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Video-Enhanced Training to Support Professional Development in Elementary Science Teaching: A Beginning Teacher's Experience

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Elementary teachers are expected to teach complex and authentic lessons and integrating multiple disciplines. In so doing, they must take many elements into account, such as disciplinary content, learning standards, and pedagogical knowledge, in an ever more complex environment, including pupils' increasingly heterogeneous characteristics. Our study aims to understand a beginning teacher's classroom activity in the context of a research-training program involving the use of video. The teacher involved was observed giving a science lesson (on buoyancy in a fourth-grade classroom) and then took part in two interviews involving self-confrontation with researchers at 1-week intervals, returning to the classroom between these interviews. Specifically, this article presents a program aimed at training and mentoring a beginning elementary school teacher using video recordings of her classroom activities in Quebec, Canada. The analysis describes the teacher's experience during this training process. In particular, the results indicate that the teacher's participation in this training program changed her concerns related to science education at the elementary level. Her focus shifted from classroom management (e.g., managing hands-on activities in science education and pupils' interactions) to supporting an approach favoring scientific inquiry that truly engages pupils and is anchored in sociotechnical controversies.

Like the rest of Canada, Quebec has undergone major social changes in recent years that have had an impact on the school context: population decline in nonurban regions leading to what are referred to as multiprogram classes (Conseil supérieur de l'éducation, 2009), rising immigration, particularly involving a young population (Institut de la statistique du Québec, 2014; Ministère de l'Immigration et des Communautés culturelles, 2015), and an explosion in the number of pupils living with disabilities or experiencing adjustment or learning problems (EHDAA) integrated into regular classrooms (Ministère de l'éducation, du Loisir et du Sport, 2009).

This increasing social and cultural diversity among pupils has made the work of teachers more complex, putting new demands upon them. In fact, elementary teachers are expected to teach complex and authentic lessons, integrating multiple disciplines and making use of various technologies. In so doing, they must take many elements into account—such as disciplinary content, learning standards, and pedagogical knowledge—in an ever more complex environment including pupils' increasingly heterogeneous characteristics (Council of Chief State School Officers [CCSSO], 2013).

These expectations generate many challenges for beginning teachers, such as not knowing how to plan specific lessons when provided with only general standards, and offering learning tasks that integrate various disciplines while not necessarily mastering the content, especially when it comes to teaching science (Van Driel & Verloop, 2002). Indeed, a lack of mastery of the content of science lessons presents one of the greatest challenges for both experienced and beginning teachers, since they must master several complex contents (Poland, Colburn, & Long, 2017).

This lack of knowledge leads some teachers to spend a large portion of their lesson-planning time reading up on the subject and the lesson content in question rather than planning the actual lessons (Kauffman & Johnson, 2002). It also sometimes leads teachers to modify the curriculum to make their lack of knowledge less apparent (Beyer & Davis, 2012) or to plan activities without fully exploring their link with the curriculum (Strangis, Pringle, & Knopf, 2006). Many beginning teachers, thus, find themselves in survival mode rather than in a professional development posture (Certo, 2005; Kauffman & Johnson, 2002). However, many studies have shown that it is possible to offer these teachers better support (Dymoke & Harrison, 2006; Le Maistre & Paré, 2006).

In particular, the use of video in initial teacher education and as new teachers integrate into the profession is often put forward as a means of supporting teachers' professional development (Marsh & Mitchell, 2014; T. R. Tripp & Rich, 2012). Several studies have concluded that using video this way allows teachers to develop their capacity for observation (in particular, of pupils and their learning), engage in a more specific and critical reflection than when relying solely on memory, and change their teaching practices (Gaudin & Chaliès, 2015; Marsh & Mitchell, 2014; T. Tripp & Rich, 2012; Wang & Hartley, 2003)

More generally, the use of video has been shown to help change preservice and in-service teachers' conceptions of teaching and contribute to the construction of their professional identity (Cherrington & Loveridge, 2014; Koc, 2011; Orland-Barak & Rachamim, 2009). Training programs that use video in an interactive way, wherein participants can exchange views with their peers or a trainer, are seen in a particularly positive light by participants (Tripp & Rich, 2012). Nevertheless, viewing video recordings in a group situation can raise some concerns, such as the feeling of discomfort experienced by some participants when they see themselves on screen (Gaudin & Chaliès, 2015; Ria & Leblanc, 2011).

More specifically, engaging in an analysis of their classroom activities in collaboration with researchers may allow teacher participants explicitly to bring out the tacit dimensions of their professional action, leading to professional development, and possibly influencing their professional development paths (Leblanc, Ria, Dieumegard, Serres, & Durand, 2008). Such an analysis is carried out not only from an outside perspective (interactions, context, etc.), but also from the perspective of the participants and the elements that they find significant (Theureau, 2003).

Theoretical Framework

This study is based on an ontology of situated action. This approach is constructivist in the sense that it fundamentally views human activity as an interaction between actors and their environment. It proposes to describe any activity (including learning) in situation, giving predominant importance to the actor's point of view in a global way (without a priori distinguishing between action, cognition, emotions, and learning), while also taking account of its social and cultural dimensions (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Suchman, 1987; Theureau, 2004).

More specifically, our description and analysis of a beginning teacher's activity in the context of a training program aimed at supporting the teacher's professional development were based on the course-of-action semiological framework (Theureau, 2006). To describe activity in a given situation (for example, a learning situation), as illustrated in Figure 1, the course-of-action semiological framework proposes linking an extrinsic description (characteristics of the actor and his/her environment and culture) to an intrinsic description (what is significant for the actor in this situation).

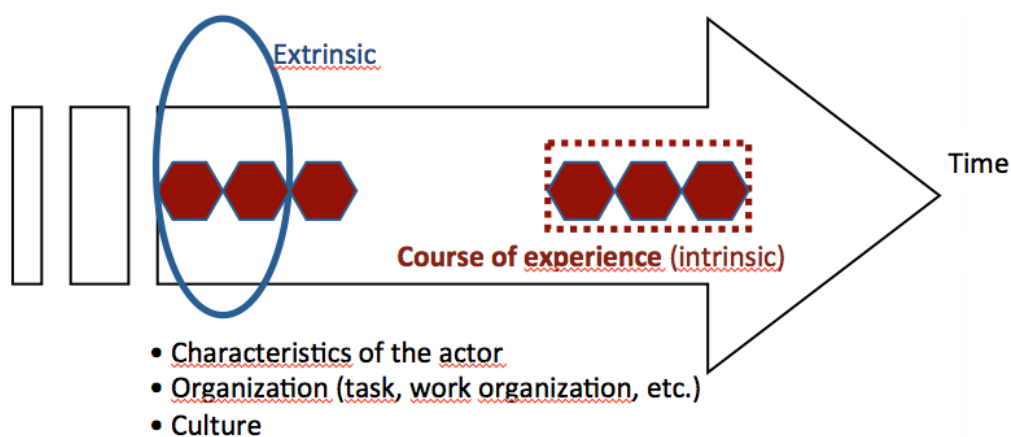


Figure 1. Linking the extrinsic and intrinsic description of the actor's activity.

This framework can help explain why, for example, teachers might choose to teach science from a workbook: They may be concerned about personal mastery of the scientific content (intrinsic description), or they may be taking up the teaching model that they were exposed to during their initial teacher training (extrinsic description).

Linking the intrinsic and extrinsic elements thus allows for a richer description of human activity, taking account of the dynamics underlying the activity, its context, and its

significance for the actor. Within this theoretical framework, the aim is to describe human activity in its totality and all of its complexity, including its cognitive, emotional, corporal, and developmental dimensions. This theoretical framework has been used to describe learning situations in numerous studies in education sciences, particularly with the aim of contributing to the design of training programs (Leblanc et al., 2010).

More specifically, as illustrated in Figure 2, the course-of-action semiological framework defines the object, namely the actor's course of experience, as the dynamic of prereflective awareness; that is, what is significant for the actor at any given moment in the situation. The course of experience can be described as a set of units. A unit can be an action, a comment (e.g., made to pupils or a colleague), private or public discourse concerning personal teaching practices, or an emotion, as long as it is significant for the actor.

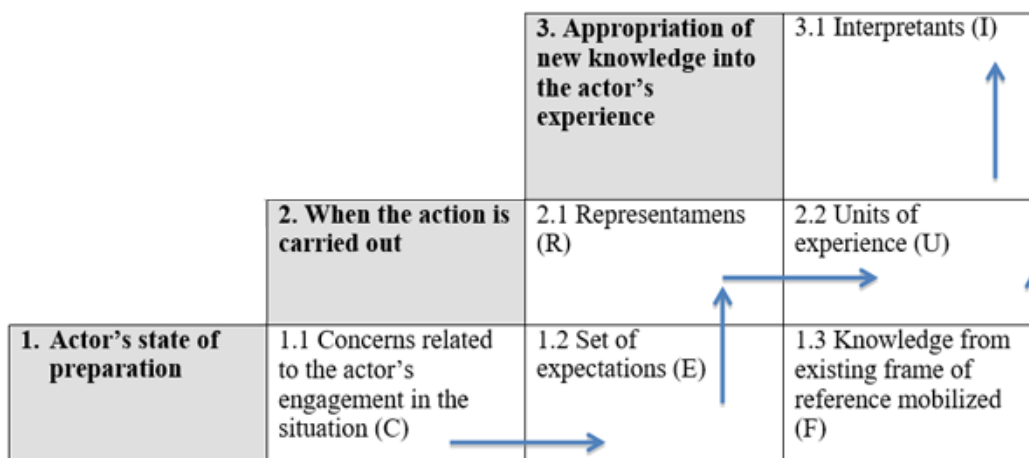


Figure 2. Dimensions of hexadic signs as a function of the steps involved in carrying out the action (adapted from Haué, 2003, p. 102).

Based on the work of Peirce (1931-1958), Theureau proposed describing the dynamic of prereflective awareness in terms of a series of hexadic signs, or signs comprising six components. These hexadic signs are illustrated in Figure 1 as hexagons. As seen in Figure 2, these six components enable a description of the experience of the actor in three successive chronological steps, represented horizontally.

From the start, before the action itself is carried out, the actor's experience is characterized by a set of concerns reflecting personal engagement in the activity (1.1), which can be more or less well defined and more or less important (e.g., being concerned about the pupils' learning while aiming to respect the schedule.) The actor's experience is also characterized by a set of expectations (1.2), comprising both active expectations (what the actor expects to do) and passive expectations (what the actor expects in the situation; e.g., the pupils' reactions), given what the actor knows (knowledge from his/her existing frame of reference; 1.3).

Based on these concerns and expectations, during the phase in which the action is carried out, some elements of the situation emerge as being significant for the actor at any given moment, *t*. These elements, referred to as representamens (2.1), can be either perceptual cues (something seen, heard, or felt) or mnemonic cues (something remembered). The emergence of representamens, superimposed onto the actor's concerns and expectations,

gives rise to units of experience (2.2). The actor can then mobilize some knowledge from his/her frame of reference (1.3).

Last, in some cases, the situation leads the actor to add new knowledge to this frame of reference or to question, modify, or invalidate other knowledge. It can thus be said that the actor has appropriated this new knowledge—referred to in the theoretical framework as the interpretant—into his/her experience. For example, being concerned about the pupils' learning (engagement in the situation) and expecting them easily to understand the notion taught (expectation), based on the knowledge that this notion is easy for pupils to grasp (knowledge from the teacher's frame of reference), teachers might be surprised by the pupils' reactions to their explanations (representamen) and mobilize their experiential knowledge which tells them to intervene quickly when pupils do not understand (knowledge from teachers' frame of reference).

Teachers might thus provide the pupils with another example (unit of experience—action) and question their prior assumption that the notion would be easy for the pupils to grasp (interpretant). Teachers will then have appropriated this new knowledge into their experience, and this modified knowledge can then be mobilized in a future situation (having been integrated into teachers' frame of reference).

Describing the actor's experience as a series of signs allows for a detailed description of the activity in all of its complexity, bringing out the dynamics underlying it and any changes that occur. It can also bring out any tensions in the activity, from the point of view of the actor, by identifying the concerns perceived to be contradictory.

Research Questions

The aim of this study was to enhance understanding of the experience of a beginning elementary school teacher participating in a training program aimed at supporting her professional development through the use of video. The teacher's name was Marie. In line with our theoretical framework, our main research question and related subquestions follow:

What was the course of Marie's experience during this training program?

1. What were her concerns and how did these concerns evolve during the training process?
2. What was significant for her during this process (representamens)?
3. What knowledge did she mobilize (from her existing frame of reference)?
4. How did her frame of reference change (interpretants)?

Methodology

Study Context and Participant

This was a single-case study. It combined research and training project was conducted in collaboration with a beginning elementary school teacher in Quebec, Canada, named Marie. Marie had completed her initial teacher training and obtained her teaching certificate in 2015. She had subsequently taught various groups of pupils at three different schools. At the start of the project, she was teaching three groups of pupils at different levels in a mid-sized elementary school in an urban and relatively privileged setting. She was mainly teaching two subjects delegated to her by these groups' regular classroom teachers,

namely, science and technology and social sciences (geography, history, citizenship education).

This study focused on the science instruction component of her teaching practice, since her teaching contract was only in science that year. Marie was observed giving a science lesson (on buoyancy, fourth grade) and then took part in two interviews involving self-confrontation with researchers at 1-week intervals, returning to the classroom between these interviews. A third self-confrontation interview was conducted using selected video segments from the first two interviews to analyze the teacher's experience during the training process.

In line with our course-of-action semiological framework, the self-confrontation interviews had two aims. The first was to bring out explicitly Marie's prereflective awareness (extrinsic description) of a previous activity (e.g., during the observed period in the classroom or an earlier interview). The second was to analyze Marie's activity along with her (intrinsic analysis; Theureau, 2003).

Research-Training Program

The research-training program implemented was based on the premise that describing work-related activity from a comprehensive perspective, in situ, using artefacts—video in this case—represents a professional development opportunity for participants. By focusing on the experience of the actors and encouraging them to share their intrinsic perspective on this activity, the researcher gives practitioners the opportunity to put their practices into words, explicitly bring out the less visible dimensions of these practices and, individually or as a group, modify their trajectories accordingly, thus contributing to their professional development (Ria & Lussi Borer, 2015).

This study fits into an "activity-oriented" conception of adult education, which suggests that in order to lead to significant changes in practice training to support professional development must not prescribe the trainees' activity but, rather, support them in their concerns and identity-based questioning (Durand, de Saint-Georges, & Meuwly-Bonte, 2006; Leblanc et al., 2008). In the field of teaching, this approach has demonstrated its epistemic (i.e., producing knowledge on teachers' classroom activity, in particular, among beginning teachers), developmental (Ria, 2009), and transformative potential, both for individuals and groups of teachers. However, it entails a dual process of acculturation, involving both practitioners (i.e., appropriating the approach and its underlying premises) and the researcher-trainers (i.e., becoming sufficiently familiar with the school context involved).

Implementing the Research-Training Program

The research-training program was implemented in an informal way by three university professors working in teacher education, along with the occasional involvement of a science didactics expert, also a professor at a Quebec university. This mentoring project involved various modalities, including mainly a 75-minute period of classroom observation by two of the three trainers; three self-confrontation interviews lasting an average of 1 hour each with different trainers using artefacts of Marie's teaching practice (video recordings, photos); a discussion with a science didactics expert; regular discussions during which records of the activity (photos, etc.) were exchanged between Marie and one of the professors on a chat platform; and a final interview following the third self-confrontation interview aimed at reflecting on the overall process.

The aims of the self-confrontation interviews were twofold, namely, to produce knowledge on Marie's classroom activity (particularly self-confrontation Interviews 1 and 2) and her experience during the training program (particularly, but not exclusively, self-confrontation Interview 3; codescription component), but also to support her professional development (component involving co-analysis and identification of development paths).

During Interviews 1 and 2, Marie was invited to codescribe and coanalyze video excerpts of her initial classroom activity. With the support of the trainer, she had to describe what was going on in her class from the video as well as analyze what she saw. No excerpt was selected a priori. The video could be interrupted at any time by either Marie or one of the trainers.

The first self-confrontation interview was led by a member of the research team in November. During this interview, approximately 30 excerpts of the classroom activity were viewed. A second member of the team was also present, mainly as an observer in the codescription phase but intervening more often during the co-analysis phase.

The second self-confrontation interview was led by a different member of the team in December. Approximately 15 segments of different lengths of Marie's classroom activity were viewed, since it was the second viewing of the same activity.

During the third self-confrontation interview, led by the observer of the first interview, video excerpts of the first two self-confrontation interviews were codescribed and co-analyzed with Marie around April. These excerpts (five in total) were chosen by the trainer to represent the different phases of the two earlier interviews (codescription and co-analysis), including moments when Marie appeared to experience tension or doubt. Last, some excerpts from the first interview were also selected because they came up during the second interview (reference to something said by a member of the research team). At all three interviews, Marie was told that she could interrupt the video at any time or ask to see any segment of her choosing, but she never exercised this option.

Data Analysis

All three self-confrontation interviews and the final reflective interview were transcribed verbatim with the aim of describing Marie's concerns and sources of tension, how her concerns evolved over the course of the training process, and the significant elements that influenced her professional development trajectory, in particular, through interaction with the trainers. We then chronologically reconstructed her activity during the research-training program by creating an activity history using three-column tables (Time Marker, Observable Activity, Marie's Verbalizations) to take account of the temporal dynamics of her experience rather than the way her discourse was organized throughout the interviews.

Thus, for example, a reference made during the third self-confrontation interview to something that transpired during the first interview was reported in the "Verbalizations" column at the place corresponding to the appropriate moment in the first interview. A chronological account of each of the key moments in the training program was thus reconstructed, including both extrinsic elements (coming up during the training program: initial observation, or interviews) and intrinsic elements (elements reported by Marie as being significant, such as her preparation for the trainers' presence in the classroom or activities carried out with her pupils in connection with the self-confrontation interviews).

Based on these chronological accounts, we reconstructed the signs (units of experience, concerns reflecting Marie's engagement in the situation, expectations, representaments, knowledge from her frame of reference, and when relevant, interpretants), describing in

detail the course of her experience during the training program. The relevant extrinsic elements (characteristics of the participant and her situation or culture) were also identified.

In all, 129 signs and 718 components of signs were identified. Next, a second-level coding and, where applicable, a third-level coding were conducted for each of the components. The coding was done by the researchers assisted by a graduate student. Table 1 presents the categories of this second-level coding, distinguishing between the categories adapted from the theoretical framework or previous studies that have used it (in bold) and those that emerged during our coding (in italics).

Once all the signs and their components were reconstructed, they were then coded using NVivo software to better establish the sequencing of the signs and facilitate the identification of data. This coding involved both the components of the signs and their subcomponents. An analysis of all the data brought out the most important components of the signs for each key moment in the training process.

Table 1
Categories and Subcategories of the Components of the Hexadic Signs

Second Level	Definition and Examples
Units of experience	
Actions	Excluding comments. Example: moving around in the classroom.
Communication	Any comments directed at pupils, colleagues or any other person, with the exception of the researcher-trainers.
Public discourse	Discourse (justification, explanation, etc.) directed at the researcher-trainers (e.g., from now on, I'll do such and such; I did such and such)
Private discourse	Internal discourse reported after the fact in a self-confrontation interview (e.g., I told myself such and such)
Emotions	Emotions reported by Marie (e.g., I felt some tension)
Concerns reflecting Marie's engagement in the situation	
<i>Related to the pupils</i>	Concerns related to making sure the pupils learned the lesson content and enjoyed the lesson, and ensuring their safety, etc.
<i>Related to herself</i>	Marie's own concerns, such as developing professionally and ensuring that she would be hired again the following year.
<i>Related to the training program</i>	Including the concern of meeting the trainers' expectations.
Set of expectations	
<i>Related to the pupils</i>	Marie's expectations related to her pupils (their reactions, their potential difficulties, the way they learned, etc.).
<i>Related to the training program</i>	Marie's expectations related to the training program, including how the interviews would unfold and regarding the trainers themselves (e.g., expecting the trainer with expertise in classroom management to address this aspect of her teaching practice).

<i>Related to the school setting</i>	The participant's expectations related to the school setting (in particular, her understanding of what was expected of her in this setting).
Representamens	
<i>Related to the pupils</i>	Marie's perceptions of the pupils (based on what she saw and heard, etc.) deemed by her to be significant.
<i>Related to Marie's teaching practices</i>	Aspects of Marie's teaching practices deemed by her to be significant.
<i>Related to her colleagues</i>	Colleagues' actions or comments deemed by Marie to be significant.
<i>Related to the training program</i>	Characteristics of the training program (how the interviews unfolded, questions asked or interventions made by the trainers, the stance taken by the trainers, etc.) deemed by Marie to be significant– with the exception of the use of video (see next category).
<i>Related to the video excerpts viewed</i>	Situations in the video excerpts viewed during the training program deemed by Marie to be significant.
Knowledge from existing frame of reference mobilized	
<i>Content</i>	The knowledge mobilized by Marie (relating to the pupils, the lesson content, the school setting, etc.).
<i>Source</i>	The source of this knowledge (initial or ongoing teacher training, teaching experience since being hired or the training program itself).
Interpretants	
Knowledge from existing frame of reference validated	Knowledge from Marie's existing frame of reference was reinforced by her experience.
Knowledge from existing frame of reference invalidated	Knowledge from Marie's existing frame of reference was deemed not to be valid or was questioned based on her experience.
New knowledge constructed and added to frame of reference	New knowledge was added to Marie's frame of reference based on her experience.
New areas of professional development opened up	Interpretant wherein Marie targeted something that could potentially be learned without engaging in it immediately.

Results

Classroom Science Lesson on Buoyancy

In order to make a video recording of Marie's classroom activity and set the research-training program in motion, two trainers went into the classroom to observe and film her

giving a science lesson on buoyancy. Figure 3 describes the course of Marie's experience during this classroom activity.

3. Appropriation of new knowledge		
3.1 Interpretants <i>No learning documented</i>		
2. When the action was carried out		
2.1 Representamens <i>Related to the pupils</i> - Pupils' reactions: they were excited and full of nervous energy, found the hypothesis quickly, gave a wide range of answers, were engaged in the task <i>Related to her teaching practices</i> The highly structured nature of the activity proposed to the pupils ("turn-key lesson plan") <i>Related to the training program</i> - Presence of the trainers		2.2 Units of experience <i>Emotions</i> - A little tense, uncomfortable - Proud, pleased, a sense of satisfaction <i>Actions</i> - Guiding the activity on the scientific method
1. State of preparation		
1.1 Concerns <i>Related to the pupils</i> - Teaching the pupils about buoyancy and the scientific method - Making sure the pupils participated in the activity and enjoyed it <i>Related to herself</i> - Following the planned steps in the lesson - Maintaining control of the class - Not displeasing the regular classroom teacher to ensure that she would be hired again.	1.2 Expectations <i>Related to the pupils</i> - Expected the pupils to be calm, attentive, engaged in the activity, able to formulate hypotheses on buoyancy <i>Related to the training program</i> - Expected the trainer to be impressed by the high quality of the teaching activity chosen	1.3 Knowledge from existing frame of reference mobilized <i>Content</i> - Knowledge relating to the pupils (greater risk of losing control of the class during experiments, pupils are able to describe their observations) <i>Source</i> - Previous experience

Figure 3. Course of Marie's experience during the science lesson on buoyancy.

For the trainers' visit to the classroom, Marie had prepared a lesson on buoyancy aimed at keeping the pupils active and enabling them to engage in a process of scientific inquiry. She was concerned about her classroom management, hoping to maintain control of the class during the buoyancy experiments (Which bar of soap will float and which will sink?). All the while, she was aware that during this type of activity pupils are usually engaged but can also get out of control.

Marie said she felt some tension, knowing that pupils enjoy science activities that are based on their interests and allow them to be actively involved. Yet, she was also aware of the need to respect the system of classroom management established by the regular classroom teacher and avoid making too much noise to respect the demands of the school setting. Being familiar with one of the trainers, she also hoped this trainer would be impressed by the high quality of the teaching activity she had chosen.

During the activity, the main elements that emerged as being significant for her (representamens) were the pupils' reactions, being very excited about their hands-on involvement in the experiment, and the fact that one pupil immediately stated the correct

hypothesis regarding why one bar of soap floated and the other sank. She also felt hemmed in by the overly structured nature of the teaching activity (“turn-key lesson plan”), which prevented her from really following the pupils’ learning pace and taking their ideas into account. Marie said she felt proud and pleased to see that the pupils were able to formulate hypotheses but also uncomfortable and a little tense, given the wide range of answers provided by the pupils and the presence of the trainers. The analyses did not bring out any interpretants for this part of the training program.

First Self-Confrontation Interview

During the first self-confrontation interview, Marie watched the video of her classroom activity 2 hours after teaching. Figure 4 describes the course of her experience during this interview.

3. Appropriation of new knowledge		
3.1 Interpretants		
<i>New knowledge constructed</i>		
<ul style="list-style-type: none"> - In order for pupils to retain what they’ve learned, the scientific inquiry must be significant for them and they must be in charge of the process. - It is possible to make better use of pupils’ answers when engaging in scientific inquiry. - Self-confrontation interviews are instructive because they put her in a reflective position rather than a passive one. 		
2. When the action was carried out		
2.1 Representations		2.2 Units of experience
<i>Related to the training program</i>		<i>Emotions</i>
<ul style="list-style-type: none"> - The trainer’s stance (asking questions rather than giving feedback, non-judgmental attitude) - Trainer’s suggestion to build on the pupils’ answers 		<ul style="list-style-type: none"> - At first: discomfort, stress, displeasure at hearing and seeing herself on screen (reaction following the pupil’s answer) - She felt better as the interview progressed
<i>Related to the video excerpts viewed</i>		<i>Private discourse</i>
<ul style="list-style-type: none"> - Found her explanations long - Saw how motivated the pupils were - Saw her own reaction when one pupil spontaneously formulated the correct hypothesis 		<ul style="list-style-type: none"> - Felt that the interview did not unfold as she had expected - Realized that her “turn-key lesson plan” did not leave much room for the pupils
1. State of preparation		
1.1 Concerns	1.2 Expectations	1.3 Knowledge from existing frame of reference mobilized
<i>Related to the pupils</i>	<i>Related to the training program</i>	

Figure 4. Course of Marie’s experience during the first self-confrontation interview.

During the first self-confrontation interview, Marie wanted to reflect on how to allow pupils to play a greater role in the scientific inquiry process by choosing activities that would keep them active and engaged in the task. She also wished to reflect on effective ways to keep track of the pupils’ hypotheses and other learning acquired during the scientific inquiry. She did not feel much tension related to these concerns, because she knew that being in a

process of professional development is normal for a novice teacher. She expected the trainers to give her feedback and suggestions for improvement. She also knew that, as a beginning teacher, she still had a lot to learn and that she had had few opportunities to receive feedback since she had started working in the school system.

At the start of the interview, she said she felt some discomfort and stress, particularly because it was the first time she would see herself on video in the presence of another person and because she felt unnerved by the stance taken by the trainer. Her previous trainers had usually given her tips and told her directly what they thought of her teaching without any video only in action. This trainer asked questions, prompting her to explain what she did in the classroom and how she felt. The stance taken by this trainer, who did not pass judgment on her teaching, as well as the questions asked by the second trainer (e.g., "Why don't you write the pupils' hypotheses on the blackboard?") were very significant for her. When she watched herself on video, she said she found her explanations too long and saw how she reacted as a teacher ("Look at the face I made!"), as well as how motivated and engaged the pupils were when carrying out the science experiment. She also noticed that she had taken charge of the entire scientific inquiry, without giving the pupils much room to direct the process, despite her intention to do so.

Marie learned that, in order for pupils to retain scientific knowledge, the activity must relate to their experience, but they must also be allowed to take charge of the activity, in particular, by making better use of their ideas and answers. She also learned that self-confrontation interviews are useful because they put her in a reflective position rather than a passive one (receiving tips or suggestions), as had sometimes been her experience during her initial teacher training.

Second Self-Confrontation Interview

During the second self-confrontation interview, Marie watched the video recording of her science lesson on buoyancy a second time, with a different trainer. Figure 5 describes the course of her experience during this interview.

During this self-confrontation interview, Marie wished to continue reflecting on how to improve her classroom management, which she still considered to be problematic. She also wished to continue reflecting on how to allow pupils to play a greater role in the scientific inquiry process, something she had begun thinking about during the first self-confrontation interview. Her verbalizations also showed that, despite the nonjudgmental training stance adopted by the first trainer, Marie was concerned about pleasing the trainer and showing that she had taken account of the feedback received during the first self-confrontation interview.

Since she knew the trainer and her field of expertise, she expected this interview to focus specifically on her classroom management. She also expected this interview to be a source of professional development for her. She did not expect to feel any discomfort watching the video during this interview because she had already seen it.

During this interview, given her concerns and expectations related to her own professional development, in particular regarding her classroom management, what emerged as representamens for her were the trainer's questions, feedback and assertions. Other representamens emerged while watching the video. For example, while viewing excerpts of her lesson on buoyancy for the second time, Marie reacted to the pupils' level of engagement in the activity and disengagement at the end of the activity and to the way she led the activity.

2. When the action was carried out		
<p>2.1 Representations <i>Related to the video excerpts viewed</i></p> <ul style="list-style-type: none"> - Pupils: noticed the pupils' engagement in the activity and disengagement at the end of the activity - Herself (scientific method): noticed that she didn't take up the pupils' answers and that she imposed an experiment on them that did not stem from a hypothesis formulated by the pupils. - Herself (classroom management): long explanations, instructions not always clear. <p><i>Related to the training program</i></p> <ul style="list-style-type: none"> - Questions asked by the trainer - Feedback from the trainer (e.g., pointed out a good transition) - Assertions made by the trainer (e.g., a good teaching activity involves many possible pathways for pupils). 	<p>2.2 Units of experience <i>Emotions</i></p> <ul style="list-style-type: none"> - Neutral emotions <p><i>Public discourse</i></p> <ul style="list-style-type: none"> - Wondered whether she was too strict in her classroom management - Mentioned that managing pupils' answers represented a challenge - Wondered whether her teaching activity was overly sequential 	<p>3. Appropriation of new knowledge 3.1 Interpretants <i>Knowledge validated</i></p> <ul style="list-style-type: none"> - Knowledge relating to pupil learning: lessons should be based on pupils' interests; new knowledge should build on previous knowledge; it is important to allow pupils to be active while learning. <p><i>Knowledge invalidated</i></p> <ul style="list-style-type: none"> - Activities that are fun or that pupils can relate to easily are not necessarily pertinent for learning. <p><i>New knowledge constructed</i></p> <ul style="list-style-type: none"> - To foster learning, teaching activities must offer pupils a variety of pathways.
1. State of preparation		
<p>1.1 Concerns <i>Related to herself</i></p> <ul style="list-style-type: none"> - Continue reflecting on how to improve her classroom management. <p><i>Related to the pupils</i></p> <ul style="list-style-type: none"> - Continue reflecting on how to allow pupils to play a greater role in the scientific inquiry process. <p><i>Related to the training program</i></p> <ul style="list-style-type: none"> - Showing that she had taken account of the feedback received during the first self-confrontation interview. - Pleasing the trainer. 	<p>1.2 Expectations <i>Related to the training program</i></p> <ul style="list-style-type: none"> - Expected her classroom management to be addressed in this interview - Held expectations regarding her own professional development - Did not expect anything new to emerge from the video (seen previously) 	<p>1.3 Knowledge from existing frame of reference mobilized <i>Content</i></p> <ul style="list-style-type: none"> - Knowledge relating to pupil learning (important that the lesson be significant for them) - Knowledge relating to the professional integration of teachers (novice teachers never manage to control the group; regular classroom teachers criticize contract teachers) - Knowledge relating to the trainer (expertise in classroom management) - Knowledge relating to herself (not an expert on scientific content, needs to control the group) <p><i>Source</i></p> <p>Previous experience</p>

Figure 5. Course of Marie's experience during the second self-confrontation interview.

In particular, she noticed again that her explanations were too long and that her instructions were not always clear and that she did not take up the pupils' answers when they formulated hypotheses. Moreover, she noted that she had suggested an experiment (heating up the soap) that did not explicitly stem from any of the hypotheses formulated.

Nevertheless, she described her emotional state as neutral or “okay,” probably because she had known the trainer for a long time.

Aside from her emotions, the units of experience documented during this interview essentially involved her public discourse, sometimes in the form of requests for validation from the trainer. In particular, Marie wondered whether she was too strict in her classroom management and whether her teaching activity was overly sequential.

As for the appropriation of knowledge into her experience, during this interview, some of Marie’s previous knowledge was validated, such as the fact that, in order for pupils to learn, lessons must be based on their interests and build on their previous knowledge. Allowing them to engage in activities without being overly strict about classroom management is important. Moreover, this interview represented an important learning opportunity for Marie by invalidating a previous belief (activities that are fun or that pupils can relate to easily lead to learning) and constructing new knowledge (to foster learning, teaching activities must offer pupils a variety of pathways, rather than guiding them step by step without engaging them cognitively).

Period of Classroom Experimentation With Support

Following the second self-confrontation interview, Marie continued teaching science to her pupils, but with the ongoing support of various trainers, especially the trainer that had led the second self-confrontation interview (with whom she was in regular contact through email or video chat), but also the science didactics expert and her former teaching practicum supervisor, whom she ran into by chance. Figure 6 describes the course of her experience during this three-month period.

As shown in the figure, during this period, Marie’s predominant concern related to the pupils’ learning. Following the lesson she had given on buoyancy and the first two self-confrontation interviews, she wished to teach science differently, allowing pupils to play a greater role and be more cognitively engaged in the process, while anchoring her teaching in a sociotechnical controversy. To this end, she implemented an inquiry-based approach.

After presenting a sociotechnical controversy to the pupils (the discharge of untreated sewage into the St. Lawrence River in Montreal), she guided them through the different steps of the inquiry process, including the formulation of the research question and the search for information. Throughout this process, she relied, in particular, on knowledge acquired from a university course she had taken on using sociotechnical controversies in teaching. She expected the pupils to be able to conduct the inquiry. Marie also hoped to foster more cross-curricular learning, taking advantage of this opportunity to develop the pupils’ writing skills through the task of writing an opinion letter.

She was still concerned about being hired again the following year, expecting that her chances of being rehired would be harmed if her experimentation with the inquiry-based approach ended in failure, especially if it revealed her lack of knowledge of the content involved. However, since she knew she could count on the support of the trainers, she decided to go ahead and try this approach with the pupils.

3. Appropriation of new knowledge		
3.1 Interpretants <i>Knowledge validated</i>		
<ul style="list-style-type: none"> - Teaching unfamiliar content is unsettling - Basing lessons on the pupils' interests requires a great deal of adaptability. - Basing lessons on the pupils' interests leads to deeper learning. 		
2. When the action was carried out		
2.1 Representamens <i>Related to the pupils</i>		2.2 Units of experience <i>Emotions</i>
<ul style="list-style-type: none"> - Pupils' decision to work on the effects of the discharge of untreated sewage on fish. - Pupils' difficulty finding information on their own. - Pupils' request to write a class letter to the Mayor of Montreal. - Quality of pupils' oral and written discourse. 		<ul style="list-style-type: none"> - Felt supported by the trainers. - Panic and a feeling of insecurity when faced with the pupils' choices and the difficulties they encountered. - Fear that she wouldn't be hired again. - Pleased that her project was well received by her colleague.
<i>Related to her colleagues</i>		<i>Actions</i>
<ul style="list-style-type: none"> - Regular classroom teacher's suggestion that they collaborate together on the project (integrating French and science). 		<ul style="list-style-type: none"> - Called on the trainers for help. - Provided additional resources to the pupils. - Drew up a summary table with the pupils. - Organized writing workshops.
1. State of preparation		
1.1 Concerns <i>Related to the pupils</i>	1.2 Expectations <i>Related to the pupils</i>	1.3 Knowledge from existing frame of reference mobilized <i>Content</i>
<ul style="list-style-type: none"> - Putting pupils in situations that allow for autonomous scientific inquiry (including choosing the question). - Anchoring the teaching of the scientific method in socio-technical controversies. - Suggesting learning tasks that foster cross-curricular learning (e.g., writing). - Getting pupils to describe their scientific inquiry in words. - Engaging all the pupils. 	<ul style="list-style-type: none"> - Expected the pupils to be able to conduct the inquiry. 	<ul style="list-style-type: none"> - Knowledge relating to the scientific content to be taught (current state of knowledge on the theme chosen by the pupils) - Knowledge relating to the pupils' abilities (e.g., research skills) - Knowledge relating to the demands of the school setting (a teacher should know the content she is teaching).
<i>Related to herself</i>	<i>Related to the training program</i>	<i>Source</i>
<ul style="list-style-type: none"> - Being hired the following year. 	<ul style="list-style-type: none"> - Expected the trainers to be able to support her in her project involving a controversy. 	<ul style="list-style-type: none"> - Previous experience - University training (course on using socio-technical controversies in teaching)
<i>Related to the school setting</i>	<ul style="list-style-type: none"> - Expected that, if she did not succeed, she would not be hired again. 	

Figure 6. Course of Marie's experience during the period of classroom experimentation with support. [/caption]

Based on her state of preparation (concerns, expectations, and knowledge mobilized), the main elements that emerged as representamens for Marie during this period related to the pupils. First, the pupils formulated a research question dealing with the effects of the

discharge of untreated sewage on fish. They had difficulty finding information but, nevertheless, made sufficient progress in their inquiry to want to write a class letter to the mayor of Montreal.

These different decisions on the part of the pupils created negative emotions for Marie, who felt insecure regarding both the theme chosen by the pupils, which she knew little about, and the pupils' desire to write a class letter (how to involve the whole class in producing a single letter). Despite these negative emotions, with support from the trainers, Marie implemented various actions aimed at supporting her pupils (organizing writing workshops, providing additional resources, and drawing up a summary table). In the end, the support of both the trainers and the regular classroom teacher and the quality of the pupils' oral and written discourse (they talked about fish in a much more specific and in-depth way than they had been able to talk about in the previous project about buoyancy) reassured Marie and made her feel proud and pleased.

As for the appropriation of knowledge into her experience, without actually creating new knowledge, this period represented an opportunity for Marie to validate some previously constructed knowledge. For example, this experience confirmed for her that teaching content she knew little about and basing lessons on the pupils' interests can be unsettling and requires a great deal of adaptability. However, it also confirmed that basing lessons on the pupils' interests and allowing them to play a greater role in the learning process leads to deeper learning.

Third Self-Confrontation Interview

Figure 7 describes the course of Marie's experience during the third self-confrontation interview. It should be noted that this interview aimed to produce knowledge on the course of Marie's experience during the training program (co-description) while contributing to her professional development (co-analysis and identification of development paths).

The data show that, from the start of this self-confrontation interview and as it progressed, Marie was concerned about answering the trainer's questions. She was expecting this trainer, like those in the previous interviews, to adopt a nonjudgmental training stance. She was also concerned about her own professional development. This concern was especially reflected in her desire to ensure that her teaching practices (in science but also generally) were coherent with her socioconstructivist conception of learning and to implement a cross-curricular approach (involving both French and social sciences, for example).

During this interview, she mobilized a great deal of knowledge on teaching at the elementary level (of a didactic and pedagogical nature), as well as on how the school environment is organized. This knowledge had been gleaned through her previous teaching experience but also, to a large extent, through the research-training program itself, such as during the two previous self-confrontation interviews.

3. Appropriation of new knowledge		
3.1 Interpretants		
<i>Knowledge validated</i>		
<ul style="list-style-type: none"> - Basing lessons on the pupils' interests leads to deeper learning. - "Turn-key lesson plans" in science are misleading because, although they appear to be socio-constructivist (hands-on involvement by pupils), they do not allow pupils to become cognitively engaged to a significant degree. - Self-confrontation interviews are instructive because they put her in a reflective position rather than a passive one (being given tips). 		
<i>Knowledge invalidated</i>		
<ul style="list-style-type: none"> - Her belief that beginning teachers cannot risk making mistakes by experimenting with new practices. - Her belief that she had trouble with classroom management. - Her belief that teachers have to fully master all the content they teach. 		
<i>New areas of professional development opened up</i>		
<ul style="list-style-type: none"> - The possibility of applying the inquiry-based approach when teaching social sciences. - The idea of exploring other approaches that were coherent with her conception of learning. 		
2. When the action was carried out		
2.1 Representations		2.2 Units of experience
<i>Related to the training program</i>		<i>Emotions</i>
<ul style="list-style-type: none"> - Questions asked by the trainer. - Trainer's suggestion to apply the inquiry-based approach when teaching social sciences. - Subjects addressed in the discussion. 		<ul style="list-style-type: none"> - Felt stressed in the presence of the trainer. - Felt some tension related to the system of classroom management established by the regular classroom teacher. - Felt uncomfortable about teaching social sciences. - Was afraid the pupils would get tired of the inquiry-based approach.
<i>Related to the video excerpts viewed</i>		<i>Public discourse</i>
<ul style="list-style-type: none"> - Excerpts from the second self-confrontation interview. 		<ul style="list-style-type: none"> - Said she was taking account of the pupils' answers to a greater degree since the first self-confrontation interview - Said she had been a "false" socio-constructivist (called herself an imposter). - Discussed the stance taken by the trainers and her experience during the self-confrontation interviews. - Said she would try to apply the inquiry-based approach when teaching social sciences.
1. State of preparation		
1.1 Concerns	1.2 Expectations	1.3 Knowledge from existing frame of reference mobilized
<i>Related to herself</i>	<i>Related to the training program</i>	<i>Content</i>
<ul style="list-style-type: none"> - Engaging in a process of professional development. - Making sure her teaching was coherent with her socio-constructivist conception of learning. - Continue reflecting on her professional identity. 	<ul style="list-style-type: none"> - Expectations regarding the stance taken by the trainer (expected to be asked questions rather than receive tips and feedback). 	<ul style="list-style-type: none"> - Knowledge relating to the difficulty of teaching social sciences (history, geography) - Knowledge relating to the characteristics of the school setting (difficult to implement a cross-curricular approach, little support for novice teachers). - Knowledge relating to pupil learning (fun activities do not necessarily lead to learning). - Knowledge relating to classroom management (did not believe in behaviourism as a means of managing behaviour). - Knowledge relating to herself (high-performing personality).
<i>Related to the pupils</i>		<i>Source</i>
<ul style="list-style-type: none"> - Favouring a cross-curricular approach to allow pupils to play a greater role in their learning. 		<ul style="list-style-type: none"> - Knowledge gained during the training program (e.g., during one of the self-confrontation interviews) - Previous experience
<i>Related to the training program</i>		
<ul style="list-style-type: none"> - Answering the trainer's questions. 		

Figure 7. Course of Marie's experience during the third self-confrontation interview.

During the interview, the main elements that emerged as being significant for her in this situation (representamens) concerned the trainer (her questions and suggestions, such as applying the inquiry-based approach when teaching social sciences). Some video excerpts viewed during this interview also emerged as representamens. These were excerpts from the second self-confrontation interview, during which Marie discussed classroom management with the trainer. Marie experienced negative emotions, regarding both the trainer (stress of the interview situation) and her teaching practices (tension related to the system of classroom management established by the regular classroom teacher; feeling uncomfortable about teaching social sciences; afraid the pupils would get tired of the inquiry-based approach).

Aside from these emotions, the other units of experience documented in this interview were related to Marie's public discourse. She mentioned that she had made changes to the way she taught (taking account of the pupils' answers to a greater degree) and hoped to incorporate further changes in the future (attempting to apply the inquiry-based approach when teaching social sciences). This interview proved to be a rich source of learning for Marie, allowing her to appropriate new knowledge into her experience. A substantial amount of knowledge that Marie had constructed previously was validated during this interview, namely, knowledge pertaining both to teaching (basing lessons on the pupils' interests leads to deeper learning; just because pupils are physically active during a lesson does not mean they are cognitively engaged) and the most effective professional development tools (usefulness of self-confrontation interviews).

Some knowledge was also invalidated, in particular, her belief that she could not risk trying out new practices for fear of making mistakes or because she did not fully master the lesson content concerned. This invalidation led to the opening up of a new area of professional development: the possibility of applying the inquiry-based approach when teaching social sciences.

Discussion

This study aimed to describe the course of experience of a beginning teacher who participated in a research-training program involving the use of video. More specifically, it aimed to describe Marie's concerns and how they evolved over the course of the training process, the elements that were significant for her during this process, the existing knowledge she mobilized, and when applicable, the learning she acquired (knowledge that was validated, invalidated or constructed or new areas of development that opened up).

Marie's Concerns

The results unequivocally show that Marie was constantly concerned about her pupils' learning and engagement in classroom activities, particularly in science. In fact, from the very start of the training process, Marie was concerned about her pupils' engagement in the learning tasks, although her definition of engagement was initially less complex (wanting to make sure the pupils were active and involved hands on).

Over the course of this training program, Marie continued to be concerned about her pupils' learning but became increasingly focused on the importance of using activities that led to deeper learning by allowing pupils to truly become cognitively engaged and take charge of the learning task. By the end of this training process, after much new knowledge had been constructed and appropriated (e.g., to foster learning, teaching activities must offer pupils a variety of pathways), Marie became concerned with ensuring that the teaching activities she was using with her pupils in science, but also generally, were

coherent with her socioconstructivist conception of learning. She also expressed a desire to experiment more with a cross-curricular approach, for example, when teaching social sciences. This learning could allow her to better reconcile the complexity of the task facing beginning teachers at the elementary level and the demands of schools and society regarding elementary school teachers in general (CCSSO, 2013).

Constant Tension in Her Concerns

From the very start of this research-training program, Marie repeatedly referred to the tension she felt between her desire to teach in a way that was consistent with her conception of teaching (in science and generally), while also meeting the demands of the school setting and her colleagues, to ensure that she would be hired again the following year. Thus, although she was constantly seeking to become a better teacher, she also experienced strong emotions and a sense of insecurity regarding the teaching activities she was using with the pupils (e.g., allowing them to choose the themes and providing several possible learning pathways). She feared the possible repercussions of these decisions in the school setting and how they would be perceived by her colleagues and the school administration.

This finding is not surprising, given how complex the professional integration of new teachers can be and in light of the fact that in Quebec novice teachers are often given teaching contracts involving a limited number of subjects, including science, taught to several different groups. Like Marie, many elementary school teachers do not feel sufficiently versed in science to teach this subject (Strangis et al., 2006) and are afraid to implement complex and pupil-centered teaching activities when they do not fully master the scientific content involved (Van Driel & Verloop, 2002).

In this sense, the fact that the training program allowed Marie to invalidate her belief that teachers need to master scientific content in order to develop significant learning tasks for pupils appears promising for her professional development. This finding could also be transposed to initial teacher training, where this case study could be used to illustrate to preservice teachers that a beginning can implement more complex teaching activities without fully mastering the lesson content involved by adopting an approach favouring the coconstruction of knowledge with pupils.

Supporting the Creation of Knowledge

Marie is no ordinary beginning teacher. Few beginning teachers would have agreed to participate in this kind of training program so early in their professional integration process and demonstrate such a clear desire to improve their teaching practices, since beginning teachers are usually more in survival mode than professional development mode (Certo, 2005; Kauffman & Johnson, 2002). The fact that Marie's concerns and expectations were so focused on her desire to develop professionally right from the start of the training process likely contributed to the emergence of the numerous and transformative representaments for her.

Both the trainers' interventions and the video excerpts viewed contributed to her learning throughout the entire training process. During each phase of the training program, Marie's activity showed an evolution in her concerns, but also a transformation in her knowledge (whether validated or constructed). Much of this transformed knowledge was not new in itself. Marie had already adopted a socioconstructivist conception of learning, reflected in her concerns and the knowledge she mobilized. However, the training program reinforced this conception for her, as demonstrated not just in the statements she made but also in the action-type units of experience that were documented. This knowledge was put into

action in the classroom, in particular, through the support of the trainers. This finding confirms the relevance of professional development programs that focus on supporting participants in their concerns and identity-based questioning rather than trainers imposing on participants their own concerns and prescriptive views on teaching (Durand et al., 2006; Leblanc et al., 2008).

Combining the Use of Video and Interventions

While Marie had the desire to develop professionally, she also had expectations regarding the trainers. Thus, although the trainers chose to focus on asking her questions as a way of helping her progress, she did not hesitate to clearly express her own expectations of them from time to time as well. She expressed her expectations particularly when the pupils chose to work on the effects of the discharge of untreated sewage on fish, and she felt that she was at the limit of her own abilities.

The trainers' questions, along with the viewing of the video excerpts, allowed her to acquire new learning. Accessing new resources suggested by the trainers allowed her to meet her more specific professional development goals. The effectiveness of the combined use of self-confrontation interviews and ongoing support from trainers, in a spontaneous and rapid way (through email or Skype), appears to show the need to support the participants of professional development programs outside the formal timeframe (i.e., during interviews), in real time, in response to questions that arise during the participants' actual teaching activities. This approach makes it possible to meet needs that are not clearly expressed during the interviews themselves and that arise between these formal scheduled meetings.

Moreover, a substantial amount of new knowledge relating to Marie's professional development was constructed during the training program, such as the importance of adopting a reflective rather than a passive stance, allowing herself to be unsettled and make mistakes and seeking support from a variety of resources. She also learned trying out new teaching practices is constructive and that doing so will not necessarily harm her chances of being rehired.

Moreover, the high number of representamens related to the video excerpts shows, as suggested by Koc (2011), that the use of video contributed to Marie's professional development. While the first self-confrontation interview helped her to identify new avenues for her classroom activities, viewing the same video excerpts during the second self-confrontation interview, along with the questions asked by the trainers, truly helped Marie appropriate new knowledge into her experience. The second viewing of the video excerpts, especially, allowed her to better observe the pupils as well as her own teaching practices (Marsh & Mitchell, 2014; Tripp & Rich, 2012).

Conclusion

In sum, the analysis of the course of experience of a beginning teacher during a research-training program involving the use of video showed that this type of program can have benefits for the participants' professional development. By focusing on the participants' concerns and expectations, such programs can help them integrate new knowledge into their frame of reference and apply it in a concrete way in the classroom. In light of the data gathered, trainers can expect these changes to be accompanied by various emotions (negative as well as positive emotions). However, under favorable conditions, these emotions can be channelled to lead to real professional development.

As brought out in our study and many others, these favorable conditions include real engagement in the program on the part of participants right from the start; the adoption of a nonjudgmental training stance on the part of the trainers; and ongoing support in real time that is adapted to the participants' needs. The use of video also appears to constitute a favorable condition, as it can be unsettling for participants in a fruitful way, as long as it is used in conjunction with the other conditions.

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