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A Different "Noticing": Examining Principal Perceptions of STEM Instruction

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Abstract

This exploratory study investigated the instructional perceptions of four middle school principals regarding STEM instruction. By seeking to better understand their own experiences as teachers and administrators, their preferred teaching style, their use of observation instruments, their vision of STEM instruction, and their practices regarding observation and feedback in the middle school level, the researchers sought to provide insights on how principals perceive STEM instruction and their role in working with teachers. Four principals were showed clips of classroom mathematics instruction. As the four principals' perceptions and feedback varied, it indeed appears that there was a different "noticing" apparent even though these four middle school principals served within the same district and had experience with the same observation protocols and related trainings. Based upon the narratives provided by the four administrators, it was determined that there is divergence in identifying what good STEM instruction is. It is evident from the principal interviews that feedback can vary from person to person even when employing the same observation protocol and training. Given the lack of STEM instruction training for a number of today's highly qualified principals, it is important to consider how principals interpret STEM instruction, and how they impact teaching and learning. The results suggest that there is distance yet to travel to effectively provide all teachers with the feedback necessary to meet our school based goals of STEM literacy.

Keywords

STEM Instruction, Mathematics Instruction, Principal, Teacher, Instructional Leadership

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1. Introduction

An important aspect of the principal's leadership role is that of instructional leader [1-3]. Principals work with teachers at myriad grade levels and subject areas. They are mandated to supervise and support the work of teachers in the classroom [4]. In an era where the instruction of science, technology, engineering, and mathematics (STEM) is seen as critically important for student success and where reports have cited the urgent need for improving both the quality and the size of the STEM teacher workforce in the United States, the role of principal as instructional leader of STEM instruction is of vital importance. There are over 90,000 principals that serve as administrators in our nation's schools, yet not all principals have served as STEM teachers nor received extensive training in the areas of STEM [5-6].

Without an understanding of effective STEM instruction, principals may struggle in "helping teachers acquire teaching strategies consistent with their instructional goals and compatible with their general teaching styles that increase the capabilities of students" [7]. District leaders, including principals, may interpret reform initiatives for mathematics instruction

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differently and often miss the disciplinary details of the reform [8]. Yet with an increased focus in building STEM capacity, it is important to consider what curricular and instructional practices are being utilized and the "ultimate effects on students, teachers, and the overall learning community" [9].

This exploratory study investigated the instructional perceptions of four middle school principals regarding STEM instruction. By seeking to better understand their own experiences as teachers and administrators, their preferred teaching style, their use of observation instruments, their vision of STEM instruction, and their practices regarding observation and feedback in the middle school level, the researchers sought to provide insights on how principals perceive STEM instruction and their role in working with teachers. Research [10] shows that "scores of studies show that student achievement is strongly affected by the leadership of school principals." This study seeks to build on the notion of principal as instructional leader by considering how principals view STEM instruction and how they influence the work of the teacher.

2. Purpose

As noted in Figure 1, this study focused on three research questions. First, it sought to understand the principals' teaching experience and views on teaching. Second, the study sought to understand principals' perspectives on STEM instruction, specifically in what teaching looks like in a specific classroom setting. Third, the study sought to understand what sort of feedback principals offer to teachers following the observation of STEM instruction. Instructional leadership, contextualized through the lens of the specific subject area of middle school math, is further examined through the lens of the principal as instructional leader.

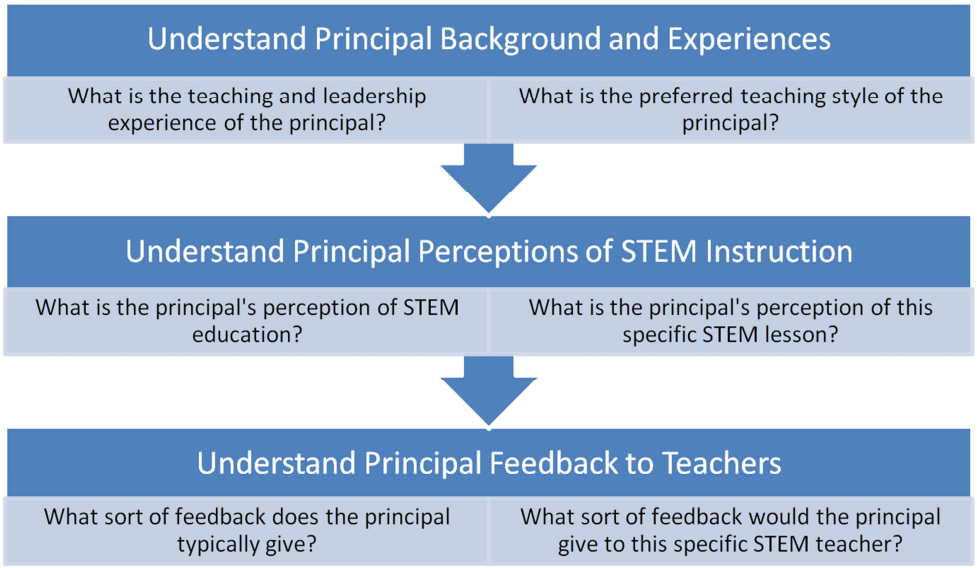

Figure 1. Perceptions and actions of principals and STEM.

3. Research Significance

Though it is known the role of the principal is pivotal in affecting classroom instruction, there is a limited amount of research, outside the elementary school setting, regarding how principals impact teaching and learning [11]. It must be understood how principals interact with teachers who provide STEM instruction to help answer the question of "How do principals perceive STEM instruction, and what do they do about it?" The answer to this question can provide insights and action steps to those who prepare and support the work of principals and STEM teachers in the field. Given that principals are tasked with being instructional leaders and helping foster school improvement [12-14], it is important to consider their vision. The literature identifies several types of vision. *Professional vision* is "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group" [15]. Professional vision includes selective attention and knowledge-based reasoning [16].

The professional vision of a principal may be quite different than the vision of a classroom teacher because it is role-specific [17]. In mathematics education, researchers built upon the professional vision literature and described *professional noticing of children's mathematical thinking* as three interrelated skills: (a) attending to children's strategies, (b) interpreting children's understandings, and (c) deciding how to respond based on children's understandings. Another type of vision is *instructional vision* [18-19], which is the vision of high-quality mathematics instruction. There are

three related dimensions of classroom instruction involved in instructional vision – roles of the teacher, classroom discourse, and mathematics tasks. Munter distinguished instructional vision as vision *of* instruction while professional vision is vision *in* instruction [19].

Research indicates that expert teachers and teacher candidates, for example, see science instruction in classrooms in different ways, as expert teachers see "beyond the superficial features of classroom practice" and interpret instruction differently [20]. Lochmiller [21] noted that there is limited research regarding how secondary-level administrators address content-specific instruction. Given the lack of STEM instruction training for a number of today's highly qualified principals, it is important to consider how principals interpret STEM instruction, and how they impact teaching and learning.

DiPaola and Hoy [22] describe instructional supervision as an "informal process, during which principals and teachers interact in a collegial, professional manner with the expressed goal of improving the quality of classroom instruction and student learning." These interactions between principals and teachers are thus seen as impacting teaching and learning. Better understanding the perspective, or vision, of the principal is of utmost importance in better understanding the potential impact. For this exploratory study about administrators' vision, the researchers examined the administrators' background and experiences, what they saw when they observed middle school mathematics instruction and the feedback they would give to the teachers.

4. Method

This research project was funded by a university award, the Charles L. Cahill Grant for Faculty Scholarship, at the University of North Carolina Wilmington, and utilized a case study approach in which an in-depth focus of four middle school principals regarding their instructional observation practices allowed the researchers to examine "the context and other conditions related to the cases being studied (as) integral to understanding the case" [23]. This exploratory, descriptive approach allowed the researchers to better understand the principals' perspective of STEM instruction and their feedback to teachers. The sample of four principals came from one school district in North Carolina. The district is considered a leader in STEM education in the region.

The researchers invited five principals who had at least 3 years of experience at their school in order to provide the *purposive sampling* [24] desired for this study; four of the five principals agreed to participate (Table 1). The researchers completed the process for human subjects research through the Institutional Review Board at the university and each of the participants agreed to be interviewed. For the sake of anonymity, all four principals are referred to as "Principal A" (or B, C, etc.), respectively, in the data sets below. The subjects chosen represented information-rich cases across a diverse sample of middle school principals, and their location in the region was utilized as the most effective use of limited resources [25].

The researchers showed the participants two different video clips of authentic classroom instruction that showcased National Board Certified Teachers teaching middle school students in mathematics; the short video clips were designed as a part of the Accomplished Teaching, Learning and Schools (ATLAS) series [5]. The first clip was 4.5 minutes long, featuring a teacher working with seventh grade students who were converting between algebraic forms to solve multi-step problems. The teacher asked a pair of students to share their strategy to a problem focused on algebraic representations of a situation involving tables and number of seats. The second clip was 4 minutes long and provided a view of a sixth grade mathematics classroom focused on modeling multiplication of fractions with manipulatives. The video showed a teacher walking from group to group to discuss a problem related to multiplying a fraction and a whole number with the use of M & Ms.

A semi-structure interview was utilized featuring questions about what stood out for the principals during the video clip and what feedback principals would provide the teacher. For consistency purposes, all interviews were conducted by the same researcher, recorded and transcribed for accuracy. Three researchers then separately coded each of the participant responses and assigned meaning. The researchers came together to discuss the emerging themes. Key ideas in context were highlighted from each of the respondents and collected in a Microsoft Excel spreadsheet. All themes were discussed and debated for their naming, meaning and application. Patterns within and across respondents were recorded.

Table 1. Middle School Principals' Teaching and Leadership Experience.

Name (anonymized)	Years of teaching experience	Subject area teaching experience	Years total as school administrator (including assistant principal	Years as principal
Principal A	3	Middle School Counselor	11	9
Principal B	12	Middle Grades Math	10	7
Principal C	15	High School Science	10	4
Principal D	12	Middle Grades Math, Science, Language Arts, and Social Studies	11	7

5. Results

Background and Experience

As noted in Table 1, the four principals had varied teaching backgrounds and experiences. One had served as a school counselor for three years prior to becoming a school administrator. The other three had taught for at least 12 years; one was a middle school mathematics teacher, one a high school science teacher, and another a middle school teacher who taught all core subject areas (math, science, social studies, and language arts). Thus, two of the participants had middle school mathematics experience, the specific area where the instruction in this study was examined.

In terms of teaching styles, all four principals considered themselves student-centered, using terms such as "workshop style," "hands-on," "inquiry-based," and "engaging." Only one participant described whole-group instruction as being meaningful; the other three tended to focus on phrases such as "PBL," "hands-on and relevant" and "workshop" when discussing what sort of instruction they hoped to see in the classroom.

5.1. Effective STEM Instruction

The principals were each asked to describe what they hoped to see in STEM classrooms. Here, their answers were similar. Principal A noted "engagement, higher-order thinking skills, and problem-solving, inquisitive learning, inquiry-based" instruction. Principal A added that "if you didn't know what you were going in an looking for, it might look chaotic, because at any one time there's 10 modules that the students are working on... but high-level engagement." Principal B also emphasized engagement, noting that "content knowledge is important but what are the students doing." Principal C similarly hoped to see "kids highly engaged in their units, because everybody's kind of doing something different. I want to see them actively learning they shouldn't just be sitting and getting. I expect there to be chatter and motion." And Principal D looked for students to be "as creative and far-reaching in their thinking as they can be" and sought relevance and real-world application.

5.2. Principals' Perspective and Feedback with Classroom 1

The principals' responses varied in responding to the question about what they saw in the first clip that featured a teacher working with seventh grade students who were converting between algebraic forms to solve multi-step problems. Principal A remarked, "I liked the student presentation piece, but the teacher was doing all of the work. So there was compliance on the part of the students, but not engagement." Principal B, a former mathematics teacher, observed, "It's a good algebraic problem where students are making sense [of] a table problem in terms of input and output, X and Y, the number of tables versus the people.... there was some good and some bad there. I feel like the teacher was being unnecessarily challenging when she was talking about being precise talking to math. I thought that was off track." Principal C pointed out limited engagement, noting that "the teacher did a whole lot of talking, and other than the two children that were up at the Elmo, this was the only one that is participating, the rest of the kids are unengaged in the lesson… it was just teacher-led. I'm not sure everybody was getting where she was going." Principal D, on the other hand, observed that the teacher "allowed them the opportunity to discover how to solve it, but then pointed out other things that they need to consider in terms of getting to the correct solution. But again there was no just concrete right, wrong for this type of situation, so it's definitely the dialogue. So it allows one of the students to hear what's going on and allows them to understand the thinking process, which is also very important." Principal D did not point out the lack of engagement in the same manner as did Principals A and C, and Principal B zeroed in on the mathematics operations while noting that a discussion about mathematical precision seemed somewhat "off track."

Likewise, the feedback that each of the principals would offer varied. Principal A followed up on the engagement aspect, noting that "the kids are all sitting there looking, they look like they are bored to me, the two are up there engaged, with the other 15 or so just kind of watching. They weren't doing anything at their seats, and one or two participated by answering a question but there was a lack of engagement." Principal A thus offered the following reflective questions, "How do you know that the 15 kids sitting at their desk have mastered the concepts here? How are you formally assessing the performance of it? How do you know those kids sitting there are paying attention, or are engaged and what's happening? I mean it's really between the two kids participating and the teacher, but what about the other 15 kids in the room- What do you think they got out of it?"

On the other hand, Principal B would offer "favorable feedback for the design of the lesson, the concreteness of the lesson in talking about abstract connections between symbolic language and tables and graphs with a concrete problem," wish to also see "what other application scenarios she designed to further the dialogue and the discourse" and "what level of independence the students had as they worked through this." Interestingly, Principal B did not have a reflective question for the teacher but referenced prior

personal teaching experience, saying, "I don't have something where I want her to ponder because I feel like she did a pretty good job of bringing it back together which is the part of the lesson we're observing. Let me just say I do consider myself an expert in middle grades math, I mean I was the person in (district name) when we had to design PD when I was a teacher, this is an area that I feel like I speak to, I do consider myself, to be my area of strength instructionally." The principal thus did not have a question for the teacher regarding the lesson.

Principal C, similar to Principal A, focused on engagement, suggesting that every table "do a presentation, and rotate through stations." Principal C offered several reflective questions that might encourage thought about more engagement, such as "How is she sure that everybody knew what they were doing that day? How is she sure that everybody understood slope if that's what the purpose of that assignment was. And how did she know that? I would want to know what was her essential question for the day. If it was slope, do you understand slope within the tables? Looks like they were using a table or diagram. How is she sure that everybody got it at the end of the lesson?" Ensuring that all students had a grasp of the learning objective was a concern for Principal C, again speaking to engagement.

Principal D, on the other hand, opined that the class was, in fact, engaged, but focused more on encouraging student voice, offering that "Because the other students appear to be engaged, but again it's that dialogue where the students felt confident enough to talk about it… she really didn't have to pull out the answers, she kind of led the discussion looking at initially where it began and then students following, and prompting them, but they kinda went with it on their own. So there's that understanding that it's okay to talk and share. Definitely that encouragement." In terms of reflective questions, Principal D wanted to know "how she thought the lesson went. Did she feel like it met the goal, or the objective of what she wanted out of the lesson? Being the right answer, understanding the equation process, was there a bigger real world piece that she was aiming for and was that successful as well" Making the connection to the real world was of key importance for Principal D.

5.3. Principals' Perspective and Feedback with Classroom 2

In responding to the research question about what was noticed in the second clip that featured a four and a half video of a sixth grade teacher working with 24 students in modeling multiplication and fractions with M & M candies as manipulatives, the principals' insights varied yet again. Principal A noted greater teacher presence and student engagement, remarking that "What stood out to me was that she was able to assess how each group of students were doing by spending two to three minutes at each table group, and asking questions to assess what their level of mastery was." The principal continued, "so instead of watching what one student was doing or what the teacher was doing, all students are hands-on, actually solving the problems using the manipulates, so ensuring all students were in engaged." Principal A offered the following reflective questions that related to the mastery of the lesson, including "Were you satisfied with the lesson? Whatever whole group instruction she had been previously to establish that base knowledge, were they working independently where she expected them to be? Were there any surprises for her, were they getting it any quicker than she thought they would be, where there any areas of struggle where she would go back to whole group instruction because maybe it didn't go as smoothly as possible?" Principal A's focus was on fostering independence and mastery while maximizing the independent learning in the classroom.

On the other hand, Principal B regarded the second clip as "a little more elementary," noting that "the questioning was pretty basic." The principal elaborated, "Dividing numbers, seeing how many times certain factors went into a number, 3 goes into 18 six times, 12 / 3 equals 4, or you can pull them into three groups. And I understand she is trying to show them multiple ways to divide the whole amount into groups, but I did think that was a little bit on the elementary side. I thought she did have, the rigor did increase a little bit when she finally got to the 5/6 of 12 equals 10, you know, 6 into 12 equals 2 so they divided them." Principal B spoke in further detail about the concrete nature of the lesson and the fact that the teacher was utilizing a worksheet. For feedback, the principal focused on the rigor of the lesson, noting that he was satisfied with the content. In particular, Principal B offered, "I didn't see a whole lot of rigor there for a typical sixth grade mathematics student and so I do think that most sixth grade students don't need to split 12, one M&M at a time, to make three groups of four, you know what I mean, that should be very automatic and so I do feel like that's a waste of time. After you do it once I feel like there's more rigorous fraction content that you would want to get to. I know this might be the beginning of a fraction unit so, there's a lot of questions I would have here because I did not feel like the rigor was there." Principal B also focused on ensuring that a handful of students were not dominating the entire group in terms of participation and discussion.

Principal C, on the other hand, thought that perhaps the teacher was allowing too much independence for the sixth grade level, observing that "Everybody else was at her back, in 6th grade I would probably not do that, although if it's a very good class I could do that. It seemed like all the kids

knew what they were doing, they understood the process… the instruction about what they were supposed to be doing. She didn't give them the answer; she asked more leading type questions… And like I said, in the chatter that you could hear it sounded like mathematics chatter. In the parts that we could see the kids were actively involved in what they were doing at the table. Which is very different than the other one where they were just kind of sitting there and the teacher was talking." Principal C praised the level of independence in the classroom, specifically that with "some classes you might not trust with M&M's. And some classes you can. But she trusts them to work as a team with M&M's while she helped other groups that might be struggling." Principal C noticed that all students appeared to be engaged in completing the worksheet. In terms of feedback, the principal offered positivity, observing, "I thought she asked good questions. Like I said my only concern would be that part of the time her back was toward some of the kids, but there didn't seem to be an issue." Principal C noted that no reflective questions came to mind as the teacher was visibly present and engaged with all students.

Finally, Principal D praised the level of dialogue and participation, highlighting "the level of collaboration, the small group conversation, her interacting with all of them… I definitely like the why, and them being able to verbalize the why. At the end, when she came back around and she brought them all back together, she discussed the good points that she had with the interaction and the different thinking processes." Principal D praised how the teacher highlighted the students' thinking processes and took time to bring them back collectively to share. In terms of reflective questions, Principal D focused on mastery, noting that while they were in smaller groups, it was important to focus on how each student was learning individually. "Could she still make that connection within a small group?"

6. Discussion

As the four principals' perceptions and feedback varied, it indeed appears that there was a different "noticing" apparent even though these four middle school principals served within the same district and had experience with the same observation protocols and related trainings. Interestingly, as the principals' teaching experiences varied, so did their responses to the instruction that they saw. For example, the principal who served as a former middle school mathematics teacher saw the teaching in Clip 2 as "more elementary" and "lacking rigor" whereas her colleagues praised the dialogue, the collaboration, the differentiation and the opportunity to discover. Interestingly, when identifying the content of the principals' responses with regards to instructional vision, the former middle school mathematics teacher's discussion focused heavily on Munter's [19] dimension of mathematics tasks while the other principals focused on the dimensions classroom discourse and role of the teacher.

For Clip 1, the principals noted the dialogue, levels of engagement, and collaboration, yet with varying perspectives. For example, Principal C observed limited engagement that "was just teacher-led" whereas Principal D lauded the teacher "allowed them the opportunity to discover how to solve it" and the subsequent dialogue which allowed a greater understanding of the thinking process. There is truly a divergence of teacher feedback in the same observed instructional practice. One can conclude the middle school teachers may be getting mixed messages in terms of student engagement and collaboration from their administrative leaders.

While each principal had a decade of experience as a school administrator and currently served in the same school district, using the same mandated observation tools, each had a different background in terms of teaching and different visions for effective mathematics instruction. The principal who had mathematics teaching experience assumed expertise in middle grades math, whereas the principal who had served as a school counselor prior to serving as an administrator noted that "I don't always have the content knowledge, which is hard for me" and a tendency to defer to teachers who had been "teaching middle school mathematics for 10 to 15 years on what they know works," adding that "you have to trust the teachers" as experts. Each of the principals had unique positionality yet are similarly tasked with observing teachers in the classroom setting.

7. Limitations to the Study

There were some limitations to the study that should be noted. Based upon the limited funding to complete the research, the scope of study and the sample size was limited to four administrators to be interviewed. The researchers did purposefully select the four administrators from the same grade level (middle) and the same school district so that we could control for the variance of professional development experiences. For further research and greater generalizability, it would be beneficial to interview middle school principals from different school districts across the state.

Another limitation would be the limited amount of time the researcher committed to interview each participant. Recognizing that each school administrator has a multitude of competing responsibilities for their time, the interview protocol was designed to be completed in 30-45 minutes. Two 4-5 minute video segments of National Board Certified Teachers were purposefully selected and employed to

generate administrator feedback. For further research, it would be useful to have each administrator view longer segments of the videos as well as provide additional time for reflection and interview responses.

8. Implications

This study offers insights regarding four principals' instructional vision and professional vision. And understanding both, as Munter [19] described, as the vision *of* instruction and the vision *in* instruction, respectively, can lend insights into the practice of instructional supervision. Principals have an impact on instruction through their work with teachers in the classroom. This case offers insights on the important role that principals play in several key areas:

8.1. Perception of Effective STEM Instruction

The four principals wanted engaging and creative STEM lessons to be evident; they offered agreement in their perception of the ideal STEM classroom where students were engaged and able to lead. This indicates that the desired state is somewhat similar for principals. Further consideration on how principals perceive particular aspects of STEM, such as middle grades mathematics, would be a potential next step in a study.

8.2. Feedback to Teachers

There was definite variance in feedback to teachers. Different principals saw the same instruction differently. There was a different noticing in each of the classrooms. Thus, the feedback to the teachers was different based on the principal. The variable that changed was the principal and their perspective. Continued research on the way that principals interact with teachers following the observation could lend insights on reaching the goal of "improved instruction and increased student learning" [22].

8.3. Professional Development

The four principals indicated that they had each been trained on a district and state observation tool; thus there was clearly similar language in being prepared to look for instruction that was "workshop style," "hands-on," "inquiry-based," and "engaging." Further professional development might deepen this language to stronger focus on instructional and professional vision [19].

8.4. Preparation of Principals

The manner in which principals are prepared to be instructional supervisors must be an area in which is further explored. It is clear that principals have different paths to the leadership role; some teach for years in the level and subject in which they lead, whereas others, as noted in this study, do not have teaching experience in the level (elementary, middle, or high) in which they lead. Furthermore, the extent to which they are trained to be instructional leaders and the way in which they work with teachers must be further examined as their role is integral in supporting teaching and learning.

9. Conclusion

Revisiting the initial objectives, this study focused on three research questions. First, it sought to understand the principals' teaching experience and views on teaching. The researchers concluded that a principal's past teaching experience does appear to impact their views on teaching and the feedback that they provide to teachers. Second, the study sought to understand principals' perspectives on STEM instruction, specifically in what teaching looks like in a specific classroom setting. Based upon the narratives provided by the four administrators, the researchers can determine that there is divergence in identifying what good STEM instruction is. Third, the study sought to understand what sort of feedback principals offer to teachers following the observation of STEM instruction. It is evident from the principal interviews that feedback can vary from person to person even when employing the same observation protocol and training. The results suggest that further work is needed to effectively provide all teachers with the feedback necessary to meet school-based goals of STEM literacy. Today's principals must be prepared to support, supervise, and reflect on instruction with all teachers, including teachers of science, technology, engineering and mathematics. The way in which principals communicate and collaborate with teachers is an important part of the school leadership role. And what principals notice in the classroom, when it comes to teaching and learning, is a vital component of continuing the reflective conversations that impact instruction.

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