speaking turn: struggles, obstacles, tensions and clashes (Sannino, submitted for publication). Not all speaking turns were related to these types of conflicts; some expressed the actions that led to their resolution and to the building of the second stimulus.

Once that the first level of analysis was completed, an important challenge we faced was to take into account the overlap of the present, the past and the future in the teachers' narration (Virkkunen & Newnham, 2013). In Section 4 of this article, we will present the conflicts of motives the teachers encountered and the ways in which they were resolved over the two years. In May 2011, a first session was held with both teachers. The 400 speaking turns of this session were analyzed and used to orient our informal meetings with the teachers and with the principal between September 2011 and March 2012, and eventually in the last three sessions that were held with them in May–June 2012. In May 2012, both teachers joined us for a session and a month later we conducted individual sessions with them. Table 1 presents the details of the sessions with the teachers in terms of speaking turns. The percentages of speaking turns illustrate the dynamics between the contributions of each participant who attended those sessions.

Focusing on the sessions with teachers only is not sufficient to understand how the formative intervention unfolded. Since agency is not only expressed in discourse, but also in actions, the analysis of the speaking turns of the teachers was triangulated with examination of ethnographic notes, teaching documents and students' discourse and productions. During the first year, the ethnographic work and the analysis of the teaching documents preceded the five-hour interventions in the classes. In 2012, 20 h of interventions

**Table 1**

Overview of the data in terms of speaking turns.

| Date        | Duration | Participants       | Speaking turns (participation %) |
|-------------|----------|--------------------|----------------------------------|
| 2011/05/25  | 01:22:29 | Student-researcher | 117 (29.25%)                     |
|             |          | Teacher A          | 142 (35.50%)                     |
|             |          | Teacher B          | 141 (35.25%)                     |
|             |          | Total              | 400                              |
| 2012/05/08  | 01:25:18 | Student-researcher | 94 (26.93%)                      |
|             |          | Teacher A          | 121 (34.67%)                     |
|             |          | Teacher B          | 134 (38.40%)                     |
|             |          | Total              | 349                              |
| 2012/06/14  | 00:52:27 | Student-researcher | 57 (37.25%)                      |
|             |          | Researcher         | 29 (18.95%)                      |
|             |          | Teacher B          | 67 (43.79%)                      |
|             |          | Total              | 153                              |
|             | 00:51:01 | Student-researcher | 38 (37.62%)                      |
|             |          | Researcher         | 17 (16.83%)                      |
|             |          | Teacher A          | 46 (45.54%)                      |
|             |          | Total              | 101                              |
| Grand total |          |                    | 1003                             |

**Table 2**

Data used to prepare the sessions with teachers.

| Type of data   | School years   |  |
|--|--|--|
|  | 2010–2011  | 2011–2012  |
| Researcher and student-researcher's ethnographic notes | Research meetings:<br>Researcher, teachers and school principal (1 h)<br>Student-researcher teacher B (1 h)<br>Researcher and school science department (2 h)<br>16 e-mail | Research meetings:<br>Research meeting with school principal (30 min)<br>17 e-mail<br>Intervention in the classrooms (20 h)                            |
| Teaching documents                                     | Intervention in the classrooms (5 h)<br>Planning of the teaching sequence<br>Evaluation matrix for communication skills  | Planning of the teaching sequence<br>Video of an expert<br>Evaluation matrix: content and communication skills<br>Matrix for peer review               |
| Students productions                                   | 12 definitions of environment<br>27 Prezis <sup>a</sup>  | 26 initials definitions of climate change<br>21 written documents describing actors involved in climate change<br>21 Prezis<br>65 peer reviewed Prezis |
| Speaking turns   | 203 for students<br>400 for teachers   | 614 for students<br>603 for teachers   |

<sup>a</sup> Prezi is a cloud-based presentation software that allows people to share ideas in a collaborative and dynamic way.

in the classes preceded the sessions with students and teachers. Table 2 presents in more detail the data that was collected and analyzed to prepare for the intervention sessions with the teachers.

Five audio-recorded focus groups with students were conducted over the two years. They were key data for preparing the sessions with teachers and were analyzed thematically (Charmaz, 2005). As presented in Table 3, two focus groups were conducted with 12 students in June 2011 and three with 26 in June 2012. In June 2011, the analysis of 203 speaking turns and 12 written documents produced by students oriented our meetings with the teachers in September 2011. In June 2012, the analysis of 614 students' speaking turns oriented the sessions with the teachers. The analysis of the ethnographic notes of 20 h of interventions in the classes in 2012 was an important element to orient our sessions with the teachers at the end of the 2012 school year.

## 4. Results and discussion

### 4.1. The decision forming process emerging from the data analysis

In 2010, we focused on gaining a deeper understanding of the problematic situation of the teachers. We focused our attention on the struggles, obstacles, clashes and tensions they expressed during the interviews. As we described in the first section of this paper, it seemed that the problematic situation they were experiencing was polymotivated. In order to meet the new curriculum demands,

**Table 3**

Students' speaking turns analyzed in preparation for sessions with the teachers.

| Date       | Duration    | Participants         | Speaking turns       |     |
|------------|-------------|----------------------|----------------------|-----|
| 2011/06/10 | 00:33:24    | Researcher           | 62                   |     |
|            |             | Student-researcher   | 3                    |     |
|            |             | 6 students           | 58                   |     |
|            | 00:26:56    | Total                | 123                  |     |
|            |             | Researcher           | 40                   |     |
|            |             | Student-researcher   | 2                    |     |
| 2012/06/05 | 01:00:04    | 6 students           | 38                   |     |
|            |             | Total                | 80                   |     |
|            |             | Student-researcher A | 77                   |     |
|            | 01:04:03    | Student-researcher B | 1                    |     |
|            |             | 9 students           | 76                   |     |
|            |             | Total                | 154                  |     |
|            | 00:56:11    | Student-researcher A | 125                  |     |
|            |             | Student-researcher B | 1                    |     |
|            |             | 10 students          | 123                  |     |
|            | Grand total | Total                | Total                | 249 |
|            |             |                      | Student-researcher A | 106 |
|            |             |                      | Student-researcher B | 1   |
|            |             | 7 students           | 104                  |     |
|            |             | Total                | 211                  |     |
|            |             |                      | 817                  |     |

they were being asked to: 1) change their teaching style to engage students to respond to open-ended questions, 2) address the topic of environment as a controversial issue, and 3) meet the principal's and the parents' expectations.

In terms of double stimulation, these specific requests translated into clashing motives. Early on, we felt that both teachers were still at the mercy of their environment and were weighing the positive and negative sides to their situation. At this point, it can be difficult to distinguish between stimulus and motive: "As motive, we understand a complex system of stimuli connected with the construction, formation, or selection of one of the reflex curves... intruding into a certain system formed to evaluate the set-up and habits... This complex, reactive formation crystallized around the stimulus is a motive. ... The motive is, in a certain sense, a reaction to a stimulus" (Vygotsky, 1997, p. 214).

Three types of conflicts of motives emerged from our analysis: 1) conflicts related to teaching strategies, 2) conflicts related to the concept of environment itself and its controversial aspects, and 3) conflicts related to the values promoted at the school. Merely classifying speaking turns into the categories of conflicts of motives may be too mechanical to allow making sense of the data and to understand the decision forming process. This is why we present and comment on a narrative in which the types of conflicts of motives sometimes intersect.

The challenge related to changing the teachers' teaching style was a real struggle and many questions were raised by both teachers in relation to what would be the best way to manage a 10th grade high-school class. Their teaching load was heavy and they had to deal with 32 students in each of their classes besides teaching more than one subject. Moreover, their limited experience in a science class coincided with the implementation of a demanding provincial reform. They seemed to have lost their bearings and were also in the process of inserting themselves in a school where the educational focus was centered first and foremost on the student and where parents had an important role to play.

In the following excerpt, reflecting on his way of approaching ecology, Teacher A stated that he was aware that his teaching was boring to students and admitted that he could do better: "Well, when we get to the section related to ecology, we talk about the wolf who eats the squirrel, who eats the grass.... I have problems teaching that, and poor students they must find it pretty mediocre. I would much prefer to engage in a project, answer a question, maybe we wouldn't study everything, but it would be more educational that just being focused on evaluation." As this excerpt indicates, Teacher A was evaluating his own teaching habits and strategies and was beginning to demonstrate agency. To borrow the expression used by Vygotsky (1997), the teacher "vacillated" and this only reinforced one of the motives: to engage in a project to focus more on educational aspects and less on evaluation.

Being interested in the topic of environment and not having enough planning time were other important issues in the case of Teacher A: "Maybe, if I were passionate about the topic, I would transmit it better. I confess that I am not at ease... not because it doesn't interest me but because I don't have a lot of time to investigate environmental questions in general."

Nevertheless, both teachers were facing curricular demands and weighing their pros and cons:

- Teacher A: *Since the curriculum asks us to talk about one of the four environmental problems, I think that what is interesting about it is that there is a lot of available information. Some of it is good; some of it is bad. There is no definite answer. That is where it gets interesting. The students will learn anyway and we have to figure out a way to make it happen.*
- Teacher B: *Take control over your own learning, be autonomous, take initiatives and if you fail then you will have learned. We learn from our mistakes.*

In our opinion, these are key excerpts. Teacher A hesitated less and less about the pertinence of talking about environmental issues in a different way. Both teachers were starting to accept that it was possible for students not to come to a common agreement on the issue and figure things out by themselves. The researcher then took the opportunity to focus on their goals as science teachers:

- Researcher: *What do you want to develop with your students?*
- Teacher B: *My goal is to see that they would begin to understand that what people think is not necessarily the truth. They must therefore use information to make their own judgment.*
- Teacher A: *Critical thinking is very important to me and it is pertinent to develop it with students. But I don't think they have ever heard about environmental issues in a classroom before this year.*
- Teacher B: *I think that we have to stop putting scientists on a pedestal... as people who know everything, who can answer any question, who are superior to every way of reasoning.*

We find it especially revealing that, against the background of her extensive academic training, Teacher B wanted to make "sure that scientists are not put on a pedestal." She had an undergraduate degree in physics as well as a masters and PhD degree in molecular and cellular biology. She had been teaching for the past seven years. It is well documented in the field of science education that empirico-realistic science teaching approaches never really question the status of scientific activities over the more political dimensions related to socio-scientific debates (Roth & Lee, 2004). This certainly presents a clash of values for a science educator with regard to his or her own academic training. Both of the teachers pointed out the importance of having the students think by themselves and become more critical when seeking information. These results are coherent with a study conducted by Bencze and Hodson (1999) in which two science teachers changed their views on their teaching strategies regarding the complexity of the relationships between science, technology, society and environment.

- Researcher: *In the program now, they are asking you to make students more responsible...*
- Teacher B: *Yes.*
- Teacher A: *I think that our society wants us to make sure that students get good grades. So, we, teachers, think accordingly... make students write their exams and forget about other important things such as critical thinking. But critical thinking is not evaluated so... There*

are two clans, no I mean, two extreme ways of seeing the way we teach... Last year, people from the Ministry of Education sent us some assessments for our students. Although it was supposed to be in relation to environmental issues, almost no environmental aspects were touched. It was only difficult content related to theoretical questions demanding to apply a formula.

The teachers were torn between the necessity of giving more freedom to students during their classes so they would develop autonomy and the capacity to think by themselves on the one hand, and the motivation to focus on contents and assessments on the other hand.

The following excerpt focuses more on the third type of conflicts of motives we identified, namely the one concerning values.

- Researcher: I remember you telling me about your school's philosophy being to ensure the students were ready to take their place in society's elites.
- Teacher A: Yes.
- Researcher: Do you have the same goal with your students?
- Teacher B: No, I don't necessarily have the goal to mold decision makers, but to educate people to be able to think by themselves. I try to educate anti-sheep citizens.
- Teacher A: I share the same philosophy. It would be too bad if students left high school not being able to do that.

There is a definite clash in values here between educating "society's elites" and educating "anti-sheep citizens" who would "be able to think by themselves." At this point, the participants were starting to make sense of their conflicting motives. A progressive redefinition of them was happening. According to Leont'ev (2005), "a volitional act is an act carried out under conditions of polymotivation, when different motives have different affective signs, that is, some are positive and others are negative" (p. 82). It took approximately four months for both teachers to pinpoint the kind of actions they would start engaging in with their classes. Building on the acceptance of the possibility that a controversial environmental issue would be discussed at school, not necessarily predicating the adhesion of all their 10th grade students on an identical position on a controversial issue, they decided to engage in planning a new teaching sequence.

Accepting, choosing and deciding to engage students into debating on a controversial issue were steps the teachers went through before they engaged in planning the new teaching sequence. It is important to point out that even if they seemed ready to engage in planning that sequence, they did not know yet what form it would take. Table 4 presents our reading of the way both teachers attributed meaning to the conflicts of motives that led to the formation of an auxiliary motive that would trigger their agency.

Both teachers were now ready to engage in transforming actions. From then on, they would have to turn to external means and make sense of them in order to be able to act and break away from their current practice.

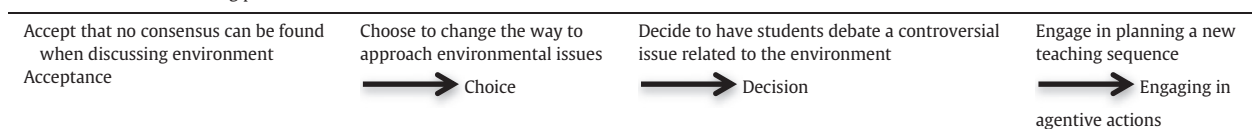
#### 4.2. Building the second stimulus: formulation and reformulation

In 2010–2011 the two teachers started planning a teaching sequence that would be centered on an environmental issue. They decided to adopt an open-ended approach but, around December 2010, they did not yet know how to formalize it on paper. What would inspire them to break away from a lecture-based teaching approach was the idea that a broad question would be fruitful to let students build their own representations of a controversial issue and focus less on assessments. They started looking at different resources already available to them to foresee a practical way to actualize the new approach in their science classes.

- Researcher: I would like you to tell me why you chose the open-ended interdisciplinary teaching approach. You found something on the Internet? Do you usually do that go on this site?
- Teacher A: ... we go from time to time. Why did we choose to integrate controversial aspects other than the scientific ones? In fact, we were looking at something about climate change but not necessarily an open-ended interdisciplinary teaching sequence.
- Researcher: Ok.
- Teacher B: Also, we were not necessarily looking at climate change. We were looking for something related to the environment.
- Teacher A: Related to the environment, yes that's true. But the fact that the site proposes an overture for talking about it is good. What is interesting is that it gives a lot of latitude, and that is something we wanted, we liked, we like in our teaching... meaning giving latitude so students may do their things their way.

The researcher reminded both participants that they had been familiarized with an open-ended approach requiring students to consider various societal issues when forming an opinion in response to a broad question during their formative years. After giving it some thought, the teachers decided to exploit and adapt an existing model, Fourez's (2002) "rationality island" teaching strategy,

**Table 4**  
The teachers' decision forming process.



to promote their students' autonomy in relation to societal debates. A rationality island is a metaphor used to represent how students elaborate an island of informed opinion amidst an ocean of ignorance in response to a broad question. This metaphor became the starting point of the formation of a second stimulus for the teachers.

The teachers had never thought it would be possible to implement this strategy in their classes and had remained lukewarm about it. In a nutshell, students would have to engage in a quest to answer: What is global warming about? The evaluation assessment would be centered on their ability to debate the question in front of their peers, not on the degree of appropriation of related scientific concepts. The teaching sequence would ultimately aim at promoting the students' autonomy in relation to societal debate.

The external neutral stimulus was from then on invested with meaning. Even if it took some time to formalize it, the teachers' intentions were eventually put on paper. They were ready to implement the sequence in their eight classes. Table 5 presents the full-blown second stimulus, the artifact that was produced and shared with the research team.

It took three weeks to implement the teaching sequence with 128 students. Interesting discussions took place in all the classrooms and the research team members attended the presentations.

Despite the fact that both teachers seemed to be content with the way students engaged in responding to the question "What is it about?" and believed that the implementation would allow them to break away from their previous practice, they expressed an increasing number of conflicts of motives after implementing the project with four classes at the end of the school year 2010–2011.

- Teacher A: *You remember that at the beginning of the year, and still now, the students ... I think that since we are changing our teaching approach, they are not really in...*
- Teacher B: *... in control...*
- Teacher A: *... in control of even mastering how they learn...*
- Teacher B: *...reassured...*
- Teacher A: *... never reassured on how it works with us... they don't know what the assessments will look like. They always feel out of balance. And often, they go back to see Peter, their teacher from last year ... and, without criticizing him, he just does his work in a very different way from us...He talks, gives information, gives them exercises to do, so they feel secure... and it is he that they go to see to feel reassured.*
- Teacher B: *Last year, it was the teacher who would plan everything and manage what he expected from his students... but it doesn't help to motivate students! It doesn't make them autonomous if they want to pursue their studies... they need to learn to be responsible for their own learning.*
- Teacher A: *They were destabilized at the beginning of our project but now they seem to be adjusting. They all had the same reflex: how are we going to learn, you are not explaining anything! They were upset but they came to understand that they actually learned better this way.*
- Teacher B: *I live with the frustrations I create. I don't think I can do otherwise.*

Our ethnographic notes reveal that the teachers found it quite challenging to adapt to their students' requests. Some students went to meet their science teacher from the previous year complaining about the strategies used by their current teacher and trying to find a way to be reassured. Being present during most of the lessons and attending the debates, it was quite obvious to the research team that students were pressing their teachers to tell them what to do and where to go.

Both teachers resisted. Interestingly enough, there was resistance on both parts: teachers and students. Resistance plays an important role in the emergence of agency through double stimulation (Sannino, 2010). We noticed that the teachers' will was strong: the significance they had attributed to the resolution of the conflicts of motives during the first part of the school year seemed strong enough to keep them on their chosen path. The teachers decided to remain firm in their convictions and live with the frustrations they had created until the end of the school year. In June 2011, the experience was positive enough for both teachers and they decided to keep working on what they considered an improvement of the teaching sequence.

At the beginning of the school year 2011–2012, reflecting on their experience, both teachers felt that they had given too much latitude to students and were concerned about the end-of-year evaluation. Having the students choose by themselves which scientific concepts were pertinent to the question of climate change appeared a bit too risky for them. They decided to adjust the planning of the sequence and re-model it. A documentary on climate change was to be introduced the first time students would start the project. The idea was that all four classes would start on a common ground. After that only, they would work in teams and share their

**Table 5**

The first modeled teaching sequence (December 2010–May 2011).

|             |  |
|-------------|--|
| Lesson 1    | Introduction and presentation of project to students<br>Formation of teams   |
| Lesson 2    | Students share with members of their team their alternative conceptions on global warming, they draw what elements should be considered, they identify economic, political, social, environmental, ethical issues related to climate change (homework) |
| Lesson 3    | Research at the library. Homework.   |
| Lesson 4    | Research on the internet. Homework.  |
| Lesson 5    | Closing the process and taking position: students decide to investigate scientific concepts they find relevant to better understand climate change. Homework.  |
| Lesson 6    | Co-elaboration of the representation of climate change in response to "What is it about?" Homework.  |
| Lesson 7    | Co-elaboration of their representation of climate change in response to the question "What is it about?" Homework.   |
| Lessons 8–9 | Scientific symposium: teams share their representation of climate change using Prezi, debate and participate in evaluating their peers.  |

conceptions on climate change. They also felt that they needed to invite a specialist to present a scientific point of view. Since carbon cycle is a key concept when discussing climate change, a laboratory work session became mandatory. The previous year, not all students had actually decided to investigate the concept of the carbon cycle and both teachers were concerned about it.

Table 6 presents how the teachers reformulated the teaching sequence. The modifications made from the previous year are presented in bold.

From May to June 2012, it took more time to implement the teaching sequence: 13 classes instead of 9. More artifacts, built by teachers and an expert in geology, contributed to reformulating the teaching sequence. These new artifacts included a documentary on climate change, an online *Google.doc* questionnaire on students' conceptions on climate change, a new criteria evaluation matrix pinpointing controversial issues, a 50-minute online video and a peer-reviewed evaluation grid of the Prezis.

After the implementation of the reformulated sequence in June 2012, both teachers expressed, quite unanimously, a good degree of satisfaction with their experience and the difference they saw in the students' interest in class: "Asking students to discuss environmental issues was quite troubling. They would demonstrate agency in seeking information. The librarians told us that it was quite incredible. They had never seen students starting to seek info before the class started. No discipline had to be imposed. Students appeared to be deeply engaged and interested in their findings, even after one hour!" Teacher B mentioned to us that although "they didn't prepare them in a better way to write the Provincial exam, they prepared their students in a better way to face the reality of their lives as citizens."

But all was not so glittering for them. Changing the teaching approach for a while had many repercussions within the school community. At the end of 2011–2012, the principal was receiving complaints about Teacher A's new approach. Teacher A, possessing a bachelor's degree in engineering physics, had a temporary teaching certificate. This work status might explain why he felt so vulnerable. Teacher B, who happened to be a member of the union, supported him and openly discussed Teacher A's situation with the research team. The following illustrates how more conflicts of motives emerged after the teaching sequence had been implemented in eight science classes with 256 students in 2012.

- *Teacher A: Indeed, we are not encouraged to change our practice and try new things. Being afraid of possible complaints from the principal has been a huge pressure on me.*
- *Researcher: So, you were saying that the community, the parents can exercise power?*
- *Teacher B: ... concerning my colleague, some parents were saying that the way we were teaching...it just fell on him because it is the parents of his students who complained but I teach the same way.*
- *Researcher: So, as we may say, there is pressure...for some I mean.*
- *Teacher B: The umbrella that the school should put above our heads, well, it is pierced in many places. You know, it depends on who complains and how often they do so. Sometimes there are knives being thrown and they end up going directly to the teacher. That's it. There are holes.*
- *Teacher B: The most difficult aspect is really, really, really that we try to put into place things but we are blocked by our structure. In the sense that we are not able to find adequate support... but at the same time, I understand, we need a proper framework, we need to fit in the school frame.... Yes, management is far from its teaching staff. They have no idea about what is going on in our classrooms.*

The conflicts had now moved to another level. The teachers had succeeded in transforming their classroom environment for a while and students appreciated discussing climate change. But more conflicts of motives emerged in their broader teaching environment. The excerpts give us the impression that they were going back to one of the categories of conflicts of motives we identified: the one related to the values at their school. The values of the teachers were clashing with the parents' expectations. Both teachers were struggling with the fact that they did not feel supported by their institution, using the analogy of a "pierced umbrella" when talking about the protection they were getting from their institution. Although the teachers criticized the "knives being thrown," they also expressed the need "to fit in the school frame." It remains to be seen how this emerging conflict of motives will be resolved in the years to come.

**Table 6**  
The reformulated teaching sequence (September 2011–May 2012).

|                 |   |
|-----------------|---|
| Lesson 1        | Introduction and presentation of project to students<br><b>Presentation of a documentary on climate change</b><br>Formation of teams  |
| Lesson 2        | Students share with members of their team their alternative conceptions on global warming and decide what elements should be considered. They identify potential economic, political, social, environmental, ethical aspects related to climate change. Homework. |
| <b>Lesson 3</b> | <b>A climate change specialist visits the classes.</b>  |
| <b>Lesson 4</b> | <b>Laboratory work on carbon cycle</b>  |
| Lesson 5        | Research at the library. Homework.  |
| Lesson 6        | Research at the library. Homework.  |
| <b>Lesson 7</b> | <b>Reading of chosen texts in the classroom</b>   |
| Lesson 8        | Closing the process and taking position: students decide to open related scientific concepts they find relevant to better understand climate change. Homework   |
| Lessons 9–11    | Co-elaboration of the representation of climate change in response to "What is it about?" Homework  |
| Lessons 12–13   | Scientific symposium: teams share their representation of climate change using Prezis, debate and participate in evaluating their peers.  |



## 5. Conclusion

In the first part of the paper, we proposed that, in the context of environmental and science education, Vygotsky's (1997) principle of double stimulation would allow us to better understand how science teachers facing a conflict of motives could break away from it. Focusing on the identification and resolution of conflicts of motives expressed in the form of teaching strategies, the teachers' conceptions of environmental issues and their values helped us understand how the decision forming process unfolded. Our analysis shows that the agentive actions taken by the teachers were indeed triggered by conflicts of motives and crucially facilitated by the formation and implementation of an external second stimulus, in this case a plan for a novel teaching sequence.

It is not common in Quebec that science students are given a lot of latitude when it comes to information seeking or constructing an informed opinion on a controversial environmental issue. In that sense, it is not surprising that we documented resistance on the part of the students and anxiety on the part of the teachers who wondered whether they had moved too far away from some important scientific concepts related to climate change. Our analysis demonstrates that work on the conflicts of motives may continue for lengthy periods and prompt the actors to reformulate their second stimulus to better cope with the evolving conflicts.

In the case analyzed in this article, the expansive resolution of conflicting motives by the two teachers led to new ones which involved the values and culture of the entire school. Perhaps it is inevitable that bold actions of transformative agency require the involvement of communities beyond individual practitioners. Analyses of and interventions in such collective processes of double stimulation are an important challenge for future research.

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