# Sources of Shifts in Pre-Service Teachers' Patterns of Attention: The Roles of Teaching Experience and of Observational Experience

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Abstract

A key requirement of successful initial teacher education is the development of professional vision, which includes shifting attention to features of the situation relevant to the specialized goals of teaching. Existing research hints at the value of targeted video-based courses in the development of professional vision, but often raises questions about the sources of shifts in the pattern of attention. We argue that existing work makes it difficult to distinguish if shifts seen across video interventions are the results of the intervention, teaching experience or methodological issues with the unbalanced use of videos in the data collection in these studies. Our first study suggests pre-service teachers' teaching practice experience does not notably affect attention, but that choice of video does. Our second study addresses the methodological issues and suggests that we may discount different or unbalanced videos as a source of the shifts in the pattern of attention. Finally, by introducing a new synthesis of the results in the literature, we identify a previously hidden key distinction between studies and suggest reasons why different studies have shown different results in this area.

Keywords: Teacher noticing; Professional development; Mathematics education; Video

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It is claimed that a person receives up to 11 million bits of information every second, but may be able to attend to and act on only a few tens of them (Nørretranders 1998). In order to engage pupils successfully with their learning, teachers must first be capable of shifting that very limited attention to the key features of the classroom environment and the actors within it. Successful experienced teachers seem to differ considerably from novices in where they place their attention (Miller 2011).

Miller argued that not only do skilled teachers attend to different aspects of the classroom environment, but are able to do so while conducting the lesson, scanning widely and systematically, and shifting focus quickly as the circumstances allow. Being able to attend appropriately to aspects of the classroom is vital for three reasons, particularly for pre-service teachers (PSTs): it is a prerequisite for responsive teaching, helps prospective and practicing teachers learn from teaching, and allows them to decompose practice in order to "directly address key practices and develop a common language for discussing [them]" (Sherin et al. 2011, p. 6).

Much of the research about the development and importance of this aspect of teaching discusses it in terms of 'teacher noticing'. Given the importance of noticing to the role of the teacher, it is no surprise that much work has been undertaken in trying to develop noticing skills amongst PSTs and practicing teachers, particularly through teachers watching and reflecting on videoed lessons (e.g., Barnhart and van Es 2015; Santagata and Guarino 2011; Sherin and van Es 2005). The aim of much of this research has been simultaneously to evaluate a structured program to develop noticing with videos and to measure how the participants' focus changes as a result. Inevitably, such work compounds different effects: as teachers move through a program, they become more experienced (both as teachers and observers of videos) and, as the choice of videos changes across sessions, the impact of the program on what participants attend to is conflated with the content of the different videos. That is, if participants are seen to focus more on mathematical thinking in a video at the end of a year-long program than in a (different) video at the beginning, is the shift of attention a result of the program, the difference in the videos, or the fact that the teachers have one year more experience of teaching? Disaggregating those effects so that one can be sure that shifts in noticing can be attributed to particular sources appears problematic with the existing research.

Thus our aim is to distinguish between the development of attention which may come about as the natural consequence of teaching practice within PSTs' education (Study 1, detailed below) and that which might be attributable to video program interventions (Study 2, detailed below). We also aim to distinguish between shifts in attention which come from watching different videos or watching the same video twice (which is also addressed in Study 2). In doing so, we help eliminate some of the methodological problems which affect this area. Finally, we will introduce a new synthesis of existing research which highlights one noticeable difference between groups of studies.

## 1 Noticing and Professional Vision

One aspect of professional skill is the development of *professional vision*: seeing phenomena in a scene from the area of expertise which are different from those arising from lay viewings of the same scene (Goodwin 1994). The idea of professional vision in education is often conflated with and overlaps that of teacher noticing, and as these notions have developed in education, different distinctions have been made within them. While some retain the focus of their definition solely on the identification of the noteworthy (Star and Strickland 2008; Star et al. 2011), others add a second process: interpretation of what has been identified (e.g., Sherin 2007). Still more research splits professional vision in three. For example, with the focus on children's mathematical strategies, Jacobs et al. (2010) distinguish attending to strategies, interpreting understanding and deciding how to respond.

In general, however, these frameworks distinguish observational processes from others which they see as consequential: one cannot interpret or respond to that which one does not see. But even with the simplest aspects of professional vision and noticing, there are depths of complexity: Schoenfeld (2011) notes that knowledge, beliefs, and orientations will impact on where attention is directed. Moreover, recognizing noteworthy phenomena is not a passive process – it involves more or less conscious decision making about what *not* to attend to as well as what to bring forward for further thought.

Our research is centered on the basic process of identifying the noteworthy, rather than the processes of theorizing or responding, albeit that we use one element ("stance", described below) which sits at the border between noticing and theorizing. So, given the multiple, overlapping uses of "professional vision" and "noticing" which often encompass multiple processes, we will talk mainly about teachers' *patterns of attention*.

A further complexity within this area is in the nature of the situation and timeframe in which the observation is taking place. In noting the value of professional vision to responsive teaching, learning from teaching, and decomposing teaching, Sherin et al. (2011) implicitly distinguish noticing which happens in the classroom (and helps direct the flow of the lesson) from reflecting back on teaching or in observing others teach – either live, or on video. This article focuses on the latter.

**1.1 Influence of video-based courses on noticing**

Clearly, reflection on observation is expected to be crucial to developing professional vision, and much of the research is focused on interventions where participants are guided to reflect on videoed lessons. Some studies focus on practicing teachers (e.g., van Es and Sherin 2010) and some on PSTs (e.g., Stockero 2008; Stockero, Rupnow and Pascow 2017). Some have looked at the use of participants' own videos as a development tool (e.g., the 'video clubs' of Sherin and van Es 2009; Roller 2015) and others have used what we will call 'public' videos – those made available for wider use and not featuring the participants (e.g., Star and Strickland 2008). Some have been centered on video snippets (e.g., Sherin and van Es 2009; Author 2010) and others on videos of whole lessons (e.g., Santagata et al. 2007). But the thrust of the research is on what factors appear to impact on noticing. This is also the focus of the two studies reported in this paper.

In reviewing the literature on the use of video in the development of teachers' professional vision, we highlight some of the methodological issues and potential confounds within this literature which led to the development of our studies.

It would appear that the opportunity to reflect upon practice may be an important element of developing professional vision, and how that reflection is scaffolded could be crucial. A number of studies have looked at how more or less structured video based courses can support that development and, within them, different scaffolds have been developed which aim to draw attention to specific aspects of the classroom.

These include the Mathematical Quality of Instruction (MQI) analysis framework (Mitchell and Marin 2015); Star and Strickland's (2008) five observation categories (classroom environment, classroom management, tasks, mathematical content and communication); the "video lesson analysis methodology" (Alsawaie and Alghazo 2010); the VAST framework which both highlights aspects to be noticed in the lesson and draws attention to the need to provide evidence and interpretation (Sherin and van Es 2005); the Lesson Analysis Framework

(Santagata et al. 2007; Santagata and Yeh 2014) and the MOST (Mathematically significant pedagogical opportunities to build on Student Thinking) framework (Stockero, Rupnow and Pascoe 2017). There have also been experimental studies which compare the effect of different frameworks (e.g., Santagata and Angelici 2010).

These scaffolding structures have been used with video observations in a variety of contexts: within methods courses for PSTs (e.g., Alsawaie and Alghazo 2010; Roth McDuffie et al. 2014; Star et al. 2011; Stockero 2008), in courses combining video analysis and teaching practicum (e.g., Santagata and Yeh 2014) or video clubs for PSTs (e.g., Mitchell and Marin 2015; Stockero, Rupnow and Pascoe 2017) and practicing teachers (e.g. Berliner et al. 1988; van Es and Sherin 2008, 2010; Sherin and van Es 2005, 2009).

Despite these different scaffolding structures and the different contexts, the studies tend to provide a consistent message: that video observation courses appear to result in increased attention on the components of and relationships between instruction and student learning. For example, Santagata et al. (2007) found that introducing PSTs to their framework "improved their analyses of teaching by moving from simple descriptions of what they observed to analyses focused on the effects of teacher actions on student learning as observed in the video" (p. 138). Roth McDuffie et al. (2014) reported a deeper level of awareness of different aspects of teaching and learning after PSTs were asked to analyze videos through four specific lenses: teaching, learning, task, and power and participation. Stockero, Rupnow and Pascoe (2017) found out that the majority of PSTs' noticing became directed at individual students and focused on the specific mathematics in an instance. Working with more experienced teachers watching excerpts of videos from each other's classrooms, Sherin and van Es (2005) noted a shift from comments on pedagogy to comments on student thinking.

However, not all of the findings are entirely consistent: while Sherin and van Es (2005) noted an increase in interpretative comments, Stockero (2008) found that at the end of their intervention there was still a "substantial amount of reflection at the describing and explaining levels, even in the later whole-class discussions" (p. 389), and Star et al. (2011) found no improvement in noticing features of tasks or mathematical content.

### 1.2 Methods for analyzing noticing

Clearly one could account for these differences by noting the varying contexts, frameworks and observational tasks, but there are also varying methods used by researchers;

some of which aggregate different factors together. This can make it difficult to determine the source of the results they report and the differences between studies.

For example, some studies are based on a small number of (presumably very broad) units of analysis (e.g., the first study in Sherin and van Es 2009 had just 7 "teaching-initiated idea units" at each video club meeting for one group). Some use written responses (e.g., Blomberg et al. 2014), some interviews (e.g., Mitchell and Marin 2015) and some transcripts of group discussions (e.g., Roth McDuffie et al. 2014). Similarly, many studies report quantitative measures at the group level (e.g., Stockero 2008) where individual responses are combined into one or where a group response is used as the measure. This does not allow the assessment of variance within the group and therefore one cannot get as clear a sense of the shift as one gets from measuring it in individuals (e.g., Santagata et al. 2007).

While we might argue that small numbers of units of analysis increase between-group variance or that different methods of obtaining responses may bring different aspects of the response more or less into focus, these methodological issues themselves should not lead to conflating the sources of any potential shifts they uncover. Other methodological issues, however, are more fundamental and make it impossible to disaggregate these sources.

First, in video interventions which take place over a number of weeks or months, usually participants are not only taking part in the intervention, but are also gaining experience as teachers. That is, one cannot distinguish between shifts in attention which might be attributed to the intervention from those which might be attributed to extra teaching experience. This is particularly problematic where the participants are in the early stages of training to be teachers, where even a few extra days spent in school will be a larger proportion of their exposure to situations in which their noticing might develop than for more experienced teachers.

A second key issue is the nature of pre- and post-design for intervention studies. If a study uses a different video in its measurement of noticing at the start and end of the intervention (as in van Es and Sherin 2010, Alsawaie and Alghazo 2010, or Stockero 2008), then one cannot disaggregate the influence of the video from the influence of the intervention: if attention is focused more on students than the teacher at the end of the course, it may be evidence of the intervention resulting in a shift in attention, or it may be that the post-intervention video has more student-led events to which an observer could attend.

Even if one uses the same videos in pre- and post-intervention measures (e.g., Mitchell and Marin 2015; Santagata et al. 2007), one cannot exclude a learning effect as a threat to validity: that is, the comments made post-intervention may be a result of seeing the same video for a second time – particularly with intervening time, during which participants might have time to think about it – not a result of the intervention.

It is also worth mentioning one further, more subtle, methodological issue which may impact on some of the shifts of attention reported in studies: there may be an impact of ignoring the compositional nature of the data in these frameworks: that is, when data are categorized into proportions of a whole (see Aitchison 1982). For example, van Es and Sherin (2008) found the percentage of the units of analysis which were specific in nature increased after the intervention (from 48% to 74%) and also found that the percentage of those which were general decreased (from 52% to 26%). But this should not be considered as two separate findings since, in the framework (described in more detail below), statements are either categorized as general or specific – the percentages must sum to 100 – and so the shifts are not independent. Aitchison notes that statistical methods designed for independent dimensions might not result in accurate conclusions when data is compositional in nature.

In sum, the existing literature has two areas which we believe need further exploration in relation to the source of shifts in attention: are these shifts related to teaching experience, and are they artefacts of methodological issues (such as seeing different videos before and after the intervention or seeing the same video twice)?

This led us to address the following two research questions:

RQ1. To what extent are PSTs' experiences of teaching practice linked to their shifting patterns of attention in videoed mathematics lessons?

RQ2. To what extent are these apparent shifting patterns of attention due to guided observation of videoed lessons rather than methodological artefacts, such as the balancing of videos?

Study 1 addresses the first research question. Following the analysis of Study 1, we note that its design (as with the existing literature) does not exclude the possibility that apparent shifts of patterns of attention may be a consequence of failing to balance the order in which videos are seen, so Study 2 was designed to examine the second research question. In the analysis of both studies, we address the final, subtle issue of the compositional nature of the data by using the appropriate analytic methods.

## 2 Study 1: The Role of PSTs' Teaching Practice

As noted above, it is possible that the shifts in patterns of attention noted in the literature might be due in part to the development of teaching experience, particularly for PSTs. We were able to access the responses to a video observation task from groups of PSTs in the Czech Republic who were undertaking a standard program of teacher education, which included watching some videos, but did not include any special focus on video analysis – the groups varied in teaching practice, but had not undertaken an explicit video intervention aimed at developing their noticing.

### 2.1 Methods and participants

The participants in this study came from three groups from a two-year master's degree program for PSTs of mathematics in the Czech Republic aimed at preparing them for lower and upper secondary school teaching. All had completed undergraduate degrees in mathematics or mathematics for education. As is common in the Czech Republic, some of the students were studying full time and some part time, though the courses they were following were identical in content and teaching approach.

One group (coded DM1 – for the Didactics of Mathematics module) completed the task at the start of the two year program, at the beginning of the first mathematics education course, and thus had undertaken no teaching practice. A separate group, DM2, completed the task at the end of the second mathematics education course and by that point had undertaken four weeks of teaching practice (which involved a mixture of observing experienced teachers and teaching under the supervision of a mentor). A third group, DM3, did the task at the end of the third mathematics education course and had undertaken one further period of four weeks of teaching practice. While the mathematics education program did use some video material within the three mathematics education courses (watching and commenting on lessons and clips), there was no explicit focus on the development of noticing.

Participants' comments on two publicly available videoed lessons were analyzed. Both were taken from the TIMSS 1999 Video Study collection and both from Hong Kong. They are referred to here (and in the TIMSS study) as HK01 and HK04. They are grade 8 lessons and around half an hour in length, with the former focused on developing pupils' understanding of square roots and the latter introducing linear identities. While, of course, the cultural differences between Hong Kong and the Czech Republic are important, the approach taken to teaching mathematics and to managing and organizing the classroom was roughly consistent with the general approach taken in Czech classrooms. Piloting of the videos with an earlier group of PSTs had shown these were lessons with which the participants could identify. The participants were allocated to the videos as in Table 1.

| | DM1 | DM2 | DM3 | Total |
|---|---|---|---|---|
| **HK01** | 16 | 11 | 13 | 40 |
| **HK04** | 16 | 10 | 16 | 42 |
| **N** | 32 | 21 | 29 | 82 |

**Table 1** Allocation of Videos to Groups

The lessons were provided to the participants on CD. They were in English, so the CDs had subtitles in Czech. Participants were asked to write a reflection of the lesson. Unlike some research aimed at the development of noticing which gave participants prompts to structure their response (e.g., Roller 2015; Alsawaie and Alghazo 2010; Santagata et al. 2007) or other studies that tried to deliberately elicit responses under specific headings (e.g., Jacobs et al. 2010; Star and Strickland 2008), no directive prompts for the reflection were given. Participants were given no time or word limit, were assured that they were not being assessed or judged on their responses, and were told to write about what they found interesting and important.

### 2.2 Analysis

The most widely used and elaborated framework for analyzing reflections on teaching is that developed across the work by van Es and Sherin (2008, 2010). It identifies a number of dimensions including Actor, Topic, Stance, and Specificity. The actor is one of: Teacher, Student (or students), Curriculum Developer (e.g., when there is a reference to a textbook author), Self (when the observer discusses themselves in relation to the video), or Other. The second dimension, the topic, includes Classroom Management, Climate (the social environment), Mathematical Thinking, Pedagogy, and Other. The third dimension, Stance includes Describe (a straightforward recounting of an event), Evaluate (a judgment about the event), and Interpret (making inferences or links to the event which might help account for it or understand it). The final dimension, Specificity, captures whether the statement relates to a specific event visible in the video (Specific) or refers to some aspect of the whole class or whole lesson or makes a generalization beyond the class (General). In some work, the authors also included a dimension about whether the comment is related to the video or not.

In the development of professional noticing, various authors have separated out the identification of salient aspects from reasoning about what has been seen and acting on the basis of that reasoning. We are focused primarily on the first element by exploring the pattern of *attention*, but note that one could argue that 'stance' links the processes of attending to those of reasoning.

We chose to use this particular framework because it has been widely used in research, albeit that it has also been modified according to subsequent authors' intentions. For example, Stockero (2008) used "describing", "explaining", "theorizing", "confronting", and "restructuring" for the 'stance' dimension to better capture the quality of participants' reflections. Still other authors used the above framework in one way or another to support their own coding structure (e.g., Santagata and Yeh 2014; Roth McDuffie et al. 2014; Stockero, Rupnow and Pascoe 2017).

Given that our research questions were directly motivated by the literature and, particularly, the seminal work of van Es, Sherin, and their colleagues, we closely followed the methods and analytic framework they developed. In particular, we adopted their dimensions and categorization for identifying the key foci of the units of analysis. We adopted the coding scheme as follows. It became clear from the first early rounds of coding the responses that there was no reference to non-video sources in the data, so we omitted the video/non-video dimension. Nor was there a need to use the Other code in the topic dimension: every unit of analysis was assigned to a named topic code.

The whole response from each participant was divided into units of analysis, each representing some articulated observation which made sense on its own. In many cases, these were whole sentences, in some cases they were a clause where a sentence appeared to contain a shift of focus, e.g., when the first clause referred to the teacher while the second to the student. Each unit of analysis was allocated codes against four dimensions:

Actor – Student, Teacher, Curriculum Developer, Self, Other

Topic – Classroom Management, Climate, Mathematical Thinking, Pedagogy

Stance – Describe, Evaluate, Interpret

Specificity – Specific, General.

The descriptions of the categories in van Es and Sherin (2008, 2010) were used to create a coding manual. Using the translation into English of two participants' responses, the coding manual was checked and modified for our context by all three authors, and then an inductive process of coding scripts and agreeing on meanings of codes was undertaken by the second and third authors, working with the original Czech responses. Inter-rater reliability was assessed using Janson and Olsson's (2001) multidimensional extension of Cohen's kappa, and once a good-to-excellent level of agreement ($\iota = .71$) was achieved, the coders were randomly assigned all remaining responses to code. Table 2 gives some example units of analysis (with English translations) and the agreed coding.

| Unit of analysis | Actor | Topic | Stance | Specificity |
|---|---|---|---|---|
| **První rovnici vypočítá žák bez problémů, převede si neznámou *x* na jednu stranu a číslo na druhou a vyjde mu výsledek (*x* = 2).**<br><br>***The pupil solved the first equation without any problem, he moved the unknown x to one side and a number on the other and he got the results (x = 2).*** | Student | Mathematical Thinking | Describe | Specific |
| **Hodina byla z velké části vedena panem učitelem, byl to prakticky jenom on, kdo v hodině mluvil.**<br><br>***The lesson was mostly led by the teacher, it was practically only he who was speaking in the lesson.*** | Teacher | Pedagogy | Describe | General |
| **Nikdy jsem se nesetkal s podobným problémem- s rozdělováním rovnic na normální rovnice a identity.**<br><br>***I have never met a similar problem – with the division of equations into normal equations and identities.*** | Self | Mathematical Thinking | Describe | General |
| **Nedal žákyni ani možnost chybu opravit, ale rovnou ji sám opravil na tabuli.**<br><br>***He did not even give the pupil an opportunity to correct the mistake but he immediately corrected it himself.*** | Teacher | Pedagogy | Evaluate | Specific |

**Table 2** Examples of Coding

It was noted earlier that much existing research on the development of noticing relies on very small samples of responses and units of analysis. For example, Sherin and van Es (2009) have just seven "idea units" in both their early and late meetings of one video club (with four participants) and Mitchell and Marin (2015) have between six and eleven "noticing incidents" for each of their four respondents in pre- and post-interviews. These quantitative analyses also tend to conflate the participants' responses into one for analysis rather than treating each coding as a point in a distribution. We were able to undertake a finer-grained analysis by working with written responses from the 82 individuals, providing 2 514 units of analysis in total, which enabled us to perform a robust inferential analysis of the development of attention across the three groups.

### 2.3 Results

We were interested in whether PSTs' increased experience of teaching practice might affect the length of the responses to each video, as a measure of the amount of attention given to the video. Note that, like other studies, the videos were not balanced across these groups, so we conducted a two-way (group by video) analysis of variance (ANOVA) of the response length (number of units of analysis). There was a main effect for group, $F(2, 76) = 5.7$, $p = .0048$, but no main effect for video, $F(1, 76) = .58$, $p = .45$, nor interaction effect, $F(2, 76) = .065$, $p = .94$. Fig. 1 shows the interaction of the response length by video and group.

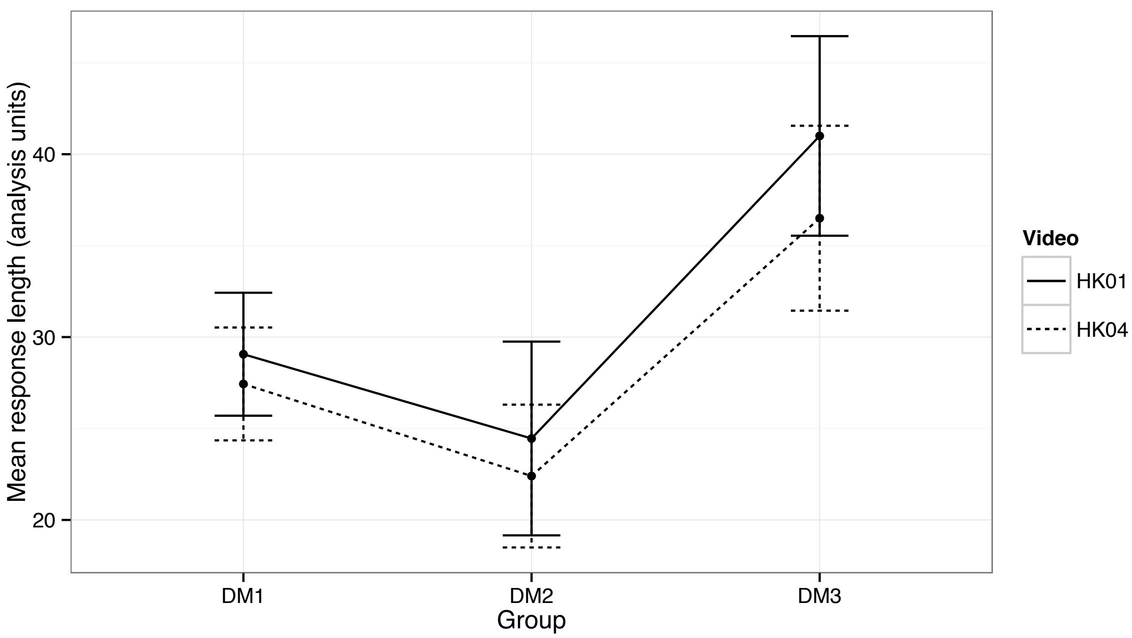


**Figure 1**. Interaction of response length with group by video

Post-hoc Tukey HSD tests indicated that the response length for group DM3 ($M = 38.5$, $SD = 19.8$) was significantly longer than those for DM2 ($M = 23.5$, $SD = 15.0$, $p = .039$) and DM1 ($M = 28.3$, $SD = 12.7$, $p = .0046$). But the lengths for DM1 and DM2 did not significantly differ.

We were also interested in the extent to which experience of teaching practice might account for the proportion of responses in each category in the framework.

As noted above, existing research fails to account for the compositional nature of the data within this framework (Aitchison 1982). That is, the proportions of responses under each category have to add up to 100%, so the categories are not fully independent: an increase in the proportion of Description, say, must result in a reduction in the proportion of Evaluation or Interpretation (or both).

In order to deal with the compositional nature of the data, we accounted for zeros using the Bayes-Laplace prior approach (Martin-Fernández et al. 2011) and then transformed the data with an isometric log ratio. We then undertook a two-way, multivariate analysis of variance (MANOVA) of the transformed proportions of responses for Actor against group and video. Box's M suggested the transformed data acceptably followed a multivariate normal distribution with equal within-group covariance matrices, $\chi^2(20) = 21.6$, $p = .37$.

The MANOVA indicated no significant main effect for group, $F(2, 76) = 1.18$, $p = .31$, or for group by video interaction, $F(2, 76) = 1.29$, $p = .25$, but there was an effect for video, $F(1, 76) = 4.37$, $p = .0032$. Stepdown ANOVAs exploring that difference between videos showed effects for the Curriculum Developer, $F(1,80) = 9.02$, $p = .0036$, and Teacher, $F(1, 80) = 5.94$, $p = .017$. That is, responses for HK04 focused less on the teacher and more on Curriculum Developer, as shown in Fig. 2.

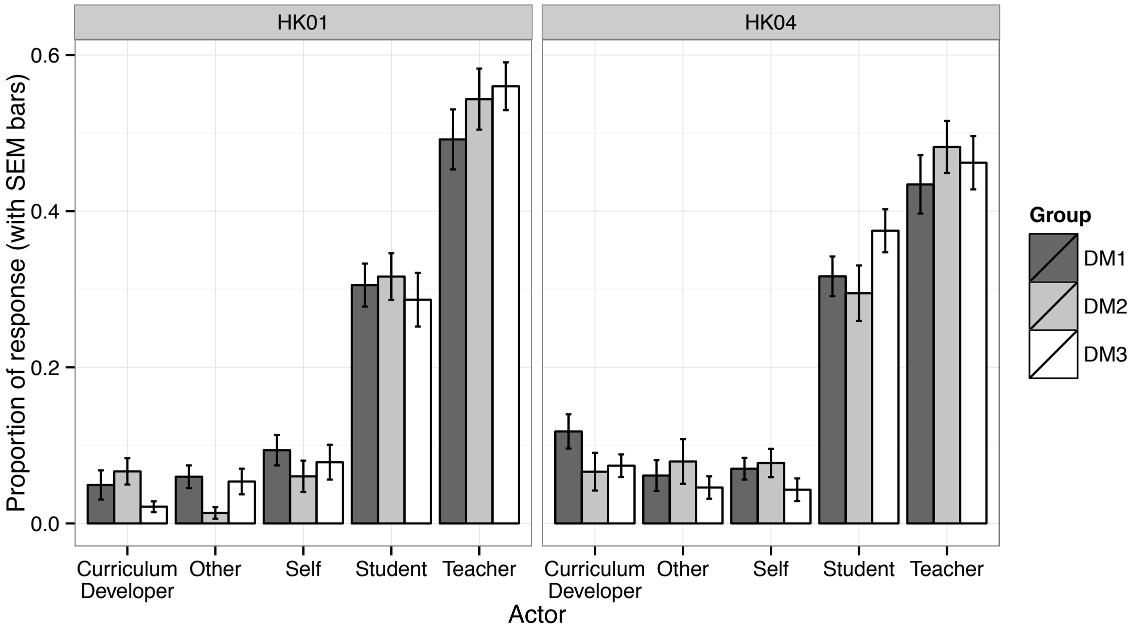


**Figure 2**. Responses for Actor

For Topic, Box's M again suggested it was appropriate to use a MANOVA, $\chi^2(12) = 10.37$, $p = .58$. The MANOVA again showed main effect only for video, $F(1, 76) = 4.17$, $p = .008$, not for group, $F(2, 76) = 1.12$, $p = .35$, or for the interaction, $F(2, 76) = 1.49$, $p = .18$. The individual ANOVAs for video indicate differences for Management, $F(1, 80) = 11.5$, $p = .0011$, and Mathematical Thinking, $F(1, 80) = 9.89$, $p = 0.0023$. That is, responses for HK04 focused less on Management and more on Mathematical Thinking, as shown in Fig. 3.

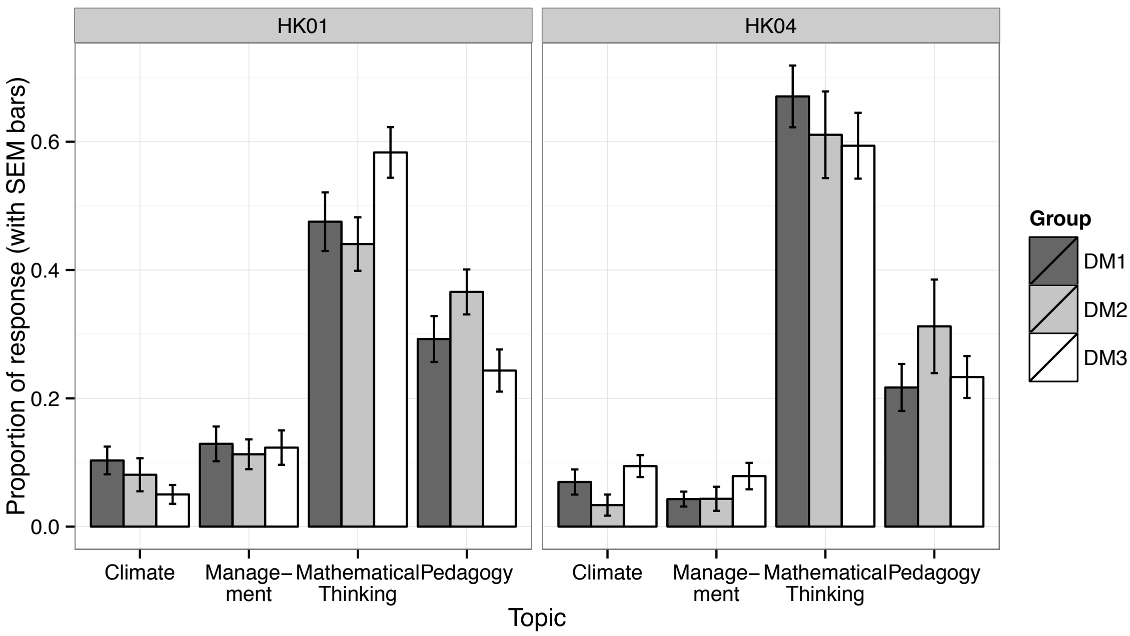


**Figure 3.** Responses for Topic

In terms of Stance, Box's M indicated the suitability of MANOVA, $\chi^2(6) = 10.1$, $p = .12$. The MANOVA indicated no significant differences: for group, $F(2, 76) = 0.40$, $p = .80$; for video, $F(1, 76) = 0.003$, p = .99, or interaction: $F(2, 76) = 0.24$, $p = .91$. The proportion of responses in each category, by group and video, are shown in Fig. 4.

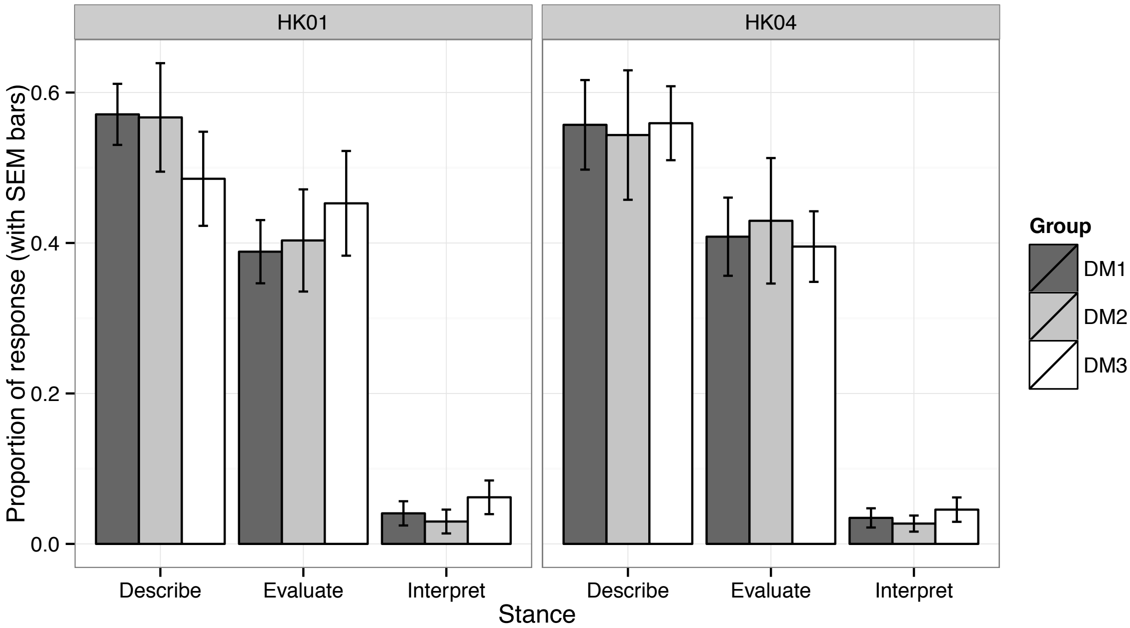


**Figure 4.** Responses for Stance

For Specificity (since it has only two categories which must sum to 100%), we conducted a two-way ANOVA. Bartlett's test for normality showed that the data were suitable for this analysis, $\chi^2(5) = 4.93$, $p = .42$. The ANOVA suggested no differences for group, $F(2, 76) = 0.64$, $p = .53$, for video, $F(1, 76) = 1.18$, $p = .28$, or interaction, $F(2, 76) = 1.75$, $p = .18$. Proportions of response for each category, by group and video, are shown in Fig. 5.

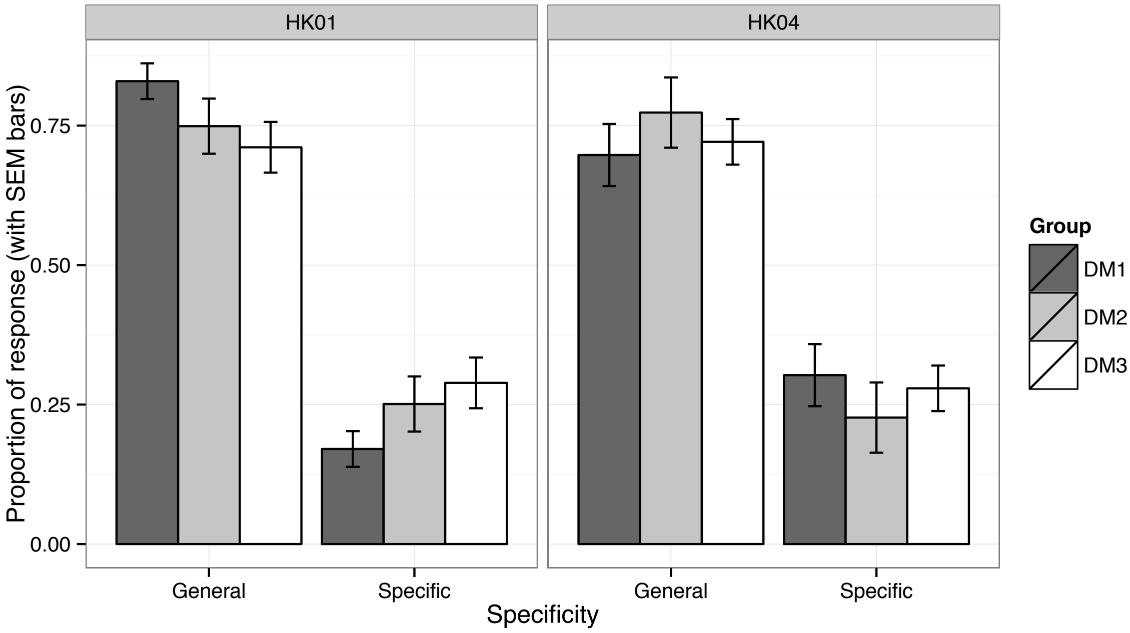


**Figure 5.** Responses for Specificity

Note that, like other studies, this study conflates two effects: DM1, DM2, and DM3 did not merely differ in the extent to which they had undertaken teaching practice, but also in the length of time they had spent undertaking the master's program. However, the lack of main effect for group is telling and suggests that neither teaching practice, nor the extra time spent in the master's program had resulted in the shifting attention seen in the existing literature. While it is possible, of course, that the two effects might counteract each other (extra practice shifting attention towards mathematical thinking and the extra master's program shifting it away, say), this seems rather unlikely. We also note that having the video on CD may have allowed participants the opportunity to view it many times and having subtitles may have distracted them at times from attending to the scene, but given that this was a constant across the groups and we were focused on differences in shifts in patterns of attention, we did not see this as a confounding issue.

So it seems reasonable to conclude from the study that teaching practice alone does not result in the shifts of attention noted in the literature for the PSTs in our sample. It appears that simply adding extra teaching practice for PSTs is not sufficient to shift attention. This seems to provide support for Santagata et al.'s (2007) view, and leads one to wonder if Berliner et al.'s (1988) finding of a difference in noticing tied solely to experience was the result of a methodological artefact or the greater differences between groups in terms of their experience: Berliner contrasted those with no experience of teaching, those just starting their teaching careers and those who not only had more than 5 years' experience of teaching but had been independently judged as exceptional teachers.

More importantly, the main effects for video in our results are worthy of attention. In Study 1, we found that those watching video HK04 focused more on the Curriculum Developer and Mathematical Thinking and less on the Teacher and Classroom Management than those watching HK01, even when we account for the difference between groups. However, in general, the pattern of responses across the videos was quite similar in many dimensions: while there were some statistically significant differences, the shape of the graphs in figure 2 to 5 above are all quite similar (and quite similar to those in other studies, e.g. van Es and Sherin 2010).

One key concern about the design of some existing studies is that pre- and post-intervention tasks used different videos, which one might expect to elicit different patterns of response. For example, van Es and Sherin's (2010) project was based on the group of teachers observing videos of their own lessons, so there were inevitably different videos seen in the first and last sessions, making it impossible to distinguish if differences were attributable to the project or the choice of video. Such conflation of video effect and intervention effect occurs elsewhere (e.g., Stockero 2008). Moreover, where studies use the same video before and after an intervention (e.g., Mitchell and Marin 2015), we cannot distinguish a difference which might be attributed to the intervention and that which might be attributed to a "learning effect" from watching the same video for a second time. For example, it may be that watching a video for a second time, after some intervening weeks, allows one to focus less on surface issues and engage with the contents more deeply, irrespective of any observation training which might have occurred in the meantime.

This led us to question whether some of the findings about the development of professional vision were the result of a failure to adequately balance the choice of video. As a consequence, we developed Study 2.

## 3 Study 2: The Role of Experience of Observation

Study 1 appears to exclude the possibility that the shifts in attention were the result of extra teaching practice for the PSTs on the Didactics of Mathematics program. However, it gives ambiguous results on whether they might have been an artifact of choice of video: on the one hand, the pattern of response did vary between videos in a number of aspects, but on the other, the pattern of responses did look quite similar (and similar to the pattern seen in van Es and Sherin 2010, in a very different context with quite different videos).

Study 2 was developed to follow many aspects of van Es and Sherin's design and the design of Study 1, but with random allocation of videos to observation tasks before and after a short program of guided observations. By randomly allocating each participant to viewing one of two videos before the intervention and the other after the intervention, we avoid confounding the shift in attention attributed to the intervention and the shift attributed to the video, as the group as a whole sees the same two videos at the start and end of the study (and the shift observed is an average across the group as a whole). It also avoids the potential learning effect threat to validity as no individual sees the same video at the start and end of the study.

So Study 2 was designed to replicate the key aspects of the literature - that is, looking at the shifts of attention over a course of video observations - while avoiding the methodological issues of previous work.

**3.1 Methods and participants**

The participants for Study 2 were all Czech mathematics PSTs following the same program as those in Study 1, in a later academic cycle. As in Study 1, there were a mixture of students including some who were already qualified as teachers of other subjects who were seeking to widen their qualification to include mathematics. In total, 32 students participated in this study, which represented all the students in the year group.

The purpose of this study was to see if a short sequence of focused observations of publicly available videos could facilitate the shift in attention which we failed to see in Study 1. In addition, we wished to see if we could discount the potential confounds in previous studies caused by the use of different videos in pre- and post-intervention designs.

The participants undertook three guided observation seminar sessions, with home study tasks, over a three month period, as part of the master's program. The sessions were led by the second author. The participants were randomly assigned to watch and comment on one of the two videos HK01 and HK04 (as used in Study 1) before the first session and the complementary video after the last session. They were not encouraged to talk about the pre-assigned video during the seminars (though, of course, we cannot discount that they did so in casual conversation). It is important to note that, during the intervention, none of the participants had additional assigned teaching practice.

The intervention took the form of three seminars in which participants' discussed their observations of different videos (from the TIMSS 1999 Video Study). It was organized as part of the first mathematics education course. Before each seminar, participants were asked to view videos and submit comments through the program's virtual learning environment (VLE) system where they were available for the course tutor to see. For example, before the first session, the participants watched the CZ02 video (on the formula for the circumference of the circle) and focused their written comments on some specific set areas (such as identifying the phases of the lesson, the way π was deduced, etc.). In the session, the participants shared their comments and then watched and discussed two more video extracts. This cycle of watching videos before the sessions and discussing the comments during them was followed twice more. When videos were not in Czech, subtitles in Czech were provided. As well as discussion about videos in the seminars, the VLE was used for the tasks before the second and third seminars to assign each participant the comments from two other participants to read and write about. This ensured that each participant had to encounter and discuss the views of other participants. However, the sessions did not explicitly introduce an analytic framework or particular lens designed to encourage a particular approach to analyzing videos.

For the pre- and post-intervention video, the procedure for responding matched that in Study 1: they were given unlimited time, no limit on length of response, and a prompt which told them they were not being assessed. They were asked to write about what they found interesting and important.

### 3.2 Analysis

Across the pre- and post-intervention responses, there were 1591 units of analysis. The analysis was conducted as in Study 1, with the same coders assigned randomly to responses and using the same coding manual as developed for Study 1.

### 3.3 Results

The presentation of our results follows the same pattern as that in Study 1. First, we were interested in the length of the responses as a measure of the amount of attention given to the videos. There was a significant effect for group, $t(62) = 3.95$, $p = .00024$, with reports after the video club being on average more than 50% longer than those before it, as shown in Fig. 6.

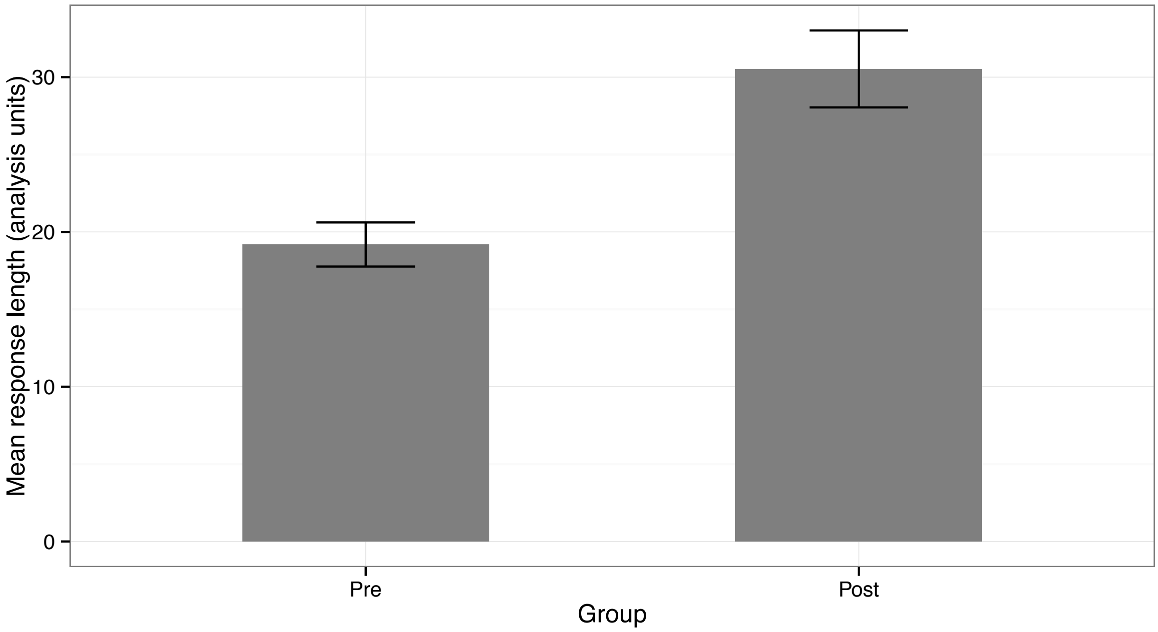


**Figure 6.** Mean response length by group

Fig. 7 shows the mean proportion of responses under each of the Actor categories for the pre- and post-intervention responses. In order to deal with the compositional nature of the data, we again accounted for zeros using the Bayes-Laplace prior approach and transformed the data with an isometric log ratio. We undertook a multivariate analysis of variance (MANOVA) of the transformed proportions of responses against group. Box's M suggested the transformed data acceptably followed a multivariate normal distribution with equal within-group covariance matrices, $\chi^2(10) = 7.7$, $p = .66$.

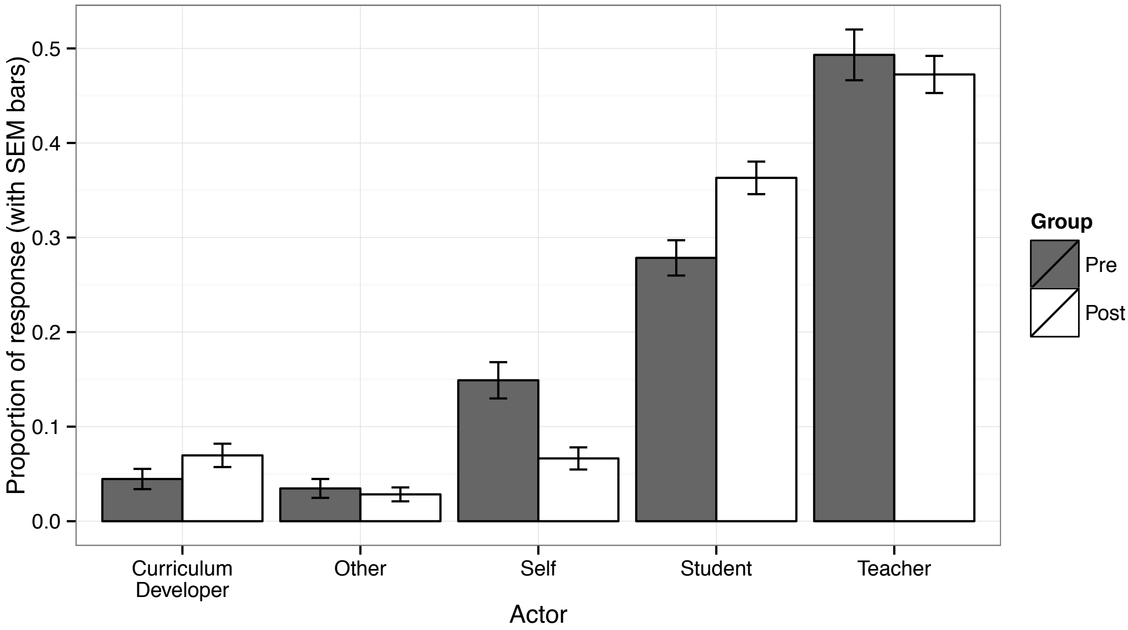


**Figure 7.** Proportion of responses for Actor by group.

The MANOVA showed there was a significant difference between the groups, $F(1, 62) = 7.19$, $p < .0001$. Step-down ANOVAs showed that the differences lay in the proportion of the responses classified as referring to Self, $F(1, 62) = 16.5$, $p = .0001$ and to Student, $F(1, 62) = 15.00$, $p = .0003$. That is, the Actor focus moved away from the self and towards the students, as shown in Fig. 7.

Undertaking the same process for Topic again showed MANOVA assumptions were met, Box's M $\chi^2(6) = 5.33$, $p = .50$. The MANOVA showed there was a significant difference between groups, $F(1, 62) = 3.67$, $p = .017$. Step-down ANOVAs showed that the differences lay in the proportion of responses classified as Mathematical Thinking, $F(1, 62) = 10.24$, $p = .0024$, which increased after the intervention, as shown in Fig. 8.

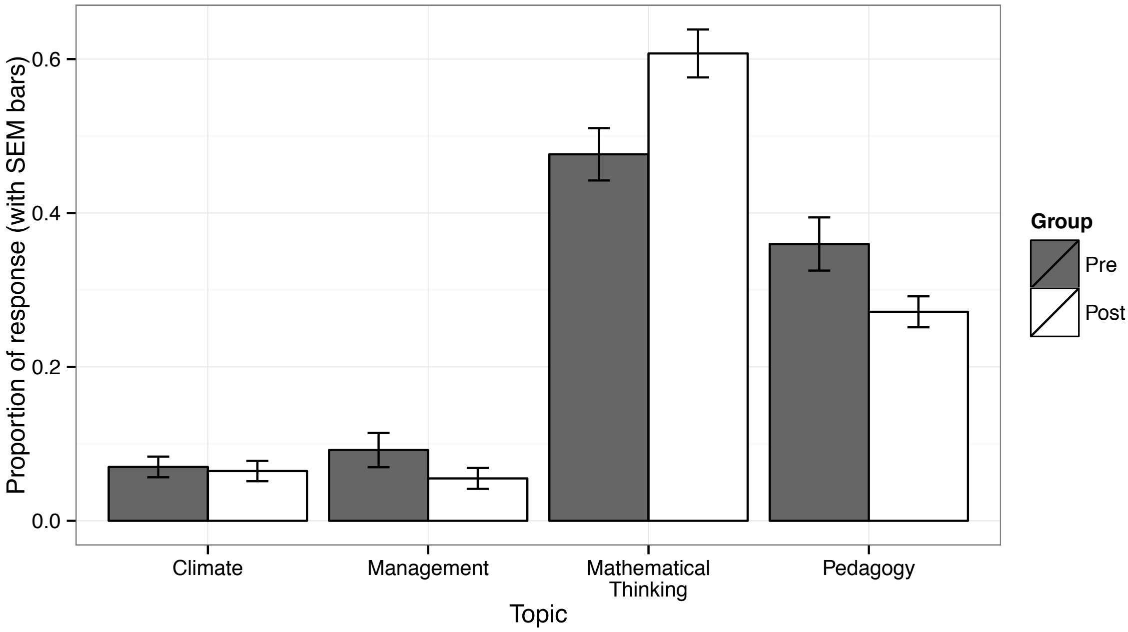


**Figure 8.** Proportion of responses for Topic by group.

Again, with Stance, Box's M suggested the data were suitable for MANOVA, $\chi^2(3) = 1.62$, $p = .65$, and that there was a significant difference across the intervention, $F(1, 62) = 12.1$, $p < .0001$. Step-down ANOVAs showed that all proportion of responses in all three categories changed across the intervention: for Describe, $F(1, 62) = 20.77$, $p < .0001$; for Evaluate, $F(1, 62) = 12.45$, $p = .0008$; for Interpret, $F(1, 62) = 8.72$, $p = .0044$. That is, the stance became more descriptive and less evaluative with less interpretation, as shown in Fig. 9.

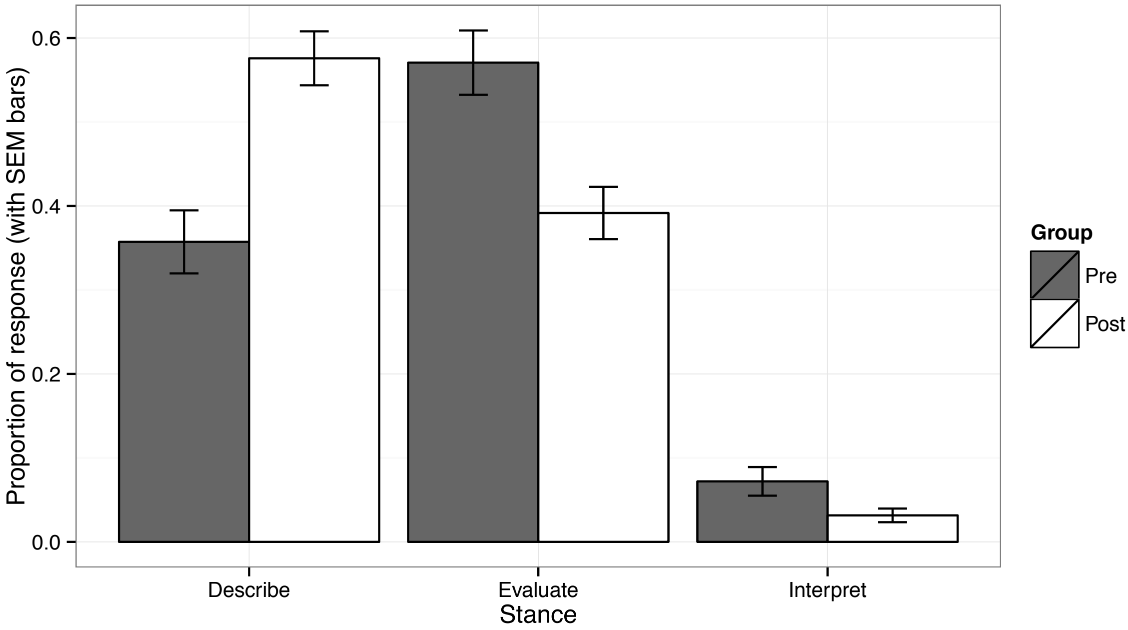


**Figure 9.** Proportion of responses for Stance by group.

A *t* test also showed that the responses were significantly more specific after the intervention, $t(62) = 2.35$, $p = .022$, as shown in Fig. 10.

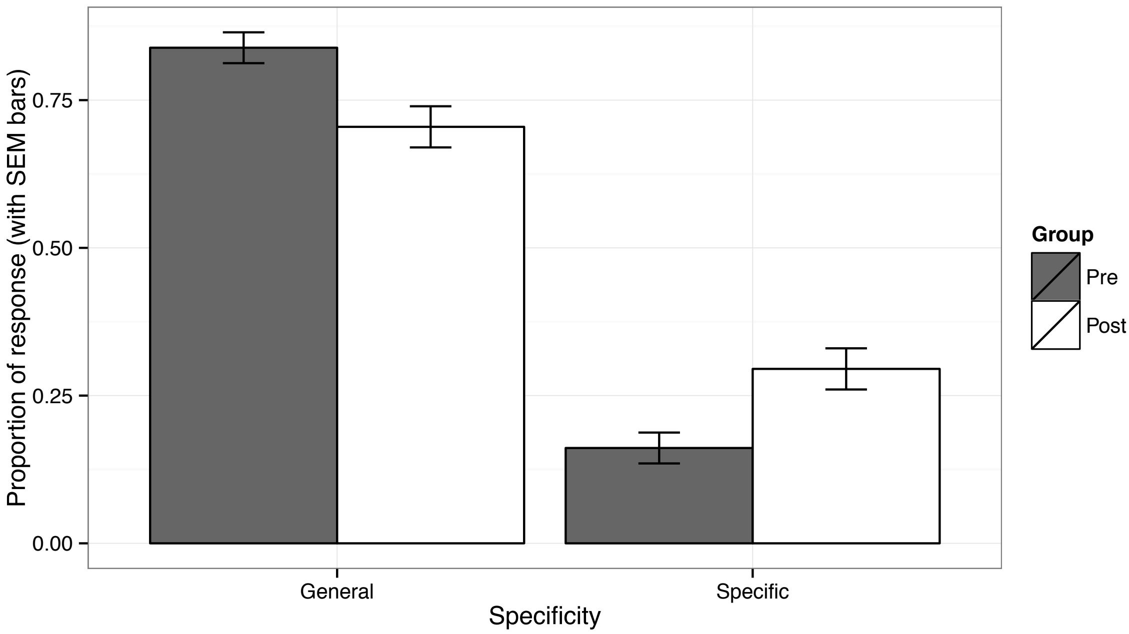


**Figure 10.** Proportion of responses for Specificity by group.

In summary, after the intervention, participants wrote more and, in doing so, they wrote proportionately more about mathematical thinking and the students in the videos, proportionately less about themselves, and they were more specific and descriptive.

## 4 Discussion

We noted earlier that van Es and Sherin (2010) found a shift in attention towards more specific, interpretative comments about mathematical thinking and the students as a result mathematics teachers' engagement in a video club. While developing an increased focus in this way is clearly of value, we argued that many previous studies are unable to distinguish four potential sources of those shifts in attention: increased experience of teaching, differences between the observed videos, a learning effect from seeing the same video twice, and the guided observations taking place in the intervention. Our first study suggested that teaching practice was not a notable factor in shifting the attention of our participants (PSTs who varied in the amount of teaching practice). The only discernible difference which was attributable in part to teaching practice was response length: those who had most teaching practice experience responded at greater length that those with less experience. This appears to agree with Santagata and Yeh (2014), who noted that the ability to focus on students during teaching and in the analysis of teaching did not develop in PSTs simply through fieldwork experience.

The first study also highlighted, unsurprisingly, that there were differences in the pattern of attention which depended on the lesson being observed. This intensified the question of whether the shifts in attention noted in the literature were artifacts of the difference in the videos or a learning effect resulting from seeing the same video twice and not the result of the video observation intervention. This was tested in our second study (by using choices of video balanced across the design of the study and random allocation to each video) along with a key question about whether the kinds of shift in attention we would value in teachers can be achieved in a short sequence of sessions on video observation based on publicly available videos.

The second study suggests a markedly similar shift in attention to that seen by van Es and Sherin (2010): participants commented proportionately more specifically and more about students and mathematical thinking. The only shift we did not observe was increased interpretation; our participants increasingly described and decreasingly evaluated the lessons and also decreased in the proportion of comments about themselves. If anything, the proportion of interpretation was seen to decrease over the course.

This led us to return to the literature to look at the shifts in patterns of attention seen across different papers which use van Es and Sherin's (2010) framework.

## 4.1 A new synthesis of studies

### *4.1.1 Visualising shifts in patterns of attention*

In order to get a sense of how our results compared to the literature, we looked at how the mean responses from the PSTs in Study 2 changed in comparison to responses reported in other studies with similar categorization schemes based on the van Es and Sherin framework. Fig. 11 shows the ternary diagram illustrating the change in the focus on Actor for the PSTs in Study 2 alongside those for Mitchell and Marin (2015), the two studies reported by Sherin and van Es (2009), and the study by van Es and Sherin (2010). Each arrow represents the shift in the mean proportions of responses categorized as Student, Teacher, or anything else for one study. For example, in van Es and Sherin (2010), the ratio of Student : Teacher : Other moved from 44 : 17 : 39 to 70 : 7 : 23 (one can read this from the diagram by seeing, for example, that if you project from the tail of the arrow heading 60$^{o}$ down and left, one hits the 'Student' axis at 44; horizontally, one hits the 'Teacher' axis at 17, and heading 60$^{o}$ up and right, one hits the 'Other' axis at 39, while projecting the head of the arrow in the same directions one hits the axes at 70, 7 and 23 respectively). This diagram would suggest that our participants moved in a similar direction to those in other studies: with an increased focus on the students.

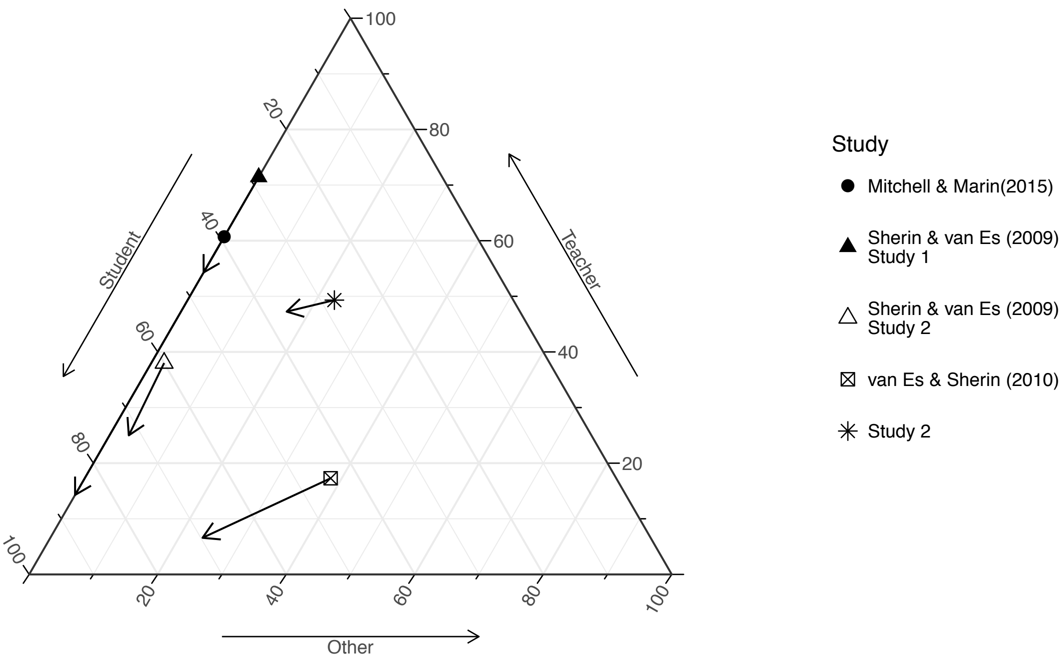


**Figure 11.** Shifts in focus on Actor across different studies

Fig. 12 shows the ternary diagram for Topic (projected onto ternary axes for Mathematical Thinking, Pedagogy, and anything else) for the same studies. It suggests a general movement in most studies directly towards mathematical thinking, albeit that Mitchell and Marin's (2015) participants also moved towards pedagogy and away from the 'other' category (which included Climate and Management). It may be that the difference in this shift with Mitchell and Marin (2015) can be accounted for by their use of the targeted MQI framework which may directly encourage the move away from the initial focus on climate.

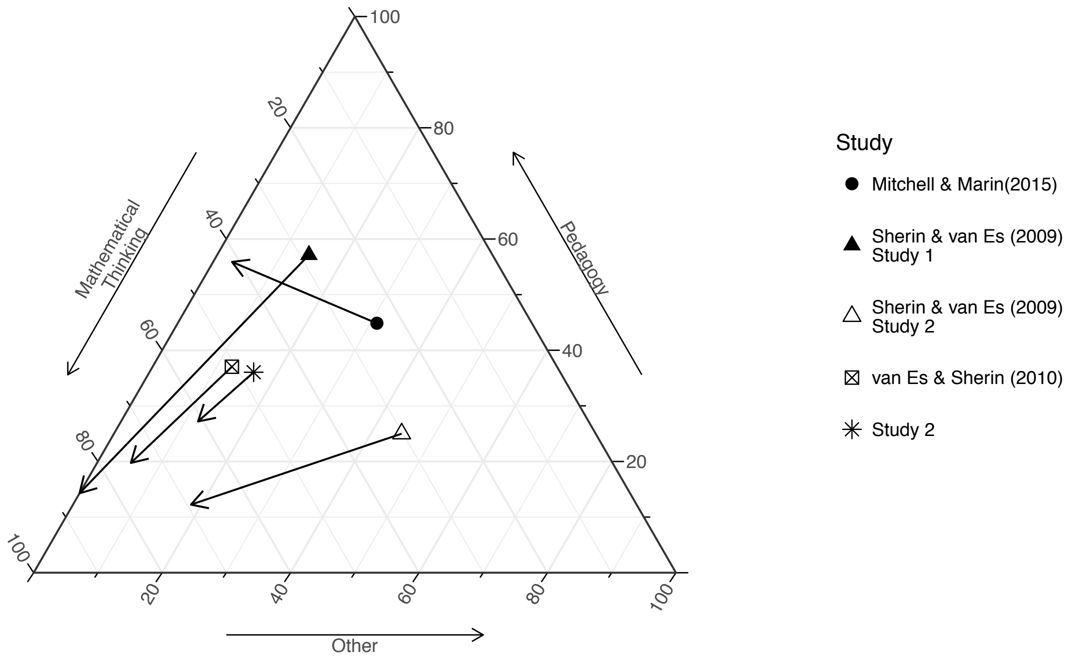


**Figure 12.** Shifts in focus on Topic across different studies

Fig. 13 shows the ternary diagram for Stance for these studies and the two studies in Blomberg et al. (2014), who directly measured stance across repeated meetings of two differently taught video interventions. This figure seems to show two quite different patterns of response. In the studies by Sherin and van Es (2009) and van Es and Sherin (2010), there is a very direct movement towards increased interpretation with roughly balanced decreases in description and evaluation. However, Mitchell and Marin (2015), Blomberg et al. (2014), and our Study 2 all show increases in description, generally at the expense of evaluation.

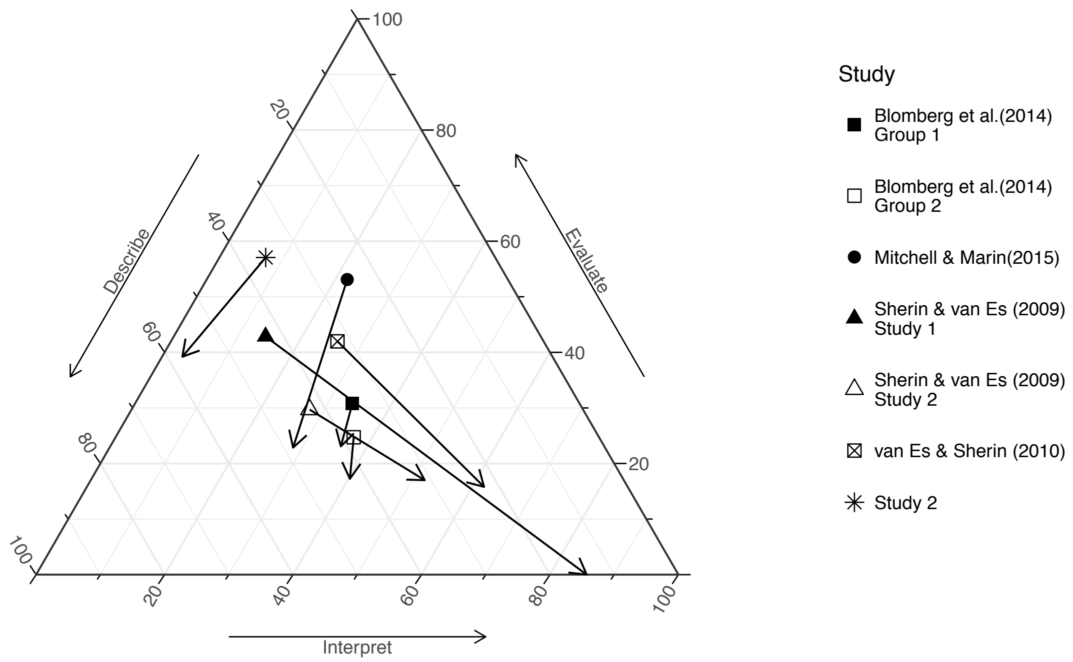


**Figure 13.** Shifts in focus on Stance across different studies

These figures suggest some important differences within the literature. All of the studies (including our own) indicate shifts in attention towards the student and mathematical thinking, but Fig. 13 suggests a split between some studies which show increased interpretation (at the expense of both description and evaluation) and some with little if any increase in interpretation, just a shift from evaluation to description.

*4.1.2 Accounting for differences in shifts of attention*

When we consider the nature of these different studies, it suggests a range of possible explanations. It remains possible that the cause is the potential confounds in the approach taken in the study and discussed above: the videos at the end of van Es and Sherin's video clubs may have been more open to interpretation, or the additional experience of teaching gained simultaneously may have led the teachers to take an interpretative stance. But these seem unlikely explanations for this difference.

It may also be possible that the framework is being used in different ways by different research groups. For example, van Es and Sherin may have had a somewhat different meaning or lower threshold for what counted as "interpret" than that being used by Blomberg et al. (2014), Mitchell and Marin (2015), and us. It may also have been the case that the video clubs run by van Es and Sherin modelled talking about the videos in a more directive way, placing much more direct focus on interpretation. Given the consistency in all other areas, however, we think this less likely than one of the following structural causes.

It has been noted that different forms of intervention can lead to some different outcomes. For example, Santagata and Angelici (2010) noted that PSTs who underwent a program with the Lesson Analysis Framework had more elaborate and higher quality responses than those who underwent a program with a Teacher Rating Framework. So one possibility is that van Es and Sherin's program had some aspects in it which directly led to more interpretation.

It is also noticeable that the three studies across van Es and Sherin (2010) and Sherin and van Es (2009) involve experienced teachers commenting on their own videos (and those of their peers), while those of Blomberg et al. (2014), Mitchell and Marin (2015), and our Study 2 involve PSTs watching videos of other people teaching. This suggests two more likely possibilities which would require further research: it may require the use of one's own videos (or those of people one comes to know) to shift attention towards interpretation or it may need a *combination* of teaching experience and guided observation activities to facilitate this shift to interpretation. Both of these seem plausible. We can presume that it is easier to interpret observed incidents in videos if you are an actor in them: you do not have to second guess the intentions of the teacher if you are the teacher (or if the teacher can be asked when they are sitting beside you in the discussion).

There is mixed evidence on this issue. Seidel et al. (2011) showed that science teachers watching videos of their own (and their colleagues') lessons focused more on components of teacher guidance and scientific inquiry but were less critical, identified fewer consequences and had fewer alternatives than the group who had watched videos of lessons taught by others.

Equally, it may be that teachers at different stages of their career and development are affected differently by video interventions in this one area. Schoenfeld (2011) argues that noticing is tied to teachers' orientations, resources, and goals and these inevitably change with experience (as well as vary between individuals). In terms of observing a classroom, then, PSTs may need to use most their observational resources simply to describe what they see. More experienced teachers, who are more practiced in seeing and talking about classrooms, need not expend as much resource in description and can shift resource to interpretation. That is, we may be seeing two short segments of a longer path: first from evaluation to description and second from description to interpretation, both of which are facilitated by guided observation programs.

Both this influence of much longer experience associated with practicing teachers compared to PSTs and the influence of using the teachers' own videos seem to be open and interesting questions for the future.

## 5 Conclusions

Our second study provides support for the idea that even a short but focused video observation course can facilitate a shift to more expert-like patterns of attention. Taken together with the first study, it suggests that potential confounds within the literature (that the shift may be the consequence of teaching experience, the use of different pre- and post-intervention videos or a 'learning effect' in the measures of noticing) are less likely to be the cause than the video based intervention. However, in illustrating the shifts in patterns of attention in our participant group alongside those of other researchers using the same framework, we notice some important discrepancies.

In most dimensions, all of the comparable studies point to shifts in roughly the same direction: towards the student and towards mathematical thinking. However, it appears that only studies with practicing teachers analyzing their own videos led to increased interpretation.

We chose the phrase "patterns of attention" to distinguish the first of the three processes which are taken to make up teachers' professional vision. Jacobs et al. (2010) distinguish attending from interpreting from deciding how to respond. When our study is viewed alongside Blomberg et al. (2014) and Mitchell and Marin (2015), it suggests that much as a video observation course may facilitate shifts to more expert-like attention, it does not facilitate shifts to interpretation, which may require much more teaching experience before it can develop.

Of course, just as we have highlighted potential limitations and confounds in existing studies, our study has some obvious limitations. In their critique of the field, Sherin and Star (2011) comment that studies such as those in the literature cited here and our own are "meters [which] tell us something about emergent features of teacher reasoning. But they do not, in any direct way, tell us anything about the underlying noticing machinery that produced those emergent features" (p. 76). That is, even though our study is more fine grained and is less affected by confounds than others, our measures are still measures of *what* and not *why*. Like others, we can see and report on shifts in attention, but we do not know from our measures why it has shifted. Neither can we report here on the quality of the attention. That would require a different approach to the data and something we have only begun to consider in relation to the quality of noticing of mathematics specific phenomena (Authors 2015).

In addition, our focus was only on the first level of teacher professional vision – pattern of attention. This is the core of the framework we were using. Other researchers have scanned more widely and looked at how PSTs and practicing teachers use more theory or make different decisions about potential responses to what they observe.

However, our research does suggest some possible implications for practice, particularly in the development of pre-service courses. One of the confounds we seem to be able to discount is that shifts in attention are simply the consequence of teaching practice. It does not seem that doing more practice placements leads to more expert-like noticing. Instead, it suggests that at least some elements of professional vision can be attained through a short and focused course in which PSTs are guided through the observation and analysis of videoed lessons.

Our analysis also suggests one possibility for the somewhat mixed messages about increased interpretation: that the path to more expert-like noticing may not be straightforward. With PSTs, Blomberg et al. (2014), Mitchell and Marin (2015) and our Study 2 do not show the same increase in interpretation or theorizing seen in the various van Es and Sherin studies. While more research may be needed to map this path in more detail, this might suggest that teacher education programs might need two distinct phases to develop noticing: the first concentrated on shifting attention and the second on theorizing. The first may be suitable for an initial teacher education course, the second may need longer term continuing professional development.

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