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Administrators' Perceptions of Evaluating Science Teaching: A Case Study

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Abstract

The focus of this case study approach was to better understand the perceptions of the practicing administrators and their evaluation of science classes. Six practicing principals were asked at least ten questions which led to conversations about their role and comfort level with evaluating science teaching. The administrators varied in their comfort levels with science instruction and knowledge of best-practices. After interviews were conducted, a follow-up questionnaire related to research-based instructional practices (e.g., inquiry, the 5E model, and other Standards-based science teaching practices was sent to each principal. Findings suggest that principals' evaluations are dependent upon their own science classroom experience and that best practices in science education are not prioritized.

Keywords: *Evaluation, Inquiry, Science*

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Administrators' Perceptions of Evaluating Science Teaching: A Case Study

Introduction

The overarching goal of science education is that students gain higher levels of science literacy. Science literacy means that students have a broad understanding of concepts and developing the skills and ability necessary to understand science in their everyday lives (National Research Council [NRC], 1996). Indeed, "A review of the history of science education shows that there have been at least nine separate and distinct goals of science education that are related to the larger goal of scientific literacy" (DeBoer, 2000, pp. 582). Arguably the most significant movement in science education, and one that continues to transcend science education to enhance student science literacy is "inquiry". "John Dewey defended science as a legitimate intellectual study on the basis of the power it gave individuals to act independently" and become more self-directed learners (DeBoer, 2000, pp. 583). An inquiry-based learning environment, or an environment that promotes scientific practices, requires the teacher to cognitively situate himself or herself through the eyes of a learner and provide students experiences for students to actively question, explore, make sense of data, and seek answers. Said a bit differently, inquiry affords students the opportunities to ask and seek out answers for scientifically oriented questions. Inquiry requires a shared commitment in the learning process, which may have been uncomfortable for educators who were not well-versed in the Next Generation Science Standards (NGSS) frameworks (see NGSS Lead States 2013), inquiry-based practices, or have a naïve view about of the nature of scientific knowledge.

Inquiry has played a prominent role in learning and science teaching. "Inquiry has a decades-long and persistent history as the central word used to characterize good science teaching and learning" (Anderson, 2002, pp. 1). Furthermore, "Research indicates that inquiry-based science instruction has the potential to move learners in the direction of independent and critical thinking" (Crawford, 2007, pp. 536). With inquiry, students are given the opportunity to have authentic opportunities to engage in scientific practices. Key features of inquiry-based classrooms are: "instruction situated in authentic problems; (teachers and students) focus on grappling with data, collaboration of students and teacher, connections with society, teacher modeling behaviors of scientists, and development of student ownership" (Crawford, 2000, p. 933).

Biological Science Curriculum Study (BSCS) team conducted a laboratory-based randomized control study to examine the effectiveness of inquiry-based instruction (Bybee, 2015). In the study, 58 students between the ages 14–16 were split between two groups, each taught the same learning goals by the same teacher (Bybee, 2015). The difference between the groups involved the approach used to teach the materials. One group was taught utilizing inquiry-based materials based on the BSCS 5E Instructional Model and the other from materials based on common teaching strategies (Bybee, 2015). According to the results of the study, "students in the inquiry-based group reached significantly higher levels of achievement than did the students experiencing common instruction" (Bybee, 2015, pp. 53).

Despite the growing emphasis on inquiry, an argument can be made that children are not exposed to science, let alone inquiry-based science. On average, elementary teachers spend less than thirty minutes a day teaching science (Fulp, 2002) and only 5- 10% of first-year teachers support student-centered instruction (Simmons et al., 1999). When inquiry does take place in the classroom, it consists primarily of structured inquiry exercises due to teachers' mistaken beliefs about inquiry, insufficient knowledge inquiry-based pedagogical practices, and insufficient knowledge of the nature of science and scientific inquiry (Tobin, Tippins, & Gallard, 1994).

Obstacles beyond resources and prior science learning experiences exist for beginning science teachers to further develop foundational knowledge about scientific practices and sound understandings of the nature of scientific knowledge. Upon entering into the most arguably the most trying years of the profession, science teachers report the factors of confidence, time, classroom management student behaviors, and administrative support impacting their pedagogical development (Loughran, 1994; Luft & Patterson 2002; Oliver et. al, 2009). The outcome, more often than not, is despite science teachers' student-centered believes, their behavior aligns more with teacher-centered instruction (Simmons et. al, 1999). The impact not only attributes to attrition in the profession, but the overall impact this has on students' understandings of scientific inquiry.

"For students to understand inquiry and use it to learn science, their teachers need to be well-versed in inquiry and inquiry-based methods" (Olson & Loucks-Horsley, 2000). While many science curriculums and other relevant science education resources would highlight the benefits of utilizing an inquiry-based approach to learning, if teachers are not well versed in this approach or are limited in prior knowledge or prior experience, then the inquiry approach may not be conveyed in the way it was intended. Olson and Loucks-Horsley went on to say, "most teachers have not had opportunities to learn science though inquiry or to conduct scientific inquires themselves. Nor do many teachers have the understanding and skills they need to use inquiry thoughtfully and appropriately in their classrooms" (2000, pp. 87). Additional barriers beyond exactly how science educators define inquiry and the vernacular debate is teachers' perceptions of the constraint of having to teach mandated concepts that are difficult to teach through inquiry, as well as concerns with classroom management (Crawford, 2007, pp. 535). Arguably, teachers' prior science classroom experiences impact their practices.

Parallel to the above mentioned concerns, is whether teachers have the support systems in place necessary to shore up any inadequacies in their understandings and abilities to use inquiry. Indeed, studies show that the lack of high quality support to beginning teachers is the biggest reason for new science teachers to leave the profession (Pickett & Fraser, 2002). While some research shows that mentors with inquiry experiences can help develop their protégé's knowledge (Crawford, 2007, pp. 535), there is a dearth of scholarship that explores different contexts and includes other stakeholders invested in promoting high levels of student learning. Understanding how other educational leadership in a school system conceive of inquiry and best practice and are able to support best practice can help fill the research gap aimed to explore how to achieve the vision of modern science education reform.

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Statement of the Problem

When considering all the known barriers teachers face for implementing inquiry, or implementing scientific practices into instruction, is it possible that administrators and their evaluations need to be added to this list of "barriers"? There are few studies that shine light on this specific concern. Brogdon (2015) examined the role of science in two schools, which was based on the interactions of administrators with colleagues, science content, and state standards (Brogdon, 2015). Another study conducted by Hixson (2014) researched how to improve the administrative role and function in teacher evaluation systems. These studies showed that while administrators understood there was a need for science education within the elementary schedule (Brogdon, 2015), their ability to develop teachers' professional knowledge was significantly limited (Hixson, 2014). One argument, is that elementary principals often use a one-size-fits-all evaluation tool that limits the scope of evaluators' feedback on best instruction for promoting students' scientific practices. Arguably, observing and evaluating the unique features of inquiry-based teaching, inquiry-based learning, and teachers implementing scientific practices into lessons requires a unique administrator skillset. As such, the purpose of the research study was to explore the relationship between principals' prior experiences and their perceptions of evaluating science lessons.

Method

Participants

The research involved five rural Missouri school districts. The participants included three principals and three assistant principals. In addition, three of the participants were formerly science teachers and three of the participants were not formerly science teachers. At the end of the 2020-2021 school year, three of the administrators worked at a middle school, two were in a high school, and one was in a middle/high school setting. All of the participants had been a building administrator for six years or less.

A convenience sample was employed to ensure the participants had similar administrative experiences working in rural schools with similar student demographics, but with varying levels of prior science teaching experience (Yin, 2002). In the case of this study, the six participants were practicing middle school and/or high school administrators with at least two years experience working as an administrator. Each group was beneficial to the study because each principal had a unique perspective based on their prior experiences, with varying degrees of experience in the field of education. Table 1 outlines some of the most relevant information of the participants.

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Table 1 Background of Participants

Participant	Years as a Building Administrator	Former Science Teacher	Took A Science Education Prep Course	Took More Than One Science Education Prep Course
1	2	Yes	Yes	Yes
2	3	No	Yes	Yes
3	6	Yes	No	No
4	2	No	No	No
5	2	Yes	N/A	N/A
6	3	No	No	No

Data Collection Tool and Data Analysis

A case study approach was employed to better understand the perceptions of six practicing administrators and their evaluation of science classes (Stake, 1995). A list of ten questions were compiled to ask each interview participant. Additionally, follow-up questions were asked on an as-needed basis when clarification was needed to completely understand the interviewee's answer (Baxter & Jack, 2008). Semi-structured interviews each lasting approximately an hour were conducted, and transcripts were created (Miles & Huberman, 1994). Open-coding was used to identify three emerging themes: administrator experience shapes evaluative feedback, subject content is not commonly assessed, and science education best practices are not prioritized in evaluations (Creswell et al., 2007). A follow-up questionnaire was sent to each administrator after all interviews were conducted. Ten initial interview questions were used, but some follow-up questions were added based upon their answer to a previous question. The initial questions included:

1. In your college education, what areas were your primary focus of study?
2. What subject areas have you taught?
3. What is your subject area expertise?
4. Describe your own science education in both high school and college.
5. Tell me about your comfort level when you observe a science class.
6. What training have you had to prepare you for evaluating science lessons specifically?
7. What do you look for in the organization of a science lesson? What does an ideal science lesson look like?
8. Tell me about your comfort level when providing feedback to teachers about their science lesson.
9. When you walk into a science class, how do you know that students are learning?
10. Which evaluation tool do you use to provide feedback to teachers? How useful is this tool? What does the evaluation tool emphasize? What are the limitations to this instrument as it relates to providing feedback to science teachers?

After interviews were conducted, a follow-up questionnaire related to inquiry, the 5E model, and other relevant science teaching practices was sent to each principal. To triangulate the data, a Likert scale survey was sent to gauge participants knowledge, understanding, and perceptions revolving around their evaluation tool.

Validity and Reliability

Reaching out to multiple districts enhanced the validity of the data gathered, as administrative professional development opportunities vary by district. The interviews were valid and reliable since participants were shared their own personal experiences. A follow-up questionnaire was sent to each principal after all interviews had been conducted to allow participants to expand on their ideas. To triangulate the data, a follow-up survey was sent to principals regarding their evaluation tool (Riege, 2003).

Role of the Researcher

The Researcher conducted interviews to examine principals' perceptions surrounding best practices for teaching science, what they looked for when they were observing a science lesson, and what they looked for in the organization of science teaching. The Researcher contacted school superintendents in order to obtain permission to reach out to the appropriate building administrators. After permission was granted, the Researcher sent an email to each interview participant to set up a time to meet. Also included in this initial contact, the Researcher informed the participants that their identity would remain anonymous, as would the name of the school and district. The anonymity of the participants was preserved by only sharing data, not linking names or districts to answers. Direct quotes were labeled with "Participant," followed by a letter of the alphabet (example: *Participant A*).

The participants were told the interview would be audio recorded and their answers would be used for an educational doctoral dissertation. Before each interview began, the Researcher explained she would be turning on the audio recorder. The Researcher provided autonomy to the participants by sharing with them that if at any time they wanted to stop or skip a question, they had the right to do so. All participants provided consent to continue with the interview after acknowledging that they would be audio recorded.

Ethical Considerations

Ethical considerations were consistently monitored (Hesse-Bieber, 2017). For example, considerations of bias were considered when conducting interviews and analyzing the data. Participants were informed of the fact that the study was for educational purposes and it was voluntary, and that they may choose to opt out of any question and stop the interview at any time. Throughout the study, it was important to keep the identity of each participant unknown. Each participant and their home district remained unidentifiable and names were erased or were replaced with pseudonyms. Prior to data collection, the study was approved by the appropriate Instutional Review Board and all participants signed an informed consent document.

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Findings

The findings are presented as assertions. Following each assertion is a brief summary section of main themes espoused by the participants. Both the assertions and summaries are supported with data from the participants that serve as evidence for the claims about different aspects of principal's knowledge.

Assertion One: Principal's experience shapes evaluative feedback. Based on their prior experiences, including their own education and their background as a teacher, administrators provided insight to what they believed were best practices for science education, their comfort level for observing and providing feedback to science teachers.

In summary, all participants had some degree of comfort evaluating science teachers regardless of their own teaching certification area and perceived levels of science content knowledge. Administrators with prior science teaching within the grade-span of the evaluation expressed that they were extremely comfortable performing science teacher evaluations. Other participants were a bit hesitant regarding evaluating content, but believed they could evaluate a science teacher. Principals who served as a science teacher and/or had extensive formal education coursework specific to science methods could speak to some degree the role of the science teacher acting a facilitator, the NGSS , classroom inquiry, and the importance of asking questions. Still, however, it was evident that there was a thread of misconceptions among the administrators that 'activity', 'hands on', or 'lab' meant best teaching practices.

Participant One. Participant One was a previous science teacher who taught high school physical science, biology, biology 2, and AP biology. When describing her undergraduate classes, the participant explained that she was initially a chemical engineering major, so prior to an educational route she took "science classes, of course, tons of them. So, cell biology as well as classes like chemistry, evolution, genetics, just that kind of basic biology classes as well". The individual also went on to state her beliefs in a broadened educational perspective on current practice, "I always encourage people to work on a Master's at some level, at some point, it just makes your view a little different of what kids are going through and then also how to deal with that." Participant One received a specialist in administration and in describing the experience placed emphasis on the significance of collaboration, stating the impact of the communication with people from different types of school and backgrounds.

Participant One said science was her area of expertise. Her own science education was diverse and comprehensive taking science classes in a multitude of scientific concentrations including physical science, biology, advanced biology, chemistry, chemistry 2, genetics, and environmental science. When reflecting on her own science education, Participant One explained, "I think that in high school, especially my chemistry teacher, really engaged all of us a lot. We really liked him. He was fun, but down to earth. He was smart, but could bring it down to our level". Another notable quote that would impact future classroom observations:

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> Lower-level classes as a high school student, you're in a class with a lot of people who probably don't really want to be there. And so, that changes your perspective, and probably how your teacher teaches the class as well.

She went on to say: "I know it did for me as a science teacher, knowing that I needed to engage, even the kids who really didn't want to be there, but that were there because it was a required course".

Participant One said as a former science teacher and current administrator, when observing a science class, "I love going in there. It's really hard to stay quiet. Really hard. And sometimes I don't. Sometimes I'm right in there". She went on to state:

> But I absolutely love going in there because I feel comfortable. That's exactly where I am, that's what I know, and while I'm not always quiet when I'm in there, it's nice to be able to get to show the kids that, you know, I wasn't just always this lady who comes into your classroom and hangs out.

Participant One described her comfort level as "pretty high", but continued with, "sometimes it is hard to stay quiet and I hope that I don't make those teachers nervous; I think that's part of my wanting to jump in and help out too". Participant One explained, "I'm not really evaluating their knowledge, I'm in there to evaluate what they're doing with kids".

Participant Two. Participant Two was a former special education teacher and focused primarily on elementary math, language arts, and reading. This participant said she believed her expertise to be in "beginning reading skills, kind of teaching how to read and in the beginning of comprehension". When describing her own science education, she said she took general science classes in high school and college, naming biology and chemistry. Participant Two also said she considered going into the medical field when she first started college, so her first year of higher education was heavily science-based. A notable quote expressed regarding her science college courses indicated that she was not extremely successful:

> Coming from a small school that didn't work out real well because in high school I did fairly well in class, but then in college where it was much more, a lot more, studying…there was more lecture and less hands-on.

Participant Two explained that she was fairly comfortable with middle school science curriculum. Regarding middle school science, "I think it's still basic enough that the content is familiar to me and so then I can really pay more attention to all the other aspects of the teaching". When reflecting on the possibility of observing higher levels of science, "I think at the high school level or a more advanced level, I would struggle with understanding the content enough to really know if it was truly a quality lesson or not."

Participant Three. Participant Three went to college and studied elementary education and social studies. This individual was a former fifth-grade teacher, but was a sixth-grade

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middle school science teacher for 14 years. The participant said her area of expertise was physical science at the sixth-grade level, but that was not always the case as social studies was her primary focus, but it was the science job that was available. Participant Three reflected upon this pathway, "I thought how am I going to do that? I wasn't ever really crazy about science…in elementary whenever they did experiments, I thought that was neat…".

Considering her own science education, Participant Three said she had biology and chemistry in high school. Biology was a more enjoyable experience as her teacher prioritized hands-on learning. In college, Participant Three explained labs made learning science more interesting. These experiences impacted the participant's teaching journey, "My biggest challenge and my biggest role was to make sure that I made science fun…and found different ways to get the content to the kids, so that they didn't have the same experience I had".

Participant Three said she felt "fairly comfortable" observing science lessons. "Our district has a lot of vertical teaming and also cross curricular and so I feel like I gotten to know the high school science department pretty well". The participant went on to say, "we did a lot of digging through the different priority standards and curriculum and I helped write curriculum, so I really felt like I had a base knowledge on a lot of it". She also mentioned, "I'm definitely not at the high school chemistry level or high school physics or AP…but I feel like I've got enough of a base knowledge…I feel like I look at it from a pretty wide lens now".

Participant Four. Participant Four primarily studied elementary education while earning her undergraduate degree. She was formerly a third- and fifth-grade teacher. When describing her experience, she mentioned that as an elementary teacher, science was taught when there was time. Recalling her own science education, "Science is probably one that I remember most, but because of the lab piece of it. I remember like dissecting frogs. I remember mixing chemicals or solutions". She also noted the dynamic teachers of science past. Participant Four went on to express:

> But to speak of the content, I can't say I remember any science facts or any content necessarily, but the engagement of the class and the teacher…It was very hands-on, how to get kids engaged in that content area. And I loved that.

Participant Four explained her comfort level of observing science lesson as "pretty comfortable" and going on to explain the reasoning behind this response, "We have specific indicators that we're looking at, that are not always content related…there would be one that is content related and that's content vocabulary". The participant discussed if her feedback needed to be more content specific, she would have to refer back to standards before providing feedback or have a conversation with the teacher in order to help her better understand the content.

Participant Five. Participant Five completed a variety of science course in her undergraduate and graduate experience, studying both biology and exercise science. This participant was formerly a seventh-grade middle school science teacher, a high school biology teacher, and also taught some credit recovery science courses at the high school level. She said her area of expertise was biology. Considering her own science education, “I feel like my education in high school versus what we are trying to get teachers to do is just shockingly different. Mine was very much, take notes, and study them and take a test”. Participant Five described her comfort level as “extremely high”.

Participant Six. Participant Six studied physical education in her undergraduate program. She taught physical education, history, health, driver's education, and industrial arts prior to becoming an administrator. All of these courses she taught at the high school level. When recalling her former science classes, Participant Six said she had biology and that it was, “totally different than it is today”, then reflected upon some of the subject matter. While doing so, the participant claimed, “I don't even know it now, tell you how much of an impact that is?” Participant Six also remembered having an ecology class, which the teacher worked to make it more real, allowed for experiments and having scientific debates. The participant said, referring to the ecology class, “it was more interactive than biology. One was very teacher-driven, lectured a lot, so sit and get. Didn't really care for that too much”. She also had a zoology class and an anatomy class in high school, and an array of science classes in college. The participant identified the lessons she enjoyed were those that were hands-on and not teacher driven. She described her comfort level of observing science as “good”.

Assertion Two: Administrators, regardless of their perceived depth of evaluating science lessons, rarely, if ever, when reflecting on best teaching practices mentioned the importance of students engaging in scientific practices as outlined in the Next Generation Science Standards.

In summary, the only participant who had informed views of best practices in teaching science was participant five, whose formal background went beyond taking college or high school science classes, beyond teaching high school science classes, but whose background also included formal science methods coursework to obtain an initial teacher certification in a science area. All participants could ‘speak’ to general aspects of best practices, such as engagement, but not specifically to science teaching with how engagement relates to discrepant events, cognitive conflict, and teachable moments.

Participant One. When asked what an ideal science lesson looked like, Participant One stated, “you really need to start your lesson with some review of what you did the time before when you saw those students”. She emphasized it was less about the method of doing that, but making it a priority to connect what students did the time last class period to what they were getting ready to do that day. Participant One mentioned an evaluation may go on, where feedback was being collected, potentially in the form of reviewing an assignment. Her idea of an ideal lesson may have included a bit of lecture, review, and then getting started with the day’s objective. She stated, “You know, I'm a firm believer that the science teacher doesn't have to set everything up for the kids ahead of time…there's some learning in doing that stuff too”. The importance of an activity with follow-up to make sure everyone understood the concept was also expressed, with the teacher using a type of formative assessment to gain some additional feedback data.

When asked how she knew students were learning, “I like to see them communicating, I like to see them discussing things, I like to see them being active”. Participant One also added an emphasis on the importance of student inquiry:

> I really want them asking questions and not specifics like how to do this, but I want to see them asking questions about the content and I think that shows they're processing the information that you're trying to get to them.

Participant Two. Participant Two said she have received “very little” training on how to evaluate science lessons specifically. She expanded upon this answer with, “When we do our NEE training, there is the potential of there being science lessons that we evaluate, but there's not the option in the NEE training process that where you can choose site specific content area”. She followed-up with, “I would say my training is more just towards good teaching practices, not specifically to science”.

When asked what an ideal science lesson looked like, Participant Two said, “I would say the first five minutes, maybe 10 minutes, kind of a bell ringer activity really to do some sort of review or gauge her previous knowledge”. From there the participant explained there would then be a brief discussion about the activity. Additionally, “And then from there, go into the kind of nuts and bolts, like I said the vocabulary, the basic knowledge of whatever it is”. The remainder of a class period would be spent doing something with the knowledge, perhaps a mini-lab around the room. The participant spoke more to this concept, “I don't necessarily mean like a full-on lab. It could maybe be a word search; it could be some sort of crossword puzzle using the vocabulary…do a drawing.” Participant Two mentioned:

> I think it is good to bring in some of the language arts skills in science, so maybe whenever they talk about the different parts of the cell, maybe have them connected to something else that they know of in life.

She also stated the end of a lesson would include some sort of formative assessment to see what future lessons should cover.

Considering student learning, Participant Two said she looked for active conversation. “A science room is one that, in my opinion, should be a little bit more active than maybe some of the other classrooms, it should be one where there's more talking going on”. She went on to say students should have the opportunity to work with table partners and discuss the actual topic at hand. Participant Two said she also believed students were learning when they were asked to create something.

Participant Three. Participant Three said, in regards to receiving training on evaluating science lessons, “I would say the most training for science specific would have been when I was a science teacher because we did a lot of collaboration…sometimes we would observe each other's lessons, sometimes we would swap classrooms”.

When asked what an ideal science lesson looked like, Participant Three said there would be a clear learning target, a brief review, and then give students the opportunity for discovery. Discovery might consist of students being given information, then students working

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through a problem. This could be in the form of a lab. She also noted, "I want to see collaboration. I want to see kids working together. I want to see the teacher being more of a facilitator than standing up and lecturing". Participant Three also mentioned students may need guidance, which the teacher would provide, but, "having those kids working and having their heads together, trying to figure out, and solve, and discover, that would be ideal". An ideal science lesson would also include a formative assessment at the end. When asked how she knew students were learning, Participant Three said she looked for: "Engagement and I know that sounds kind of cliché…if I can go to a kid and ask them something and they can tell me".

Participant Four. Participant Four said she spent a great deal of time discussing how to do evaluations, but not specific to science. When asked about an ideal science lesson, Participant Four said her comfort level would be the teacher presented the objective or the learning target for the day, gave any directions or any information, and then the students conducted their investigation. She mentioned the learning took place throughout the investigation, then afterward, the class would come back together, wrap it up, draw conclusions, and solidify information.

When asked how she knew students were learning in the science classroom, Participant Four said she looked for engagement, what was on the students' desks, and conversation, "I want back and forth conversation between teacher and students. More than half the students need to be involved in that conversation to know that they're engaged". Participant Four also mentioned the importance of the teacher receiving feedback from students.

Participant Five. When asked about the science-specific training received for evaluating lessons, Participant Five stated, "I wouldn't say really any and I wouldn't say, really, that I had much training at all in the district I'm in on how to really evaluate…you have your rubric and you figure it out as you go". She said her approach was to look at the pedagogy, breaking down the standards, and evaluating instructional strategies. She also explained that those strategies should be applied with fidelity. Participant Five said her training primarily revolved around, "instructional strategies, how to unwrap standards, how to develop learning targets". She also mentioned she had done her own research of NGSS and spent time working on 5E lesson plans when she was a science teacher, which is a consideration when she evaluates other science teachers. Participant Five concluded her answer with, "But I would say that overall I consider evaluation of a science teacher the same as I would treat a math teacher, because we're looking for, you know, pedagogical components to instructional strength".

Participant Five said an ideal science lesson would involve inquiry with a visible learning target. She wanted to see that students were able to explain the objective. Ideally there would be classroom management routines, procedures, and a warm up to start the day's lesson. She also mentioned using lab notebooks, the importance critical thinking and collaboration, as well as including some direct instruction for transmitting specific content. Participant Five said students should actually be doing science, which could come in the form of a lab, "We need that kind of stuff in the science classroom because science isn't just about osmosis and diffusion, it is getting in a group, collaborating with peers, being wrong, going back to the drawing board".

When asked how she knew learning was taking place, she said, “I know they're learning by what they're doing what they're saying…that's why the learning target’s important”.

Participant Six. Participant Six said she had not received specific training to prepare her for evaluating science lessons, but rather the general “what to look for in a classroom”. When asked what an ideal science lesson would entail, Participant Six said she would want to see an introduction for what would be covered that day, a pre-assessment, a thought-provoking engagement piece, then the lesson. The lesson could be a lecture or it could be a student exploration. Conversely, Participant Six also highlighted that the majority of the lesson should be student-driven. The end of the lesson would involve wrapping up the concepts and checking for understanding. When asked how she knew students were learning in the science classroom, Participant Six said:

> One thing I do is talk to the students and see if they know what's going on…then maybe ask them some questions that I've picked up on through listening to the lesson or just from my background knowledge of things.

Assertion Three: Administrators without solid understandings of best practices in science education are limited in their own abilities to provide prescriptive feedback (Table 2 and 3) as well as offer content specific guidance using their general teaching evaluation tools (Table 4).

In summary, most if not all administrators valued the importance of engagement in teaching. However, much of their thoughts on how to provide specific feedback was about general versus content specific pedagogical knowledge (see Table 2). Science education best practices, such as assessing students’ conceptions; or the value of questioning, observation, data collection, and evidence-based explanations were not prioritized in their ideas for feedback for teachers. Apart from participant five, who had formal science education training, there was an was an absence of explicit reference to the 5E instructional model, inquiry-based learning, STEM, nature of science, or scientific practices (see Table 3). Nevertheless, there was an evident disconnect between what participants were asked to do for the evaluation, their perceptions of the value of evaluation that might be applicable to all content areas, and what a science teacher really needed to know to better their craft (see Table 4).

Table 2 Participant Ideas for Providing Better Feedback to Science Teachers

Participant	***What would help you to provide better feedback to science teachers?***
1	My teachers struggle to balance the use of online tools with actual tools. I encourage them to use online tools, but I don't want them to over-do and under-value actually conducting an experiment and hands-on learning. What would help me is to get into their classrooms more to help them evaluate if the

	way they presented the lesson was the best way and did they get the results they wanted.
2	Have a guide/road map of critical thinking/DOK skills that relate specifically to science. This would help me have a better understanding of if the teacher is pushing them to the greatest learning level.
3	More conversations with my science teachers and knowing what they need from me.
4	Evaluating specific indicators that are not specific to the content area and/or knowing the concerns of the teacher prior to the observation,
5	N/A
6	Adding technical reading and writing to science classes

Table 3 Participant Look Fors in the Organization of Science Lessons

Participant	***Response***
1*[a.]	I really hope there's some activity. That's one of the big things I'm looking for. It's so easy to sit and get. It's so easy to stand up in the front of the room and to lecture the entire time, but so many of the things that we talk about in science either need to be hands-on or there needs to be some visual.
2	I also like to see some sort of doing it activity. So either creating a foldable project, doing a lab, doing something with their hands to make it more engaging instead of just book work.
3*	I look for the differentiated instruction, and the different teaching strategies that they use and which ones are effective and which ones are not so effective.
4	I would look at student engagement and if the students are actively involved in the learning, as opposed to like a sit and get.
5*	It depends on the type of our standard, which I think probably everyone has been moved to NGSS…collaborating on a developing question…working with data, getting data, and them going back to the drawing board. Are they creating models, developing claims based on evidence?
6	What the goal is for the day…the students know that some kind of activity that engages them and that they're just not listening to the teacher…maybe struggling through productively on something, and that there are elements in there where They kind of have to justify what they're finding or what they're seeing and show evidence of that. And then some kind of check. The check for understanding…

Note[a]. An asterisk is used to identify those participants who were formerly science teachers

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Table 4 Participant Ratings of Evaluation Tool

Participant	***1[a]***	***2***	***3***	***4***	***5***	***6***
Useful	4	2	4	4	N/A	3
User Friendly	4	4	4	4	N/A	3
Training	4	2	4	4	N/A	3
Consistent	4	2	4	4	N/A	4
Measuring Student Engagement	4	2	4	4	N/A	4
Measuring Classroom Management	2	4	4	4	N/A	4
Measuring Use of Teaching Strategies	5	4	4	4	N/A	4
Measuring Knowledge of Content Vocabulary	3	2	4	4	N/A	3
Measuring Content Knowledge	3	1	4	4	N/A	3
Measuring the Use and Management of Assessments	3	2	4	4	N/A	3
Providing data to guide follow-up feedback discussions	5	4	4	4	N/A	3

Note a. 1 being not useful/friendly/effective/consistent and 5 being highly useful/friendly/effective/consistent

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Participant One. Participant One explained that when it came to the organization of a science lesson, she really hoped there was some activity:

> It's so easy to sit and get, it's so easy to stand up in the front of the room and to lecture the entire time, but so many of the things that we talk about in science either need to be hands-on or there needs to be some visual.

The participant said teachers could organize lessons in a variety of ways, with experiments and explanations taking place in different orders. She also mentioned the possibility of adding transitions every 15 to 20 minutes, especially in a block scheduling situation, where class periods were longer.

> I just really want to see the kids active and not just in lecture the entire time because that gets really heavy…if you're not having them do something with the material, it's really hard for most kids to pick that information up.

When asked about their comfort level with providing feedback to science teachers, Participant One said, “I think my comfort level is pretty high with them, as opposed to some of the other teachers when we're talking about lessons…I want to encourage them to do something different or to do something new”. She further said:

> I try to give feedback, like give a score. I try to give a reason for why they received that score and their feedback. It helps them but it's also selfishly helps me so when we sit down. I can remember what was going on and why they received that score how useful that tool is, um, I mean, I think it's really good to have a place to start from, you know, something to look at it forces us as administrators to have conversations with teachers and I think that's the most important part is that it forces me to sit down with them and talk about me being in their room. Sometimes I would really love to just sit in their room from the beginning to the end because I don't feel like you always see every piece but the purpose is to get in as many times as you can so you're hopefully seeing those things.

Participant One had a lot of insight on her evaluation tool and said that it was highly focused on feedback, as it provided direction to help move teachers forward. She did denote:

> There isn't a lot of content in that feedback system, so you almost have to know what's going on in the classroom and the curriculum in order to be able to help them if there's any sort of content issues or concerns.

Participant Two. Participant Two said she looked for a general overview of the topic that would be covered, including some background knowledge conversations and some vocabulary conversations. She also mentioned she would like to see a real-world application of the material, so students were able to apply the information to their lives. Participant Two stated, “I think a lot of times science can be very overwhelming and daunting to kiddos and so I think if we can teach them how to apply it that helps”. She also said an organization of a lesson should include an activity that was hands-on and engaging and it should be more than bookwork. She explained that her own experiences as a science student were challenging because she did not always have these learning opportunities, so it made application more challenging.

When it came to her comfort level of offering feedback to science teachers, she said it was not as high as other subjects because she did not have the personal experience of teaching science. For this reason, she primarily focused on good teaching skills, things that she saw, student engagement, and how lessons could have been more hands-on or more interactive. Participant Two also said, “I would maybe just critique transitions or management skills, those kinds of things, as far as the actual content…I think some of that I could gauge by the student’s engagement as well.”

The evaluation tool Participant Two used is rubric-based, which she said helped her administration “stay more consistent across the board”. She said it also allowed educators to compare themselves to similar teachers in the district and the state. “I also like that we’re expected to go in six to ten times a year…I like the smaller snapshots and their surprise visits…so that way it's truly seeing the teacher, day to day”. The district administrators selected the indicators to observe, like critical thinking, vocabulary, technology integration, formative assessments, and relationships. Participant Two said:

> I would say it is more geared towards good teaching practices not the content…vocabulary and critical thinking lend themselves to the content…there's no way to check if they're moving in the right direction or curriculum map or the state standards.

She also stated, “I think because it doesn't necessarily have a specific science link, or math or language arts any of them…it relies more on the principal to have that strong content knowledge…to have a strong background in that content area.” Because there was not a content-specific link:

> It's a lot more legwork for me because I really do need to dig into their curriculum maps and those state standards to make sure they're on track and on target…I think that could be a handy piece of information for the evaluation tool.

Participant Three. Participant Three said the organization of a science lesson should include a learning objective, differentiated instruction, different teaching strategies, and a hands-on activity. She stated that students should have the opportunity to do something interactive and technology should be used as well. When it came to providing feedback to science teachers, Participant Three said her comfort level was high and credits her ability to go into observations with a wide view.

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Participant Three described her evaluation tool as one that was a good resource and provided other resources through a professional development hub. She also stated there were aspects to the tool that could improve. With the indicators, the participant's district selected some and the building picked some. There were typically at least seven indicators that were observed. A few of the indicators Participant Three used revolve around engagement, relationships, and formative assessments.

Participant Four. Participant Four stated the following when it came the organization of a science lesson, "I would look at student engagement and if the students are actively involved in the learning, as opposed to like a sit and get." She also mentioned that she would want to see student engagement, content vocabulary, teacher engagement, active learning among students, hands-on learning opportunities, and relationships. Participant Four said her comfort level of providing feedback to science teachers was something she was working on by seeking professional development. Her focus in observing and evaluation was to foster teaching strategies across all content areas, increasing engagement, bringing in more vocabulary, and guiding self-reflection. She said her evaluation tool uses indicators, so it helped to level the playing field, as all teachers were being observed with the same criteria. Relationships, engagement, and content vocabulary were a few of the indicators observed.

Participant Five. Participant Five looked for the following in the organization of a science lesson: NGSS standards, students creating models, students developing, making claims based on evidence, students asking questions, and a learning target. She also stated, "No matter what content area I'm looking for that learning target." Participant Five said she tended to focus on the pedagogy, best practices, and available data.

Participant Five described her evaluation tool as using a set of rubrics with nine standards. She stated:

> In general, I do not feel like that the actual evaluation component is what has made my teachers improve. What made our teachers improve is collaboration, picking up the great things that they're doing, pushing them a little harder in data analysis and differentiation, and partnering with them and the whole aspect of teaching social emotional learning discipline
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> .

She followed-up with, "I just feel like it's not as effective as the other things like cognitive coaching".

Participant Six. Participant Six said in the organization of a science lesson she wanted to be able to see what the goal was for the day, an activity that engaged students, and elements where students had to justify their findings or provide evidence to support their findings. She mentioned there should also be some sort of assessment to check for understanding. Participant Six stated that her comfort level was 'bent' when it came to providing feedback to science teachers. She said she looked for student engagement, a critical thinking piece, ways to check for student understanding, and a good relationship between the teacher and students. The evaluation tool used by Participant Six was an in-house model that paralleled state standards. She said her observations were meant to coach teachers and to help them improve, rather than to be "gotcha system".

Discussion, Conclusion, and Recommendations

If the overarching goal is to increase science literacy, then there are specific best practices that should be present in today's science classroom. The 5E instructional model, inquiry-based learning, STEM concepts, and effective implementation the Next Generation Science Standards are longstanding best practices in science education. When evaluating science teachers, principals should prioritize science education best practices. Research supports the implementation and use of these practices in the classroom. "The superiority of inquiry-based techniques to meet a variety of educational goals has been supported by results from numerous studies involving inquiry-based and traditional classes" (Crawford, 2014, p. 536).

School districts should prioritize school administrators' professional development for evaluating content specific best-teaching practices. The evaluation tools that administrators were expected to use did not inherently align to or target key aspects surrounding best science teaching practices. Despite the level of each participant's prior science education background, all participants felt limited by their evaluation tool. None of the tools used by participants provided specific guidance for evaluating best practices in teaching science.

Building administrators are responsible for being curriculum leaders. With so many different content areas and curricula to oversee, the idea of becoming an expert in each one of these contents could seem like a daunting task given the barriers working in a small, rural district. We argue that through appropriate professional development opportunities, principals could gain knowledge on relevant best practices, content knowledge, as well as a variety of other subject specific training. Data from this study showed that administrators who had a background in science education had more confidence when evaluating science teachers and reported having provided more applicable feedback to teachers.

Collaboration with science teachers, attending content specific conferences, reading books and articles, and joining professional learning networks for science educators are a few ways principals can engage in professional development. Professional development is a great way for building administrators, whether they are former science teachers or not, to stay relevant and up-to-date in the science education world. These types of opportunities bring professionals together to discuss trends and how to best address student needs in order to prepare them as 21st century learners. Rural schools need access to professional development for administrators to focus upon best-teaching practices, and to the point of this study, specifically in the field of science education.

Limitations

In this study, the sample size was limited. The number of individuals participating was minimal; however, enough data was gathered to obtain a single perspective based upon common themes in the data centered upon principal's perceptions of evaluating science lessons in small, rural, Midwest (US) states faced with limited staffing and resources.

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