TENSIONS WITHIN TEACHERS' BELIEFS: IMPLICATIONS FOR TEACHER PROFESSIONAL DEVELOPMENT

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Beliefs that teachers hold about mathematics teaching and learning are the most investigated domain in affect-related research. These beliefs can be contradictory and thus lead to dilemmas that play a crucial role in shaping how a teacher changes her practice. In this paper, we give an account of how such contradictions have been addressed in literature and then propose a worldview lens to analyze the dilemmas of four teachers enrolled in Professional Development (PD) programs.

INTRODUCTION: CONTRASTING BELIEFS

Beliefs are propositions about a certain topic that are regarded as true (Philipp, 2007), and tend to form clusters as they "come always in sets or groups, never in complete independence of one another" (Green, 1971, p. 41). According to Green (1971), belief clusters are coherent families of beliefs across multiple contexts. Thus, beliefs have a systemic nature. Affect-related research has provided evidence that beliefs have observable behavioral consequences (e.g., Di Martino & Zan, 2011), and a change in a teacher's beliefs is likely to result in a change in their practice (Leder, Pehkonen & Törner, 2002), suggesting a dialectical relationship between change and beliefs in that one influences the other (Buehl & Beck, 2015). One of the challenges with this, however, is that such a dialectic relationship can lead towards the emergence of tensions between belief clusters. In this paper we are interested in looking closely at such tensions, to better illuminate the role of beliefs in shaping teachers' behavior.

THEORETICAL FRAMEWORK

The systemic nature of teachers' beliefs can be understood in terms of "world views" (Grigutsch, Raatz & Törner, 1998), or epistemological beliefs about mathematics (Hofer & Pintrich, 1997), including its teaching and learning. According to Grigutsch *et al.* (1998), it is possible to outline four different world views (see also Liljedahl, Rolka & Roesken, 2007): a *process-oriented view* that represents mathematics as a creative activity consisting of problem solving using different and individual ways; an *application-oriented view* that represents the utility of mathematics for real world problems as the main aspect of the nature of mathematics; a *formalist view* that represents mathematics as characterized by a strongly logical and formal structure; a *schema-oriented view* that represents mathematics as a set of calculation rules and procedures to apply for routine tasks. We can notice how world views are strongly linked to practice.

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Each teacher's beliefs, thus, belongs to (at least) one world view (Erens & Eichler, 2019), as teachers' beliefs are organized in systems of beliefs (Fives & Buehl, 2012; Green, 1971; Philipp, 2007). One aspect of a belief system relevant for our research is that beliefs are organised in clusters that are not necessarily logically connected. The fact that beliefs can be contradictory (Fives & Buehl, 2012) allows the possibility for teachers to hold beliefs that belong to different clusters. Skott (2015) suggests, however, to interpret possible contradictions in teachers' belief systems not merely as incoherences, but rather to consider the different contexts in which beliefs are evoked. As "beliefs are expected to significantly influence the ways in which teachers interpret and engage with the problems of practice" (Skott, 2015, p. 19), they cannot be exhaustively described by one cluster of central beliefs. Given the complexity of teaching and the variety of stakeholders (e.g. students, parents, colleagues, the Ministry of Education), teachers usually show a coexistence of more than one cluster of beliefs (Erens & Eichler, 2019).

These considerations shed light on two intertwined features of teachers' beliefs: they are subjective in nature and individually held, but at the same time they are (or can be) socially and contextually shaped. The context plays a crucial role in evoking beliefs, for example a teacher, talking with a colleague (context 1), might show some beliefs that are different from, or even in conflict with, the ones she enacts in class (context 2) (e.g. Fives & Buehl, 2012). Our research hypothesis is that, even in the same context, contrasting beliefs may emerge. Namely, beyond Skott's (2015) findings, we aim at exploring the existence of beliefs that emerge in the same contexts but are in conflict with each other, almost like anti-clusters, and this reverberates in a teacher's practice, as change in a teacher's practice can be understood as an attempt to balance contrasting world views held by different stakeholders (Andrà, Rouleau, Liljedahl & Di Martino, 2019). In order to frame this, we refer to research on teachers' tensions.

Lampert (1985) understood tensions as problems to be managed, rather than solved, characterizing teachers as "dilemma managers", who find ways to cope with conflict between equally undesirable (or desirable but incompatible) options without necessarily coming to a resolution. For Lampert (1985), the ongoing internal struggles presented by the tensions arise from and contribute to the developing identity of the teacher, and as such they have value in themselves. For Chapman and Heater (2010), "Meaningful change can occur when the process is initiated and rooted in the teacher's experience based on a tension in self and/or practice that is personal and real to him or her" (p. 456). We further suggest that tension research applied to beliefs can offer a new insight into the frustrations and needs of the classroom and the changes that result. Furthermore, recognition of the tension inherent in teaching can help us as researchers in better understanding those apparently inconsistent behaviours we observe, and what might be construed as minimal or no change could be recast as a rational decision that weighed the practicality of the change against its potential consequences (Andrà *et al.*, 2019). Our aim with the research presented here is to understand the tension(s) between different world views. Our research questions

are as follows: When does a tension between world views emerge? How does a teacher cope with tensions? How does a tension reverberates in a teacher's practice?

METHODOLOGY

The participants for this study come from a set of more than 200 teachers who participated in PD sessions led by one of the authors in 2016. Of them, 26 volunteered to be interviewed at the end of the sessions. The relatively limited number of interviewees is due to the fact that researchers aimed at conducting extended interviews, which were semi-structured, lasted 30 to 60 minutes, were audio-recorded, and then fully transcribed. The structure of the interview aimed at letting beliefs emerge through the narrative rather than by direct questioning. For example, we invited the teachers to describe their school, the relationship with their colleagues, and with parents. Preliminary analysis of each of these 26 transcripts revealed that 19 expressed tensions manifested as conflict between different belief clusters. Further analysis revealed that the ways in which the teachers coped with these tensions fell into one of four categories - (i) ignoring the conflict, (ii) internal struggling, (iii) balancing two worldviews, (iv) resolving the conflict. In what follows we present a deeper analysis of four prototypical cases, one selected from each of the aforementioned categories. Teachers' fictitious names are, respectively: Vicky for case (i), Julia for (ii), Ron for (iii) and Mary for (iv).

In analyzing the verbatim transcribed interviews, we used a qualitative coding method (Mayring, 2015), based on Erens and Eichler's (2019) four deductive categories described in their coding manual. Examples of statements coded as *application-oriented view* are: "mathematics helps to solve tasks and problems that originate from daily life", "the ideas of mathematics are of general and fundamental use to society", and "a sound knowledge of mathematics is very important for students in their whole life". Examples of statements coded as *formalist vie*w are: "logical strictness and precision are very essential aspects in mathematics", "mathematics is a logically coherent edifice free of contradiction consisting of precisely defined terms and statements which can be unequivocally be proven", and "in mathematics students must use mathematical terms correctly". Examples of statements coded as *process-oriented vie*w are: "there is usually more than one way to solve a task or problem in mathematics", "in order to comprehend and understand mathematics, one needs to create or (re-)discover new ideas", and "everyone is able to (re)invent or to comprehend the central ideas of mathematics". Examples of statements coded as *schema-oriented vie*w are: "Mathematics consists of memorizing, recalling and applying procedures", "doing mathematics demands a lot of practice in adherence and applying to calculation rules and routines", "nearly any mathematical problem can be solved by the direct application of familiar rules, formulas and procedures", and "to solve a mathematics task, there is mostly a unique way of solution which needs to be found". These examples are taken from Erens and Eichler's research. Each teacher's statement has been assigned a world view by one of the authors, and the other authors independently agreed or disagreed. In case of disagreement, discussion among the authors took place, until consensus has been reached.

RESULTS AND ANALYSIS

As teachers talk about (aspects of) their practice in their interviews, we analyse the tensions between worldviews that emerged. For Vicky and Julia, tensions emerge between two coexisting views, whilst for Ron and Mary the tension is provoked by an external agent. Julia and Mary significantly change their practice, Ron introduces a new practice but still employs the 'old' one, and Vicky does not show change.

Vicky: When asked to talk about her teaching method, Vicky commented that she does not "have a specific one: it is different for each class, because each one is different. […] I propose problem-based group activities, where math and physics are applied to everyday life". An *application-oriented view* emerges from Vicky's words, as *mathematics helps to solve problems originating from daily life* (see examples of codes). Vicky, then, referred to one of her classes:

> The characteristic of this class is that the traditional lessons annoy them, hence I started to propose group activities dedicated to the study of physical phenomena applied to real situations. The result has been excellent: the students have developed a high sense of critique and above all they have cooperated together for solving the given problems. Every activity has been welcomed with absolute enthusiasm.

In the last excerpt, a *process-oriented view*, which values solving problems in a creative way, emerges for the students in one of Vicky's class. When talking about her teaching, and referring to her specific classes, two different views of mathematics emerge for Vicky, but there seems to be no tension lived by the teacher, it is as if they can coexist. Overall, Vicky's teaching orientation could be interpreted as being a means to an end to achieve application and process-oriented views. These two belief clusters coexist and the reason why Vicky does not live a conflict may reside in a lack of awareness about their differences, or more likely in a worldview that tries to accomodate these differences. Moreover, Vicky's teaching practice is a blending of problem-based activities originating from everyday life and solved in creative ways. Her reference to a specific class suggests that, in other classes, she may opt for a mostly application-oriented view, as she declares that she adopts different methods in different classes.

Julia: A completely different picture emerges from Julia's words. In her interview, she does not refer to a specific class or situation, but she makes a general statement about an uncomfortable internal struggle:

> I really struggle when I see a student struggling to try and figure out a problem. I have a really hard time not giving them the answer as an example, and then letting them go from there, it's very — yeah. I really struggle with watching them struggle, I guess.

This excerpt can be interpreted in terms of a tension between a *process-oriented view* (struggling with new ideas, finding one's own path to solve a problem), and a schema view, according to which *nearly any mathematical problem can be solved by the direct application of familiar rules, formulas and procedures* and as such it may encourage a teacher to give the students the answer. Julia is well aware of the conflict.

Like Vicky, she does not mention any external force that pushes her to act in a way that contrasts with her beliefs (e.g., she does not mention any PD session she attended, where she was faced with either alternative of teaching): rather, the two views, which are specific to the role of the teacher in problem solving, coexist in her belief system and the dilemma can be read mainly as her own, subjective elaboration. We can further see that, in her practice, Julia opts for the process-oriented view, as she tells us that she does not intervene.

Ron: After having attended a PD session, Ron referred back to his first experiences of teaching: "When you're a young teacher, you love having all the lessons and your notes set and all that and all this is great, got it all set." Ron seemed, from this quote, to adopt a *formalist view*, according to which *mathematics is a logically coherent edifice consisting of precisely defined terms and statements*. A formalist view blends with a *schema-oriented* one, as Ron further acknowledged that students like taking notes. However, also a non-formalist and non-schema view emerges, as he added: "I was getting tired of giving notes, giving lessons and just having them sit there and do it and observe. Because my thinking was they can get these notes anywhere". These words suggest that Ron came to PD with an emerging tension, seeking for a way to sort it out. In fact, Ron recognized that, "once you've been doing that for a short while, you just, you realise it's kind of limiting". Rons' belief system was in motion, and the timing of the interview allowed us to capture this. A new view of mathematics was emerging:

> Getting the students to do the work in class so that you know, even if they only get one or two problems, they really got it. And just so that, if they have to come in and think. I mean, I have to come in and think too because I don't really have to think if there's a [conventional] lesson. In a conventional lesson, I already know what to say and do.

A *process-oriented view*, according to which *in order to understand mathematics one needs to create or re-discover new ideas*, started to take form in Ron's orientations, and was valued. In Ron's words, not only the students have to "come in and think" during problem solving, but also the teacher has to do the same, whilst he does not "really have to think if there is a [conventional] lesson". However, Ron has not abandoned his previous, schema-oriented view as he mentioned:

> A few of them [the students] would say to me that they like notes and so sometimes I would say, okay let's do that and then I would always tell them, see why I don't do this anymore. Some students said to me they liked the mini-lesson before, which is fair enough. But sometimes it's the questions that get you thinking in the first place, so I think it's fair enough to balance.

Ron uses the verb "to balance" to represent his way of living with the tension that is provoked by some of his students' preference for notes and formalism, which contrasts with his love for more engagement and thinking. Here, an important feature of tension emerges, that is: tensions are dilemmas that often cannot be resolved. In Ron's practice, this results in a mixture of teaching methods: sometimes students are exposed to 'mini-lessons' and take notes, while other times they 'come in and think'.

Like in Vicky's case, coexistence of different worldviews mirrors coexistence of different practices.

Mary: Mary had been accustomed to strictly adhering to grade 1 curriculum in grade 1, and grade 2 in grade 2, without mixing up the content (a schema-oriented view). Participating in a PD session created a tension that caused her to change her mind. She acknowledged a change from before the PD, when she had a *schema-oriented view* of curriculum, to the present, as she now had a *process-oriented view* of mathematics, which involves a shift of attention to problem-based mathematical activities in her lessons, rather than being too much concerned about the constraints of curriculum. In Mary's words, the tension between these two views seems to be resolved:

> It just freed up boundaries, I would say, like this is a grade one, this is grade two. You don't teach grade two in grade one. (*laughs*) It's just now that we're doing problem-solving activities it just naturally comes out and students that are ready will do it and students that are not ready just won't. The students can only learn at their own pace or at their own development level and I'm okay with that. Before, I used to worry but now, it's just, — Okay.

The tension, while currently resolved, initiated a change in Mary's practice and in certain belief clusters. Unlike in Ron's case, in Mary's case there was not an external force prompting her to compromise, at least to a certain extent, between two worldviews, she abandoned the 'old' one and the tension was resolved. Also differently from Vicky, Mary was aware of the conflict, as she contrasted the two views explicitly in her account of the change. Similarly to Julia's case, Mary makes a choice and her practice originates from that choice. But, unlike Julia, Mary does not live uncomfortably with a struggle beyond her actions.

DISCUSSION AND CONCLUSIONS

The four prototypical cases allow us to exemplify some important features of tensions among belief clusters. With reference to our research questions, tension emerges when the teacher sees the conflict between different views, but is unable to resolve it. Teachers can live an internal struggle, or try to balance between contrasting worldviews. There is no tension, instead, when the teacher ignores it, or finds a way to resolve it. Tensions can be occasioned by a PD session, or emerge as the teacher reflects upon her practice. An interesting case is Ron, who started to live a tension before PD and PD showed a way to solve it. For Mary, PD provoked a tension as it introduced a new worldview not considered before. Whilst Mary's case show that 'old' worldviews can be abandoned and tensions resolved, resulting in a significant change in practice, Ron's case show that 'old' and 'new' views can coexist in a teacher's practice, as Ron's practice is a compromise between 'come and think' and 'take notes', being the schema-view not completely abandoned. We remark that, without a tension lens, Ron's choice would have been interpreted differently, namely as beliefs' resistance to change. For Mary's, Julia's and Ron's cases, we can say that we see a change in their practice, but we can also see the struggle behind it. For Vicky, we see no change and she blends different world views in her practice. In order to enrich the

discussion, we summarise our results in Table 1, where we further distinguish between existence of external forces and 'pure' internal conflicts.

Table 1: Ways of dealing with beliefs belonging to contrasting world views

	Internal contradiction	*External force(s)*
There is tension	…when teacher values ideas, practices, behaviour that belong to different belief clusters and is aware that they are in conflict (e.g., Julia) *There is change.*	…when someone has different beliefs, and teacher values their point of view, she cares to have a good relationship with them and she sees the conflict (e.g., Ron) *There is partial change.*
There is no tension	…when the teacher lives with ideas, practices, behavior that do belong to contrasting belief clusters, but this is not a problem for her (e.g., Vicky) *There is no change.*	…when new experiences provoke a teacher change and tension between the old and the new is resolved (e.g., Mary) *There is change.*

Focusing on the column where external forces are mentioned, we notice a dual nature of world views: on one hand, they are subjective. They may conflict with external sources but are - in terms of cognition - cognitive traits (Erens & Eichler, 2019). On the other hand, however, if we consider the case of Ron, the formalist view which is tied to taking notes is also shared by Ron's students, and valued both by the teacher *and* the students. This view belongs to the teacher's beliefs system and to the 'external' source. Also the process-oriented view, which resulted in breaking the boundaries among grade-specific curricula for Mary, was shared by the PD facilitator. A teacher's world views can be altered by tension from external forces. Our data, thus, do not allow us to discard the central role of the social context not only in mirroring a person's belief system, but most importantly in dealing with contrasting world views and resolving (or balancing) the tension. A question deserves further investigation: Does an external force provoke a tension *only if* teachers hold the same view as the external force? Our results suggest the answer to this might be 'yes'.

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