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Collective noticing of teacher lesson design

COLLECTIVE CURRICULAR NOTICING WITHIN A MATHEMATICS PROFESSIONAL LEARNING COMMUNITY

Erin Barno
Boston University
ebarno@bu.edu

Leslie Dietiker
Boston University
dietiker@bu.edu

This paper explores how a professional learning community (PLC) redesigns high school mathematics lessons towards a shared commitment. We describe the nature of a PLC's collective curricular vision to illuminate how teachers can come to new understandings as a group in order to shift the ways students experience mathematics. Using the curricular noticing framework (attending, interpreting, and responding), we analyzed the meetings of a PLC with six teachers as they individually presented lessons to be redesigned with a focus on the group's shared commitment. Findings indicate three ways ideas were introduced that led to expansive responses, which suggests this analytic approach could identify ways in which a PLC can work towards new curricular decisions.

Keywords: Curriculum, Teacher Noticing, Teacher Beliefs

A central part of mathematics teaching is the design of lessons within a system of constraints (Brown, 2009). After teaching a lesson, teachers may reconsider specific design decisions based on their individual interpretations of the enacted lesson (what we refer to as *redesign*). Recognizing new curricular opportunities, however, is then limited to what prior experiences this individual teacher has had and what personal frameworks they use to make sense of their curriculum (what we refer to as *curricular vision*) (Darling-Hammond et al., 2005; Drake & Sherin, 2009). Teachers work under the demands of larger systemic constraints (e.g., policy, social messages of learning loss) as well as local constraints (e.g., administrative agendas with standardized testing, co-planning opportunities, curriculum access). Teachers, therefore, are limited within their redesign decisions — not by choice, but by pressure.

We are concerned that these constraints on curricular decision-making may prevent teachers from making ambitious changes to their teaching, thus maintaining the status quo for their students' experience and learning. Redesigning a lesson with other teachers that reimagines a given individual's curricular vision by challenging the given constraints can enable different types of experiences to inform teacher curricular decisions. When teachers are members of a professional learning community ("PLC") committed to a shared curricular vision, individuals then have new things to consider, negotiate, and think about in their own redesign choices. Therefore, we are interested in understanding the nature of collective redesign to illuminate how PLCs can come to new understandings as a group with a shared commitment in order to shift the ways students experience mathematics.

In this paper, we begin to answer the questions: (1) *What is the nature of curricular decision making for teachers with a shared design commitment in a PLC?* and (2) *What enables an expansive curricular decision?* We will illustrate how a group of teachers collectively arrived at and engaged with decision decisions that expanded potential opportunities for students. With better understanding of the potential ways groups of teachers can collectively redesign lessons, we hope to inform how PLCs with a shared commitment can potentially catalyze broader opportunities for students in mathematics classrooms.

Theoretical Framework

We use the *curricular noticing framework* (attending, interpreting, and responding) as a way to trace and describe the nature of lesson redesign in the PLC individually and across a group.

Curricular Noticing

Any decision that a teacher makes as part of the profession is shaped by the lenses (*interpretation)* with which they engage. Additionally, teachers' designs are also influenced by the phenomena (e.g., student work, textbook tasks, assessment data) to which they pay attention (*attending)*. Together, these contribute to a teacher's professional decisions to act (*responding*). Teacher's shifting lenses can contribute to teachers *attending* to, *interpreting*, and making pedagogical *responses* consistent with a particular goal when reflecting on a lesson enactment (Baldinger, 2017; Louie, 2018; Louie et al., 2021; van Es et al., 2014). *Curricular noticing* builds on the teacher noticing framework to describe how the phases of noticing (attending, interpreting, and responding) take place when teachers are designing or adopting any form of curricular materials (e.g., textbooks, enacted videos of lessons) (author, year). Although teachers may pass through a sequence of attending-interpreting-responding ("A-I-R"), the phases are not strictly sequential so that, for example, an interpretation may cause a teacher to redirect their attention. In addition, not all may lead to curricular decisions. For example, a teacher's interpretation that follows their attention may lead them to decide to not move forward with a particular action (i.e., response).

Increasingly, the noticing framework has begun to provide insight into how teachers identify patterns towards challenging systemic inequities in mathematics classrooms. Research in teacher noticing has begun to explore how individual teaching stances, such as deficit perspectives (Louie, 2018; Louie et al., 2021) or particular goals (Hand, 2012) can influence the extent to which teachers' interpretations lead to disrupting or perpetuating inequitable practices via responses. However, curricular noticing has not yet explored how a teacher's frameworks (i.e., curricular vision) can impact possible curricular responses. We argue that curricular noticing can support our understanding of how teachers challenge and disrupt systematic patterns of thinking due to the structural systems of schooling and testing, particularly within mathematics education.

Curricular Vision as a Commitment within PLCs

An individual's curricular vision, when interacting with others' own curricular vision, can create disruptive *responses* within group lesson design. Because curricular noticing happens from the standpoint of an individual's curricular vision (Dietiker et al., 2018), a group of individuals working together in a PLC means there are multiple curricular visions (potentially overlapping or shared in some cases). These curricular visions are positioned to interact and influence what responses are possible from individuals within the PLC and the PLC as a collective. When a group of teachers choose to align their own curricular visions towards new possibilities (which we will call *collective curricular vision*), their collaboration can support curricular responses related to students' potential mathematical learning experiences in new ways.

We conceptualize this shared stance for a collective curricular vision as a form of *commitment*. Evidence of a member's commitment to the collective curricular vision, therefore, is the explicit intention of aligning to a shared stance based not only on personal frameworks but also shared frameworks. The connection between a groups' shared commitment and the alignment to that commitment can either make space for new types of curricular responses (what we will call *expansive* responses) or prevent curricular responses from taking form during a group conversation (what we will call *restrictive* responses).

Methods

This study is a qualitative analysis of a lesson redesign meeting with a group of teachers with a shared commitment for how their interactions led to potential expansive opportunities for students. Pairs of teachers from three high schools (one urban comprehensive public school, one suburban comprehensive public school, and one urban private charter) in the Northeast were selected to participate. The 6 teachers, along with 2 researchers, participated in the redesign meeting. At this meeting, teachers took turns sharing video clips and data from a lesson they had taught the previous year and which they wanted to redesign. The data used here is based on audio recordings of workshops between the teacher who shared the lesson (the "lead teacher") and other teachers in the professional learning community. This design group was part of a larger project aimed at creating aesthetic opportunities for their students. Using video of enacted lessons as a form of curricular materials allows for curricular noticing to take in embodied, emotional, and verbal expressions of mathematics engagement.

Case Selection Process

Of the six redesign meetings, two were selected to be analyzed. To select, we looked for three qualities: (1) the participation of multiple members of the group; (2) conversation that specifically attended to the shape of content (i.e., curricular); and (3) conversation that included reference to the shared commitment: improving students' aesthetic opportunities.

In one session, Ms. Elm presents a lesson she previously designed and taught about the Rational Root Theorem (RRT). In another, Ms. Willow, presented an introduction to inverses lesson that she designed, taught, and wanted to redesign. Both of these audio recordings met the above three criteria, and had 5-minute segments that included all three pieces of criteria. These 5-minute segments were chosen for in-detailed analysis because of clear evidence of individual's members noticing and the noticing across members of the PLC. Therefore, the described segments show examples of exchanges towards expansive or restrictive responses.

Analytical Methods

The audio recordings were transcribed and analyzed for their curricular noticing (Dietiker et al., 2018). To identify instances of *curricular attending*, we analyzed the discourse for evidence of teachers "taking in" (ibid, p. 525) what was under discussion (e.g., presented by the lead teacher or introduced by another member of the PLC). To identify instances of *curricular interpreting*, we analyzed the discourse for evidence that a teacher made sense of what was attended to using their knowledge base in relation to their goals (e.g., evaluating a suggestion for its benefits). Finally, we identified instances of *curricular responding* by looking at decisions of action, both proposed and accepted (i.e., selecting a polynomial).

For each coded utterance, we analyzed how it related to the prior coded utterances. For example, when analyzing a coded utterance, we asked "was there a prior moment of attending, interpreting, or responding to another utterance that supported this utterance?" After compiling these threads of connected utterances, we identified the types of threads that emerged most frequently and connected to the groups' expansive responses.

Findings

With a collective curricular vision in a PLC, we found that the curricular noticing of the group of teachers were collectively shaped as follows: 1) prior responses were pulled back into the discourse as something to attend to, 2) prior interpretations were pulled back into the discourse as something to attend to with new interpretation, and 3) prior responses were impacted by the shifts in collective attending and interpreting. These characteristics, in turn, enabled this group to generate expansive responses. To show this, we present two exchanges

from different parts of the design meeting to illustrate each of these characteristics, and describe how those either led to restrictive or expansive responses. In the first, based on a lesson on the RRT, all three characteristics were present and described. In the second, focused on redesigning a lesson that is an introduction to inverse functions, two of the three characteristics were present and described. In the first, based on a lesson on the RRT, all three characteristics were present and described. In the second, focused on redesigning a lesson that is an introduction to inverses, two of the three characteristics were present and described.

The Collective Redesign of Ms. Elm's Lesson on the Rational Root Theorem

Summary of Design Meeting. [1] At the start, the group watched an abbreviated video of key moments of the lesson enacted the prior year, selected by Ms. Elm. In this lesson, Ms. Elm had students use guess and check to test potential roots of given polynomials (cubic functions and quartic functions) in order to conjecture the RRT. Within this context, Ms. Elm presented the guess and check process as identifying "suspects" towards solving the mystery of the corresponding polynomial roots. She grappled with a tension; how could the lesson have students eliminate roots in such a way that they have time to understand the concept behind the RRT while keeping the aesthetic potential of mystery intact.

[2] After viewing the video, Ms. Spruce says:

> I loved the four guesses part…that was where you could definitely see like the kids [snapping], getting excited. What I wondered was... could you implement that earlier? To like generate more excitement…as you go up in degree and complexity, start taking away the number of guesses, because I think that would also generate the sense of…excitement, but in between there do some stuff to facilitate…better guesses

[3] Immediately after this comment, Mr. Palm points out that there was no evidence of students' verbally articulating what the learning objective is, and raises a question about the curricular goal of the lesson (ex: "do you want them, by the end of this…?"), offering multiple potential learning objective goals. [4] Ms. Elm replies:

> I mean ideally, I would love them to do all the things you said…that's really a tall order for one period...the key piece…sometimes there are so many potential factors that [the RRT] doesn't seem very efficient, but as the polynomial becomes more depressed, like that process is super-efficient when you're looking at your new p and q… If there's any way... um... but like I don't know if we ever got to that idea, so, um...I just don't know.

[5] As the conversation progresses, Ms. Spruce continues thinking aloud about the polynomial's leading coefficient (p) and its constant (q), suggesting that students, although not yet understanding the relationship between the roots and the polynomials, might get a sense of what could be a root. Ms. Willow and Ms. Elm continue to discuss how students' intuitive sense of numbers can lead them to making connections. [6] Ms. Willow suggests changing the polynomials to encourage students to focus on the coefficients. [7] Ms. Elm builds on this by saying that the new choice of coefficients should not visually mislead students (such as having p=1 and q=5 when the roots are not 1 and 5. [8] Ms. Spruce jumps in and describes this option as "kinda interesting," which [9] is echoed by Mr. Ash as a potential moment of "beauty."

Characteristic 1: Attending to a Prior Response. In [2], Ms. Spruce drew *attention* to the students' embodied reaction to the prior design choice of guesses. This focus on students' emotional and aesthetic reaction is connected to the larger groups' commitment toward captivating lessons. Then in [5], Ms. Spruce *attended* to her prior *response*, interpreting it as a way to connect to students' intuitive sense around numbers (i.e., connecting roots with the

coefficients). Others continue *attending* to students' aesthetic reactions via numerical attunement [6, 7] and embodied excitement [9]. Collectively, these responses change the direction of the redesign; the focus on the original lesson in terms of students' articulating learning objectives shifted toward how the problems can make space for an increased aesthetic experience in a way that also contributes to students' learning.

Alternatively, this characteristic can limit curricular responding, such as in the case of Ms. Elm [4] attending to Mr. Palm's response [3]. The expansiveness of future responses began to close — her use of "I don't know" signifies that Mr. Palm's utterance overwhelmed her from responding at all. Unlike the previous example, here an A-I-R chain begun in [2] was interrupted.

Characteristic 2: New Attending and Interpretation of a Prior Response. Ms. Willow's prior *response* in [6] suggests that coefficients should be selected in such a way that students are learning through their intuitive sense. However, Ms. Elm in [7] *attends* to and *interprets* numerical attunement as misleading and unsupportive of sensemaking. This leads to a new *response* of a lesson design that does not have the potential to mislead students. Although this example can be read as one that restricts responses, the fact that the utterance [7] named a design challenge actually positioned the group to consider responding in two ways one, to either resolve that problem through a design-related response, or two, to shift what was attended to how it was interpreted that allows for a new expansive response. Therefore, the act of attending and interpreting a prior response enabled the group to name a problem, creating an opportunity to think more deeply about lesson redesign towards the shared commitment of student aesthetic experience [8-9].

Characteristic 3: Attending to Prior Interpretation. When Ms. Elm's *interpretation* in [7] was then *attended* to by Ms. Spruce [8], a new opportunity for students' aesthetic responses was created (i.e., the tension could potentially lead to a moment of excitement when students are able to find a pattern). This made space to consider aesthetic opportunities within the redesign. So, although the interpretation of the problem set in relation to students' numerical intuition was named as a potential issue [7], that interpretation was expansive because it was considering aesthetic characteristics within a lesson redesign. So, not only did that initial interpretation encourage continued noticing around aesthetic, but also made space for the reframing of the interpretation as an opportunity [8], which, in turn, acts as an example of enabling a subsequent expansive response.

The Collective Redesign of Ms. Willow's Lesson on Introduction to Inverses

Summary of Design Meeting. [1] In the beginning of this episode, the PLC is discussing how to adapt the opening task from the original lesson. [2] Ms. Dogwood proposes prompting students to compose $x^2 + 3$ and $\sqrt{x-3}$. [3] Ms. Spruce follows by saying, "Do you want them to have that in their minds when they go to [Problem] three?", which asks students to match functions that are inverses from a list of linear functions. Ms. Willow share this concern, saying:

> [4] Ms. Willow: Oh, I see, because then I might be giving them stuff that has squaring…
> [5] Ms. Spruce: Which isn't necessarily the end of the world, if you allow yourself to have awareness…
> [6] Mr. Ash: You could just ask for linear(s). Like on [Problem] 3…you could restrict [the given types of functions].

Following this moment, the group discusses the difficulty students might have with simplifying the composed functions. This includes [7] Ms. Dogwood wondering if students

would know to "square out" a radical, [8] Ms. Willow naming that doing so would be "really hard," and [9] Ms. Dogwood describes this process as "ugly."

[10] Ms. Willow then suggests creating a problem within the set that requires three operations to simplify the composed functions. She continues [11] by saying the three steps could more clearly illustrate the "doing and undoing" that is key to inverse functions, compared to prior suggestions that potentially resulted in the composition not "coming out nice." [12] Ms. Dogwood, in turn, articulates how inputs could influence whether the composition is "nice" and responds by suggesting that the group thinks of problems that would have a "nice" composition with the original problem's "yucky" elements (such as fractions). Ms. Willow continues:

> [13] Ms. Willow: I'm worried though, because if they try composing these…it would be three halves times two-thirds *x* plus one minus one… they're gonna be like, 'Oh, okay, so that's like *x* plus one minus one, it cancels out…
> [14] Mr. Ash: But that would be a nice opportunity for you to…because that's a common mistake that you saw happening later on…[say] maybe 'here's an opportunity, don't forget to distribute.'
> [15] Ms. Dogwood: But I think Ms. Willow's wondering…how can [the students] trouble that's not right? Then your question begs, like, 'how come? We have to distribute."
> [16] Ms. Willow: I don't know how that will make them feel when we do all the canceling…like, if they just tried to cancel and it didn't work, then suddenly all this canceling *does* work, does that feel better or worse?
> [17] Ms. Cherry: Well maybe they understand *why* it's so special, like *woah*, you know? Because everything cancels out.

Characteristic 1: Attending to a Prior Response. When considering Mr. Ash's [6] use of the prior *response* [3], we see how he encouraged the PLC to design in such a way that considers students' intuitive number sense to understand why the functions are inverses. When bringing Ms. Spruce's [3] response back into as something to *attend* to, Mr. Ash [6] opens the community to consider how clarifying what students have in their minds could be influenced by a restriction to the types of problems being presented. So, Mr. Ash *responds* by suggesting that restricting the problem set to linear equations (as opposed to incorporating quadratics and square root functions as inverse pairs) could serve as a better way to focus students' attention.

In another moment, we see a sequence of utterances where what is attended to stems from a prior utterance's response. An example of this starts when Ms. Willow [13] *attends* to Ms. Dogwood's *response* in [12] to create a pair of functions that, when composed, is "nice," although the coefficients may be "yucky." Ms. Willow *responds* [13] by naming that students' intuitive sense of what cancels could also be an issue towards their understanding of inverses and what actually cancels. Then Ms. Willow's *response* [13] was then attended to by Mr. Ash in [14], where this could be leveraged to support their conceptual understanding of the need to distribute [16]. This illustrates how prior responses that are pulled back into the discourse can result in expansive responses when the process is compounded by happening multiple times in a row.

In another example, the PLC *attends* to prior *responses* of multiple members of the group at the same time. Ms. Dogwood [15] draws *attention* to both Ms. Willow's [13] and Mr. Ash's [14] prior *responses* about students' intuitive sense by interpreting students' need to challenge their intuitive sense of canceling (as opposed to just refocusing the attention). This happens again when Ms. Cherry [17] *attends* to the same two *responses* that Ms. Dogwood just *attended* to. Here, Ms. Cherry interprets those responses by naming the importance of students understanding

why the expressions cancel in order to have a positive aesthetic experience while canceling. This interpretation results in a new response where Ms. Cherry suggests that some of the tensions named in the prior responses could potentially be a moment where students "understand why [composing inverses] is so special."

Characteristic 2: New Attending and Interpretation of a Prior Response. Ms. Spruce, in [3], *responded* when she suggested clarifying what the lead teacher (Ms. Willow) wanted students to have in their minds while solving the subsequent problems. Ms. Willow [4] *attended* to Ms. Dogwood's original *attending* in [2], but *interprets* it using Ms. Spruce's [3] *interpretation* of how prior problems in the set could influence their approach to new problems. Ms. Willow's *response* [4], in turn, becomes the same *response* that Ms. Spruce previously had — that is, that the lead teacher (here, being Ms. Willow herself) needs to clarify what she wants students to have in their mind. So, although it could be said that Ms. Willow did not contribute anything novel to the conversation, she was able to elevate the prior response in a way where members of the PLC could recognize the design challenge as Ms. Willow was *interpreting* it in relation to the commitment.

Another instance where prior *responses* are reimagined with new *attending* and *interpreting* is when Ms. Willow [16] refines the *response* of students' intuitive sense of what cancels as an issue. Here, she highlights the need to design problems that do not confuse students by *attending* to students' embodied feelings of when canceling "works" or "doesn't" work. So, Ms. Willow brings in the *interpretation* that students can feel better or worse when there are "inconsistent" responses with canceling. This new *attending* and *interpreting* of prior *responses* now brings in students' affective reactions when considering their intuitive sense of numbers and the relationship to the problem set. So, instead of only focusing on how students can mislead themselves or on the "ah-ha!" moments that students might have due to their intuition, Ms. Willow draws *attention* to the tensions that might arise during the lesson. This reimagining oriented teachers to the broader affective experience that students may have when engaging with this topic through new expansive *responses*. Students' opportunities to have positive aesthetic experiences, on the other hand, may have been restricted if the PLC had not considered the broader affective experience as presented within the redesign.

Discussion

By highlighting the role of collective curricular vision, this paper argues how teachers who collectively redesign lessons with a shared commitment can shift their attention and interpretation of what other teachers offer towards more expansive views of mathematics learning. When a PLC's collective curricular noticing is guided by a commitment that intentionally disrupts constraints within the design process, such as attending to students' emotional reaction to a mathematical concept over attending to standardized testing scores, the way in which noticing functions within the collective can lead to *expansive* responses. In addition, when a PLC's curricular noticing, despite being guided by a shared commitment, tends to stray away from the collective beliefs in any capacity (such as reinforcing design habits that are traditionally inequitable, redirecting the group from an expansive response), *restrictive* responses can emerge. In terms of the curricular noticing framework, we can see an alignment to the collective curricular vision's commitment through (a) what an individual decides to attend, interpret, or respond to with during PLC conversations, and (b) the expansiveness or restrictiveness of resulting responses. This, in turn, informs curricular responses toward reimagined ways for students to think about, engage with, and experience mathematics.

Analyzing curricular noticing as a collective practice within the curricular noticing framework sheds light on the way in which teachers are listening to each other, considering different ideas, and hearing other teachers' own attending, interpreting, and responding to the *same* noticing within the same discussion. Being able to trace the way in which members of a PLC build upon each other's contributions shows that a response helps move the group towards deeply understanding what they care about in terms of the shared commitment; we are now able to see how this is done by tracing the process of fine-tuning the question they are *really* vexed with to ensure the PLC's commitment is salient in how decisions are made within the redesign. Although individuals in a PLC bring in their own interpretations through their experiences, they are being exposed to and building off of the noticing that is happening within the collective.

This analysis illustrates that, through the product of years of teaching, collective sensemaking around aesthetic, and co-design work as part of a PLC, expansive curricular responses are possible through emergent discourse. Identifying this contributes to the mathematics education field by shedding light on the nature of collective curricular noticing and how expansive curricular responding develops in response to a shared commitment and a space to design lessons aligned to that commitment. Knowing this, there is a call for PLCs to develop a curricular vision around a shared commitment, such as increasing aesthetic opportunities for students. With this in place, we can begin to think about the emergence of expansive curricular noticing across redesign sessions between educators. This focus opens up potential opportunities for students — when a teachers' curricular noticing is including and expanding beyond content goals, a students' learning experience can begin to include a wider range of experiences is equally if not more important towards shaping an enjoyable, expansive, and engaging learning experience for young people in a space that typically marginalizes them. A shared attunement to an expansive ideology (be it aesthetic, or another touchstone towards a more equitable learning space), and the resulting curricular responses, has the potential to become expansive when rooted in a professional learning community.

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