

Critical Response Protocol: Supporting Preservice Science Teachers in Facilitating Inclusive Whole-Class Discussions

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Abstract

Despite a large body of research on effective discussion in science classrooms, teachers continue to struggle to engage all students in such discussions. Whole-class discussions are particularly challenging to facilitate effectively and, therefore, often have a teacher-centered participation pattern. This article describes the Critical Response Protocol (CRP), a tool that disrupts teacher-centered discussion patterns in favor of a more student-centered structure that honors students' science ideas. CRP originated in the arts community as a method for giving and receiving feedback to deepen critical dialog between artists and their audiences. In science classrooms, CRP can be used to elicit student ideas about scientific phenomena and invite wide participation while reducing the focus on "correct" responses. In this article, we describe our use of CRP with preservice science teachers. We first modeled the CRP process as it would be used with high school students in science classrooms, then discussed pedagogical considerations for implementing CRP within the preservice teachers' classrooms. We conclude this article with a discussion of our insights about the opportunities and challenges of using CRP in science teacher education to support preservice teachers in leading effective whole-class discussion and attending to inclusive participation structures.

Introduction

Conducting whole-class discussions is an essential practice necessary to effectively teach science because it provides opportunities for students to bring together their existing ideas with new ideas that arise through the discussion (Mortimer & Scott, 2003). Teachers ideally provide clear framing questions to start the discussion, inviting multiple perspectives that can be taken up and explicated (Michaels & O'Connor, 2012). By discussing and listening to a variety of ideas, students are able to build on one another's ideas and consolidate information, and the teacher is able to guide productive, content-focused discussion (Michaels & O'Connor, 2012). Despite the importance of whole-class discussion, even experienced teachers are often challenged to conduct discussions in a manner that promotes student engagement and inclusive participation in the discussion (Haverly, Barton, Schwarz & Braaten, 2020; Meyer & Smithenry, 2014). Common issues associated with

whole-class discussion include teacher-centered conversations that focus on correct answers, opportunities for students to opt out of the conversation (Barton, 2018), and differential engagement in discussions based on academic status (Cohen, 1990).

Academic discourse often takes a teacher-centered form, which Mehan (1979) referred to as initiation-response-evaluation (IRE), where the teacher initiates a question, the student responds, and the teacher evaluates the response. The IRE pattern of discourse is problematic for two key reasons. First, it allows students to opt out when the teacher calls for volunteers. Second, teachers often take one confident student's response as indicative of collective understanding (Barton, 2018). The IRE pattern keeps the teacher at the center of discourse and limits student agency in directing the conversation.

Classroom discourse is public, and if students are afraid of making a mistake, they may opt out of whole-class discussions (Barton, 2018). A classroom culture where students are not afraid of making mistakes and are comfortable participating in class discussions is prerequisite to effective whole-class discussions (Michaels & O'Connor, 2012); however, fostering this type of classroom culture is challenging (Barton, 2018). One reason whole-class discussion is challenging is due to anxiety about publicly making a mistake (Beghetto, 2009). Mallow (1978; 2006) first described science anxiety as a barrier to students' participation and learning. Lewis and Linder (1997) found that audience presence can negatively affect performance due to issues related to self-confidence. In order to participate in whole-class discussions, students must be willing to take intellectual risks (e.g., Barton, 2018; Beghetto, 2009; Meyer & Smithenry, 2014) and trust that their ideas will be taken seriously and treated with respect (Michaels & O'Connor, 2012), which requires a willingness to ask questions, share tentative ideas, and demonstrate a willingness to do and try new things (Beghetto, 2009).

Students' academic status, based on their perceived academic success, is one factor related to the distribution of student participation in whole-class discussions. Cohen and Lotan (1995) found that teachers encounter challenges because academic language and knowledge are not equally distributed among all students. Students with lower academic status and achievement are less likely to engage in whole-class discussions. Such methods of classroom talk are not effective when some "students who are members of the 'knowledge community' have higher status than those who are unfamiliar with the conventions of academic discourse" (Vandenberg, 1999, p. 93). When the first person to speak is viewed as the "expert" in the room, it leaves little room for others to contribute and shuts down other students. Since academic knowledge can confer a form of social status and is directly connected to talk in the classroom, then issues of equity arise and threaten the goal of science for *all* as envisioned in *A Framework for K-12 Science Education* and the *Next Generation Science Standards* (National Research Council [NRC], 2012; NGSS Lead States, 2013). Productive, inclusive science talk will fail to be enacted in many classrooms as long as access to scientific knowledge differs between groups of students (Cohen, 1990).

Despite the large body of research on the discursive practices that support science learning, including the importance of visuals for conveying and developing scientific ideas, the role of visuals during whole class discussion is largely unexplored (Evagorou, Erduran & Mäntylä, 2015). However, “positioning visual representations as epistemic objects, science education can bring a renewed focus on how visualization contributes to knowledge formation in science from the learners’ perspective” (Evagorou, Erduran & Mäntylä, 2015, p. 2). In our experience as science educators, the use of an image to introduce a science unit can contribute to building scientific knowledge from the learners’ perspective by creating opportunities for students to use their informal understanding in a manner that is not dependent upon academic language.

Borrowing a well-established protocol for critical discussion used in the arts community (Lerman & Borstel, 2003), we implemented the Critical Response Protocol (CRP) to shift student and teacher roles by disrupting IRE patterns of discussion in favor of participant structures that require shared responsibility and draw on students’ informal ideas. The CRP tool scaffolds discussions (Lerman & Borstel, 2003) and supports intellectual risk-taking by promoting meaningful learning, student engagement, and inclusive participation in classroom discourse (Meyer & Smithenry, 2014). Because CRP requires a shift in the teacher’s role toward discussion facilitator, it can be uncomfortable to implement. The role of a discussion facilitator differs from teacher-directed discussions in subtle, but important ways. Teacher-directed discussions often have a pre-established goal or outcome as well as a predetermined way to get there. In contrast, a facilitator’s goal is to help the group move the discussion forward using ideas brought up by the group. This may be uncomfortable due to the fact that the teacher cannot always anticipate ideas and questions that may arise. In this article, we discuss CRP as an innovation for preservice teachers (PSTs) in supporting inclusive student participation during whole-class discussion. We describe the process of facilitating a whole-class discussion using CRP at the start of a unit of study, PSTs’ experience of CRP as learners, and their take-aways related to using CRP as teachers.

Critical Response Protocol as an Innovation in Science Teacher Education

According to Petkau (2013), CRP “is constructivist in nature and provides... a framework of questions meant to scaffold and prompt students in critical thinking... while honoring personal associations and affective or aesthetic experience” (p. 2). Thus, CRP provides teachers with a strategy for facilitating whole-class discussion in a manner that ensures that student ideas are honored and made visible to the group. The first step of CRP is to show an image to stimulate discussion. After the image is shown, students respond to five prompts that comprise CRP:

- Describe what you notice without judgment or inference.
- What does it remind you of?
- How does it make you feel?
- What questions does it raise for you?

- What meaning or understanding can you infer is intended by the author?

CRP is based on four pedagogical principles. First, the five prompts are sequenced to scaffold the cognitive demand from lower- to higher-order thinking skills. Second, the CRP process requires 100% participation to ensure inclusivity. Each student must respond to the current prompt before the group advances to the next prompt. Third, the prompts do not have “correct” or “incorrect” answers; rather, they elicit a wide range of student ideas and make them visible to the group, as participants provide evidence to support their responses. Finally, the CRP structure shifts traditional teacher-student roles by increasing the time students are speaking and decreasing the time the teacher is speaking.

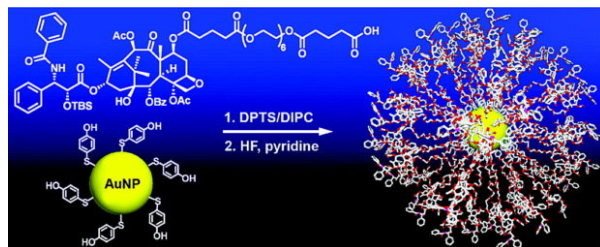
We believe CRP is a particularly useful tool for opening a new unit of science study because it allows students to connect their lived experiences to the science topic they are about to investigate. It also surfaces student ideas in a safe environment because all student ideas, including those that are scientifically naive, are respected through the CRP process. In this way, teachers learn about students’ current understandings and are able to use this information to build upon students’ initial understandings and thinking throughout the unit of instruction. Thus, CRP provides a common experience that serves as a foundation for ongoing learning about the science topic that is introduced via CRP.

Context: Implementation of the Critical Response Protocol with Preservice Teachers

There was no precedent for use of CRP in science classrooms, so the authors collaborated with a ninth-grade physical science teacher to create a CRP lesson intended for high school students. This lesson was first piloted with PSTs to test the approach, then subsequently implemented with the ninth-grade physical science students. PSTs enrolled in a secondary science methods course at a public university in the Midwestern United States participated in the CRP pilot. Each was part of a cohort of preservice secondary science teachers enrolled in a post-baccalaureate Master of Education program and had already completed an undergraduate science degree. Their degrees included chemistry, biology, physics, and environmental science, representing a range of scientific knowledge and expertise. In this course, a nanotechnology image (Figure 1) from the American Chemical Society was used. This image was selected to help PSTs prepare to write technical scientific reports, with a focus on obtaining, evaluating, and communicating information. It could also be used to introduce a unit focused on the *Framework’s* (2012) Disciplinary Core Ideas related to matter and its interactions, including the structure and properties of matter as well as chemical reactions.

Figure 1 (Click on image to enlarge)

Image used for CRP from ACS Publications (Gibson, Khanal, & Zubarev, 2007)



Steps for Implementing the Critical Response Protocol

In order to provide PSTs with the full experience of CRP, we first implemented the protocol with PSTs as learners. The first author modeled the CRP process using the lesson that was developed with a high school science teacher. This section focuses on the steps to implementing CRP, which typically requires one class period of 50-60 minutes.

To prepare for CRP, select an image that pertains to the science topic of study being introduced and prepare 10 large pieces of chart paper (two for each of the five CRP prompts). This will provide ample space for the facilitator to record all responses to each prompt throughout the CRP process, leaving the ideas visible throughout. Prepare one slide per prompt, and present one prompt at a time so that PSTs are able to focus on the current prompt without simultaneously thinking about their response to the next prompt. Move to the next prompt only after all PSTs have responded and had their ideas recorded. If PSTs are hesitant to participate, preface your introduction with a reminder that there are no wrong answers.

Describe

Begin by presenting the image with the prompt, *Describe, without judgment, what you notice*. Explain the “rules” of discussion, focusing on the requirement that each PST contribute an idea, that all ideas are valued, and that observations, not inferences, should be shared at this point. The prompt of describing “without judgment” refers to the need for comments to be limited to observable items in the image that can be explicitly named. **Tip:** PSTs will inevitably make inferences at this point, particularly if they have prior knowledge related to the topic represented in the image. To shift the conversation back to observations, ask them to identify what they noticed in the image that made them reach that inference. This presents the responder with the opportunity to rephrase the inference to make a specific observation. While it may seem like a minor point, in our experience, if the discussion unfolds by skipping lower-level scaffolds and goes immediately to higher-level scaffolds, it reinforces the problems associated with IRE modes of discussion.

Remind

Present the prompt, *What does it remind you of?* Begin by reminding PSTs there are no wrong answers because the purpose is to give them an opportunity to make connections between the image and their own experiences by responding with a memory or experience

the image triggers. **Tip:** Encourage all ideas, even slightly silly ones because the playful response often gives “permission” to PSTs to share things they normally would not in a science classroom.

Feel

After all responses from the previous prompt have been recorded, present the prompt, *How does it make you feel?* Ask PSTs to share any emotional response the image elicits and to describe their feelings in one or two words. Again, emphasize that there are no wrong answers. **Tip:** PSTs will often share negative feelings, saying the image makes them feel stupid or confused. This prompt provides an opportunity to normalize those feelings. When PSTs realize they are not the only one confused, it often alleviates or lessens the negative emotion.

Question

Present the prompt, *What questions does it raise for you?* and ask PSTs to share the questions the image raises for them. It is useful to provide a sentence stem, *I wonder...* **Tip:** While all questions are acceptable in this process, it is beneficial if at least some of the questions relate to the learning to follow and have potential for facilitating collective meaning-making. The facilitator can remind PSTs that the image is introducing a particular topic of study, so they should consider questions that relate to both the image and the topic. PSTs may benefit from time to brainstorm individually to develop a number of questions before they share.

Speculate

Present the prompt, *speculate on the meaning or understanding the image intends you to understand* and ask each PST to share their speculation. **Tip:** It is useful to provide a sentence stem, such as *I speculate that . . .* Sometimes PSTs need a moment to think about the intended meaning. We find it helpful to give PSTs a few minutes to write down a response before sharing. It is also helpful because the facilitator can collect the responses and organize them to use the following day to review the CRP process and have an open dialogue to support meaning-making.

Debriefing the Critical Response Protocol with Preservice Teachers

After the PSTs participated in CRP as learners, they participated in a debrief in which they reflected upon the process and discussed pedagogical considerations for implementing CRP in high school science classrooms. This section describes the process used for a two-phase debrief of CRP with the PSTs. The first phase of the debrief relates to meaning-making from the image and would be used in K-12 classroom implementation as well. This phase serves the purpose of closing the CRP activity and connecting it to the lesson or unit that is to follow. To start this phase, the facilitator should direct PSTs’ attention to the questions they raised

related to the image. Ask if they would like to add any additional questions and whether any of the questions have already been answered. The PSTs will likely have answered or partially answered some of the questions, so the facilitator can build on these responses. Answering some of the questions generated provides an opportunity for the facilitator to introduce academic language that will be used throughout the unit and provide prerequisite background knowledge for the upcoming unit of study. Through this first phase of the debrief, the facilitator should provide more information about the image and how it relates to the learning that will follow.

The second phase of the debrief requires PSTs to shift between the perspective of the learner and the perspective of teacher as they consider the pedagogical strategy for approaching whole-class discussion. Ask the PSTs to reflect on the protocol and how it affected their understanding of the science topic as learners. Next, ask a pedagogical question, such as, “What did I do as a facilitator to elicit your ideas and reveal pre-existing knowledge of the topic?” Prompt the PSTs to compare their prior experiences with whole-class discussions to their experience of CRP in terms of the teacher’s role, students’ roles, and how collective understanding develops (or does not develop).

Reflections Related to Preservice Teachers’ Experience of the Critical Response Protocol

Following their experience of CRP as learners, PSTs reflected upon the experience and how it contrasted with their typical experience participating in whole-class science discussions. Throughout this section, comments from the post-CRP discussion as well as from PSTs’ written reflections are shared to illustrate PSTs’ experience of CRP. In general, PSTs found the CRP experience to be useful in learning how to conduct inclusive whole-class discussions. They recognized CRP as different from typical science classroom conversations they had experienced, and they appreciated its value as a strategy to facilitate inclusive whole-class discussions. For example, one PST said:

I liked learning about the critical response tool. It is an assignment and collaboration tool that I had not learned before. It is a good tool to start a unit with, to pre-assess students’ knowledge and their feelings about a topic. It is a great way to build discourse among students and the class. It can create an environment where students express questions and feelings without the fear of being mocked.

Like others, this PST recognized the CRP process as providing a safe space for students to share their ideas and questions. From the students’ perspective, this allows for an opportunity to share personal associations and raise questions. From the teacher’s perspective, this can serve as a pre-assessment of student understanding that can be built upon throughout the unit. Students’ personal associations can become assets to be leveraged throughout instruction, with the teacher as well as other students connecting to the variety of student ideas.

The pedagogical debrief also presented opportunities to discuss shortcomings of typical whole-class discussion and contrast the CRP approach to other approaches to whole-class discussion PSTs have experienced. By reflecting on classroom practice, they gained new insights into pedagogy and developed “intermediate theories” (Hennessy, 2014) that can bridge the gap between new ideas and formal, research-based practices. Intermediate theory development refers to engaging teachers in analysis of classroom activity with the goal of gaining deeper insight and linking theoretical ideas and concepts with practice. By experiencing CRP as learners and reflecting upon their experience, PSTs saw firsthand how to facilitate inclusive whole-class discussions. In thinking about how CRP compared to typical whole-class discussions, PSTs reflected on the contributions from all learners. One PST shared that he is typically reluctant to participate in whole-class discussions after another person shares an initial idea, saying there is “no reason to use my voice.” In contrast, he saw his voice as valuable through the CRP process.

The PSTs also saw, modelled for them, how the role of the teacher shifts from that of questioner to that of facilitator. As facilitator a key task is recording student responses, including informal understandings and personal associations, rather than evaluating correctness of student responses. This disrupted IRE patterns of discourse because responses were not evaluated. All ideas were accepted and made visible when they were recorded on chart paper, so there was minimal risk in participating in the discussion. In addition, rather than a back-and-forth sequence of facilitator questions and learner responses, the CRP prompts provided structure and direction to the conversation without requiring constant facilitator input.

After participation in CRP, PSTs debated the pace of the process, which required a full class period of 50-60 minutes to complete the CRP discussion. One participant pointed out that she thought the slowed pace was beneficial to most individuals but questioned if the slowed pace might be less beneficial for more intellectually confident science students. In response to this concern, another PST explained that he has been confident in the content throughout the activity because of his science background but still found the slowed pace to be useful because it gave him time to recognize the image more holistically as a nanotechnology cancer treatment. He shared that he initially recognized a two-part chemical reaction, but having to delay speculation about the meaning allowed him to gain further insights from the comments of others that built upon his initial insights. By the end of the process, his ideas had crystallized into his description of the image: “I think it is a gold nanoparticle on the right. The top left molecule is DPTS/DIPC, the bottom is a gold nanoparticle, and in a two-step process a molecule for cancer treatment is being synthesized.”

PSTs viewed CRP as a valuable tool for facilitating inclusive whole-class discussions among K-12 students. Having experienced the full CRP process as learners, PSTs felt prepared and motivated to implement it with their own students. Following the pilot of CRP with PSTs, the authors went on to implement the protocol with ninth-grade physical science students

(Ellingson, Roehrig, Bakkum, & Dubinsky, 2016). Through this experience, we learned that CRP is effective in secondary science contexts and can support discussion of complex scientific images and ideas.

Additional Considerations/Dilemmas of the Critical Response Protocol

CRP is a useful strategy for introducing a new unit of study and can be used effectively with PSTs at any point in the semester for a variety of purposes, although it offers different affordances based on the timing of implementation. If used early in the semester, the activity could also be used to establish group norms and develop a classroom culture of sharing. Later in the semester, it could be used to reestablish the norm of everyone's voice being heard. If used several times throughout the semester, responsibility for facilitating the discussion could shift from the instructor to the PSTs as they become familiar with the process. Regardless of when it is used, CRP models a pedagogy for facilitating inclusive whole-class discussions that PSTs could implement in their classrooms.

In addition to considering at which point in the semester to implement CRP, it is also worth considering whether it can be useful at various points in the instructional cycle. We implemented CRP as a way to introduce new science units of study and found this to be a productive approach. However, we also believe it could be used mid-unit to make sense of complex data, with one or more representations of the data (generated by the students or the teacher) serving as the image. As a further alternative, CRP could be used at the end of the unit in relation to an image that synthesizes many of the science ideas discussed throughout the unit. In this way, students could work together to make meaning of a complex image by applying the science understanding they developed and building on one another's ideas. In addition, alternative scientific texts (e.g., figures, diagrams, videos, written words) could be used in place of an image. In working with PSTs, CRP could also be used to prompt discussions of pedagogy in addition to discussions of science content. For example, PSTs could view a photo of a science classroom, then follow the CRP prompts to reflect on how the classroom environment could provide opportunities and constraints for science teaching.

While English Language Learners (ELL) were not the focus of this paper, one insight we gained is how the structure of CRP provides a tool for mainstream teachers to use in support of academic language development for ELLs. The CRP protocol is well-aligned with the World-Class Instructional Design and Assessment (WIDA) standards. WIDA is a consortium of state agencies devoted to research, design, and implementation of standards-based instruction for ELL students. One of the foundational aspects of WIDA is the goal of academic language development in four domains: reading, writing, speaking, and listening. The idea being, students learn language by using it (WIDA, 2006a). CRP is a tool that gets students speaking, listening and, depending on how it is facilitated, creates an opportunity for students to write about scientific academic ideas.

Although CRP provides a useful structure for facilitating inclusive whole-class discussions, some dilemmas remain. First, instructors must consider how to use CRP to meet the needs of all learners. Engaging students with both high and low levels of interest and achievement in science continues to be a national priority within science education (NGSS Lead States, 2013; NRC, 2012). While the slowed pace helps PSTs who need more time to process information about complex science ideas, those who already feel confident expressing their ideas in the whole group discussion may find the pace to be too slow. PSTs' diverse science backgrounds must also be considered; if an image is easily interpreted by those with a particular undergraduate degree, the process will likely be less engaging. However, this challenge of students with a wide range of prior knowledge on a given topic is representative of the challenge many, if not most, classroom teachers face. Beginning with concrete observations and only inferring meaning in the last CRP prompt ensures that all students can contribute, regardless of their prior knowledge. Strategic image selection can also help alleviate these concerns. The image used is extremely important because it creates a common experience among learners with a range of background knowledge and experiences. Therefore, it must be complex enough to allow for all participants to observe unique features, ask questions, and speculate on intended meanings.

PSTs also raised concerns about efficiency and spending so much time on one topic. There were tensions between garnering 100% participation and relatively short class periods of 50-60 minutes. The CRP process could be modified to include both whole-class and small-group portions or to allow students to opt out of responding to select prompts; however, both of these modifications would present the risk of problematic participation patterns that CRP seeks to address. A more viable alternative is to spread CRP over multiple class periods, attending to absences to ensure that participants are informed about what they missed. Again, the image must be carefully selected to warrant spending a full class period or more discussing it. The image must be useful for targeting the concepts that will be addressed in the coming lessons.

Subsequent to the PST experience described in this paper, we have implemented CRP with a variety of science topics in K-12 classrooms, including the periodic table, the formation of the solar system, and ecology. These experiences again highlighted the importance of carefully selecting an image. While every group of students is different, we have found that atypical images stimulate deeper discussion than those that are typically encountered in science classrooms. For example, we used a complex map of average annual wind speed in the ecology unit; although this image was complex and required discussion to interpret the meaning, students were already accustomed to this type of visual representation, so their ensuing conversation was constrained. In contrast, when we used a collage that showed different elements and phenomena related to the periodic table, the unusual format stimulated deep discussion.

Conclusion

This article presented CRP as a tool for helping PSTs facilitate inclusive whole-class discussions in science classrooms. Although the PSTs raised some logistical concerns about implementing CRP with K-12 students, they appreciated the opportunity to engage in a whole-class discussion that differed dramatically from their prior experiences. They recognized the importance of creating a classroom culture in which all students are heard, and they viewed CRP as a useful way to create a safe space for intellectual risk-taking. CRP can be used to engage students in scientific texts (images, figures, diagrams, written words, videos) at any point, but the beginning of a learning sequence when they have little or no background knowledge is optimal. This innovation in science teacher education prompts PSTs to think more critically about how to facilitate effective whole-class discussions in their classrooms.

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