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Eliciting Students' Understanding of a Local Socioscientific Issue Through the Use of Critical Response Pedagogies

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Abstract

This study introduces a critical response pedagogy (CRP), an arts-based critical technique to facilitate meaningful dialogue in focus group settings, to secondary school science education students to engage them in discussion about sediment and chemical load in their local river basin community. Using a holistic single case design, twenty-two 11th and 12th graders (15 male and 7 female) from an environment ethics course participated in focus group interviews. The analysis of the data was made via case-by-case analysis individually performed by each researcher to identify themes, then across the cases using the long table (classic) method. The following themes were identified: (1) aroused curiosity, (2) human impact and responsibility, (3) triggering memories, (4) feeling connected to the Minnesota River, (5) outside of the captured area, (6) use of the image, (7) social impacts, (8) economy, and (9) ecological impacts. The findings indicated that student's characterization and description of the rivers is mixed although they have similar observations and experiences. In addition, using a critical response protocol created a dialogical environment where students were comfortable engaging in a conversation about a local controversial issue. Thus, the conversation shifted toward critical analysis of an issue rather than an under informed debate about perspectives. This study showed that critical response pedagogy is a non-threatening way to gauge students' knowledge and understanding of issues and identify possible misconceptions or knowledge gaps which would be useful in designing instruction.

Introduction

Since the Science, Technology, and Society (STS) movement in the 1970s there has been a strong call for the inclusion of controversial socioscientific issues (SSI) in science curriculum (Levinson, 2006); however, addressing controversial socioscientific issues in science classrooms has always been challenging (Dillon, 1994; Osborne, Duschl, & Fairbrother, 2002). Despite the pedagogical potentials of controversial SSI to enhance dialogue and discussion among students (Zeidler, 2014) and provide students opportunities to learn complex decision making processes (Burek & Zeidler, 2015), the literature indicates that such local, controversial issues cause hesitancy due to potential conflicts between teachers, students, and community members (McGinnis & Simmons, 1999). Thus, this study adapts an arts-based critical technique to facilitate meaningful dialogue in focus group settings in order to reveal participant perception of a controversial community-based SSI. Specifically, this study introduces a critical response pedagogy (CRP) to secondary school science education students to engage them in discussion about sediment and chemical load in their local river basin community.

Literature Review

Socioscientific Issues

Socioscientific issues are described as controversial social problems with conceptual and/or procedural links to science (Zeidler, Walker, Ackett, & Simmons, 2002). The literature has highlighted SSI approaches for an essential reform to science curricula, focusing on controversial and socially relevant issues (Kolsto, 2001; Lee & Witz, 2009; Levinson, 2006; Zeidler, 2014). While some science educators have expressed concerns that using socially relevant curricula can threaten the integrity of traditional science instruction and students' understanding of basic science concepts (DeBoer, 1991), several science educators have strongly advocated for

using socioscientific issues as a context for teaching science (Bingle & Gaskell, 1994; Zeidler & Keefer, 2003; Zeidler, 2014). Traditional classroom science translates, simplifies, and abstracts many concepts from their contextual origins causing students difficulty in understanding these concepts (Sadler, 2009). Socioscientific issues in science education provide a great opportunity to connect abstract science concepts with a context that is relevant to students' lives (Berkowitz & Simmons, 2003; Sadler, 2009). Using scientific principles and concepts in situations similar to those students might experience as citizens and future decision-makers in society, socioscientific contexts have a great potential to enhance students' experiences of learning science (Sadler, 2011). Despite its promise and teacher's positive attitudes for using controversial socioscientific issues in their science classrooms, the literature in science education indicates that only a small percentage of them actually incorporate SSI content into their science curricula on a regular basis (Sadler, Amirshokooi, Kazempour, & Allspaw, 2006; Lee & Witz, 2009).

Critical Response Pedagogy

Cohen (1994) describes a correlational relationship between student talk in classrooms and the development of academic knowledge. He argued that developing academic knowledge in classroom environments is directly connected to talk. One of several factors related to status in learning environments is academic knowledge. While, student talk around scientific ideas is central to intellectual development, it is usually challenging to help students learn to talk well about abstract ideas, processes, and concepts (Winokur & Worth, 2006). "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). Therefore, status differences in the classroom environment motivates educators to figure out ways to encourage all students to participate in the academic conversations that take place during instruction. As an instructional strategy to promote dialogue, Critical Response Pedagogy (CRP) provides "...a framework of questions meant to scaffold and prompt students in critical thinking ...while honoring personal associations and affective or aesthetic experience" (Petkau, 2013, p. 2).

CRP, as a form of Visual Thinking Strategies (VTS), is grounded in the observation of diverse viewer responses to a visual learning prompt (Housen, 2002). VTS is a cycle of three questions: What is going on here? What do you see that makes you say that? And what more can you find? These questions support generative observation and evidentiary reasoning, but scaffold no other forms of thinking or response. Critical Response Pedagogy extends VTS by connecting existing knowledge and prior experiences from the learners directly to a reflective learning experience. There are no wrong answers when people begin by describing or stating what they see and notice. As learners are asked to recall and share previous knowledge and experience, each participant has room to talk, connect, question, and draw meaningful insights from the work. This meaning-making through sharing insights (Perpich Center for Arts Education [PCAE], 2006) also supports the development of academic knowledge. A critical response protocol includes sequential and linear prompts: notice, remind, feel, question, and speculate. Six questions guide the discussion: (1) What do you notice, (2) What does the image tell you, (3) What does the image remind you of, (4) How does the image make you feel, (5) What questions does the image raise, (6) How do you speculate on the meaning of the image. Focusing the initial observations on the image, students' personal associations and visual experiences scaffold their critical thinking. Since the questions only aim at eliciting the connections between their personal associations and the image, the CRP method encourages participants to draw meaningful insights from the image.

Perspective Framework

Imagery has long been used by researchers to communicate scientific knowledge about complex environmental issues to public stakeholders (Smith & Joffe, 2009). Photo-elicitation is a widely used strategy to explore participant's understanding of their own environment (Prosser & Loxley, 2008). Connecting "voice to place and voice and place to landscape through photo-elicitation is powerful" (Beilin, 2005). Photo-elicitation empowers respondents, giving a focal point so respondents can share their "version of reality and meaning" (Prosser & Loxley, 2008). Prosser and Loxley (2008) also suggest that discussing "topics through an intermediary artifact" relieves pressure and builds rapport among respondents. Participants respond to the questions without indecisiveness and intimidation as they discuss the image and share their thoughts about it (Clarke-Ibanez, 2004; Hazel, 1995; Holliday, 2000). Combining an adaption of photo-elicitation and focus group interviews, this study uses a single image of the river landscapes to elicit secondary school students' perceptions about the rivers and the landscapes surrounding them.

Purpose of the Study

The purpose of this study is to investigate the ways secondary school students perceive a local controversial socioscientific issue through critical response pedagogies. This study utilizes the description of *critical response pedagogy* (CRP) as "...a framework of questions meant to scaffold and prompt students in critical thinking ...while honoring personal associations and affective or aesthetic experience" (Petkau, 2013, p. 2). Therefore, the following research question was addressed in this study:

- How do secondary school students perceive a local controversial socioscientific issue through critical response pedagogies?

Methodology

Research Design

Using a critical response pedagogy (CRP), this study was designed to gain insights into how secondary school students perceive a local socioscientific issue. Using an exploratory type of case study (Yin, 2003), it aimed to explore a phenomenon (students' perceptions of a socioscientific issue) and the real-life context (a community within a large watershed in the Midwest) in which it occurred where the boundaries between the phenomenon and context are unclear. The case study design implemented for this study is considered a single case design because the phenomenon investigated was considered a unique case that has distinctive characteristics due to its context. This type of case studies is especially useful to document the precise nature of a phenomenon that is not well-understood (Yin, 2003).

Participants and Context

The participants in this study live in a metropolitan suburb located in a major watershed. Students growing up in this suburb have witnessed its significant development over the past fifteen years, shifting from an agricultural community to a second-ring suburb of retail shopping, single-family home subdivisions, and an increasing variety of local industry. During spring semester 2014, students in a high school environmental ethics course participated in the focus groups of this study. A primary premise of this elective course is that students explore and engage in their community and environment through the investigation of real-world, community-based issues. The environmental ethics class which is co-taught by a science teacher and a social studies teacher. The class content mainly focused on various community-based environmental problems. The idea of triple bottom line, that required students to look at environmental problems from social, environmental, and economic perspectives, was a baseline for the content of the course. Twenty-two 11th and 12th graders (15 male and 7 female) participated in the photo-elicitation focus group interviews. They were selected based on their willingness to participate in the focus group sessions. The student participants in this study were Caucasian (14), Asian (3), Hispanic/Latinos (3), and American Indians (1).

Data Collection

Data employed in this study were derived from student responses in focus group interviews. Krueger and Casey (2009) identify a key purpose of focus group interviewing is to "obtain perceptions on a defined area of interest in a permissive, nonthreatening environment." Further, a defining characteristic of focus groups is that the participants have in common certain characteristics that relate to the topic of the focus group (Krueger, 2009). Three focus groups, 6-8 students each, from a single environmental science class, were the primary data sources of this study. The focus group interviews were conducted in three sessions that took 20-45 minutes each. Participants in each session were purposefully grouped by the classroom teachers create groups which might comfortably engaged in rich discussion. During each of the three sessions, one of the researchers guided the interview discussions while the other observed and took notes. The focus group sessions were audio recorded and transcribed by the researchers.

The focus group interviews were centered around an image of the confluence of the Minnesota and Mississippi Rivers. The Minnesota River Basin, where the rivers merge, has been one of the most polluted in the nation with sediment and nutrients being the primary pollutants of concern. The flat agricultural lands and steep riverbanks that rapidly erode are the main reasons for the pollution in the river. The image used to drive the CRP showed

the confluence of two rivers, the Minnesota having high turbidity (heavily sedimentation) and Mississippi being relatively clear (see Figure 1). Further, this image representing two distinct bodies of water coming together and running in tangent without mixing is an ideal artifact for secondary environmental science students to offer critical responses of their perspective to issues of a local watershed.



Figure 1. The CRP image (Photo courtesy of Area Commission, MPCA)

Data Analysis

Treating each focus group as a case, the researchers individually performed a case-by-case analysis to identify themes, then analyzed across the cases using the long table (classic) method (Krueger & Casey, 2009). This systematic process involves segmenting all transcripts by case, each in a uniquely identifiable scheme, cutting strips of responses to every question from each transcript, and grouping those responses together by corresponding section (i.e. question) on a long table or flipchart. This makes the data visual allowing the researcher to more easily to write a descriptive summary of each group noting themes and trends, frequencies, and any other significant points. After this was repeated through all of the data by each member of the team we convened to share our individual findings and look for points of agreement. A colleague familiar with the methodology and context of the study performed an independent analysis of the focus group data for verification and triangulation of themes and trends. To analyze the data, Miles and Huberman's (1994) general analysis framework was employed. This framework includes data reduction, data display, drawing conclusions, and verification. This approach allowed for the elicitation of rich descriptions that captured the essence of the phenomenon in question from substantial raw data sources.

Findings

The analysis of the qualitative focus group interview data revealed nine major themes: (1) aroused curiosity, (2) human impact and responsibility, (3) triggering memories, (4) feeling connected to Minnesota river, (5) outside of the captured area, (6) use of the image, (7) social impacts, (8) economy, and (9) ecological impacts. Each of the themes is presented in the following section.

Aroused Curiosity

When participant students received the image of confluence of the two rivers, their initial reaction was mainly to pose questions about it. In many instances, students described how curious they were to know more about the causes and consequences of the issues presented in the image, as well as how these two rivers looked in the areas that were not captured in the image. To illustrate, one of the participants asked whether it was the consequence of the actions of the people living around the river or the natural structure of the land,

I wonder if it's not, like human's fault because it's so dirty or if it's just like the land around it? Maybe it make it dirty because, like, go [name of the town] and stuff there's like valleys all over and like muddy marshes and stuff and maybe that's why it's dirty. Maybe it's not us doing it.

Similarly, another student questioned why what made the Minnesota River dirty did not affect the Mississippi River as much:

I'm curious to know, like, what like, if that like is the pollution, what's polluting that, and what's making it not in the Mississippi river.

One of the students pointing out the settlement around the Minnesota River claimed that there could be a connection between human use of the land and the pollution in the river,

I'm also wondering like, you see like, kind of like the, maybe like the buildings over here and I don't see...the picture's kind of cut off but I can't really tell if that's what's causing it like the people might be polluting it, you know, making it that bad. Maybe there's not as much population around the Mississippi River that making it that way? Or maybe they just care more?

Students were also curious about the reasons why these two rivers did not mix so that the color difference on the confluence point of the rivers was so apparent. They also wondered the meaning that the color difference on the captured image meant,

Um, the Minnesota River is a different color, but I'm kind of curious to know like what that means. Does that mean the Minnesota River is dirtier? Or are there just different things in the Minnesota River? You know.

One of the most common questions that students posed centered around how these two rivers looked like outside of the captured area. Students frequently asked whether these two rivers looked same where they started, as well as downstream,

I think a question for me would be like what did it look like at the beginning? Like I don't think it'd be as like dirty, or as (brown necessarily?) but does it have a different color to it rather than...does the Mississippi and the Minnesota start with the same color? Or are they different to begin with? That could help with a lot of the...

M1: yeah, but like, is it getting dirtier like, I don't even know how to explain it. F1: like is the Mississippi gradually getting dirtier the farther it goes? M2: like the picture over here (points off the image) like, is it staying like over here? M1: like is it dirtier over here? Or do we put more in over here than they do over here? If that makes sense. F2: yeah. M1: cool.

Lastly, some students wondered about the science behind the fact that these two rivers did not mix at the confluence point,

yeah I think the science is in what's causing them not to combine, well, no, cause it goes on, well, how much longer, do you know how much longer it goes on from that point on that it doesn't combine?

Human Impact and Responsibility

Speculating the meaning of the image, students made constant references to the responsibility of the people on the scenario presented on the image. They often compared the human used land around both rivers in order to reveal the sources of the issue. To illustrate, one of the students referred to the length of the shoreline next to the Minnesota River compared to the one next to the Mississippi River,

I don't know if it has anything to do with the river or anything, but you notice like next to the Minnesota there's a lot more shore line, whether that be people use it more, or if that's just the bank and it could be that they favor maybe a cleaner river, or it's just coincidence.

Some students also addressed the agricultural lands around the rivers. They believed that the reason for the dirtier look of the Minnesota River compared to the Mississippi River was more agricultural land next to the Minnesota River:

it could be a lot more farming near the Minnesota River so you see a lot of the sediment in there and if it is dirty it could be the reason why you see it brown. I think that's why, part of the reason.

In contrast, another student observed less human used area around the Minnesota River which resulted with more pollution going into that river. He believed that the civilized areas around the water bodies could prevent erosion causing sediment in the river,

There's more like civilization, it looks like on the Minnesota so or pollution like eroded soil can get into the Minnesota easier than in the Mississippi cause it doesn't show any, like, housing or anything on that coast or whatever.

In addition to what they observed in the image, students also speculated the scenario presented in the captured image. For instance, one of the students stated that the image contrasts the story of the people living around the Minnesota and the Mississippi rivers. It also presented the differences of people's attitudes and choices about the environment, according to the students,

it could tell a story, maybe, of the people that live next to the Minnesota River versus the people that live next to the Mississippi. If the Minnesota is polluted, it could, uh, it could suggest that maybe the attitude of the people who live next to the Minnesota aren't as cleanly, clean, as clean (laughs) as the people who live around the Mississippi. Maybe about the choices that the people living along the two rivers have made? Like, how they use the water or whatever.

Describing the responsibility of the people living around the river, students often criticized the members of their communities due to their actions negatively affecting the health of the river. Students were more concerned and sensitive about the issues around the Minnesota River than the ones around the Mississippi River. Thus, they were more critical about the actions causing pollution in the Minnesota River. For instance, some students addressed the power plant causing pollution in the Minnesota River,

I feel like no one really tries to clean up the Minnesota River either. Like, there's that plant or whatever right down by the gases place, or whatever, the fossil fuels burning place and it seems nothing, no one's really trying to make it a better river. We're all just like ignoring it and letting it go.

Another student openly criticized his community in not taking any actions to prevent the pollution in the Minnesota River. In order to extend his point, he also added that the actions taken in their own community affect other people living downstream.

I feel like we're not really doing our part to help out, um, to try to make a cleaner, cleaner place on earth because, like being, [name of the town] being on the Minnesota it's kind of like, you, I guess kind of puts some of the blame on our town because we're not really trying to like do anything to stop it from happening and we kind of ruin it for everybody else down the Mississippi river.

A similar point was addressed by another student who claimed that people polluting river do not have a broad perspective to understand how their actions directly affect the people living downstream,

I think it means people don't have a broad perspective on what they're doing and how it can affect people, I mean, people up the Minnesota River if they dumped waste into it or were polluting it somehow probably don't get, don't see the big picture of how it affects people down the river and how, I don't know, disappointing it is that the people down the river can't really choose how it's going to be, it's kind of like, it's all based on like the judgment of people up the river and they can't really choose that for them so...

When students openly criticized their community about the pollution in the Minnesota River, they also made references to the economic reasons behind the decisions. Students believed that people preferred getting economical benefits from the river, but not using that money for pro-environmental actions around the river,

I think the reason it might be so dirty is cause economically people were trying to make money and taking shortcuts and dumping whatever they had into the river to make it dirty. So it's kind of weird to, like, spend money to clean it up when you're going to make money when you made it dirty.

What's wrong with the watershed spots that make it that way whether it be, like, crop fertilizers or like company runoff. Cause I know, like, here in [name of the town] our companies are pretty close to the river. And industries, whether rain or flooding takes any of that chemicals away or something like that.

Triggering Memories

Showing students an image that captured an area that they were familiar to, students immediately shared some of their memories around the rivers. They compared the scenario presented on the image with their personal experiences and observations. One of the students referred to the things she had heard from the public conversations going on about the river-related issues,

I think this picture, yeah, it reminds me of like how it supports the idea that the Minnesota River is gross, it stinks, it's not a cool place to like fish, or boat, or canoe or whatever you wanna do. And the Mississippi is so much better. I think this picture supports that, like ideal, like mindset. That the Minnesota River is a lot grosser and maybe less clean than the Mississippi.

Some students shared their observations about the flooding events occurring every spring in their town. They stated that the impacts of the flood show people how dirty the Minnesota River actually is,

yeah I think the Minnesota kind of tells a story of, like, [name of the town], like every year or almost every year the bridge on 101 floods, and like, if you go down there in the spring you kind of see like just trash washed up from different places.

Students also connected their memories from their recreational activities around the river with what they saw on the image. Some of those activities were swimming, fishing, and canoeing. To illustrate, one student shared that although he used to go fishing on the Minnesota River frequently, he never realized that the Minnesota River was as dirty as shown on the image,

um, it reminds me of I used to go fishing with one of my old teachers on the Minnesota River a lot. I just never really realized how dirty it was...everything in, ah, I didn't really like care cause I was still catching fish so it didn't really phase me at all.

Feeling Connected to the Minnesota River

As they looked at the confluence of the two rivers, students naturally compared the Minnesota River with the Mississippi River, as well as how much people cared about these two rivers. The statements of the students revealed that most students did not believe that the government treated these rivers equally. For instance, one of the students stated that the government took more actions to clean the Mississippi River,

or it could show the role that the government plays with the environment. On each side of the, like one could care for it more and have more action cleaning it up than the other one.

Another student believed that the people pay more attention to the issues around the Mississippi River because it was a bigger river which caused people all around the country care about it. She also added that those people usually underestimate the fact that problems around smaller rivers could affect the health of the bigger rivers like the Mississippi,

I think it shows, like, people think that a small river like that can't affect the bigger river like the Mississippi so they don't really pay attention to that they just pay attention the bigger, the bigger picture like the Mississippi where they should be focusing their attention more on the small rivers that feed into that, ah, big river.

Outside of the Captured Area

Despite the fact that the image helped students focus on a specific area where the image was captured, the confluence of these two rivers, some students still made references to outside of this area. Students often wondered the conditions of these two rivers at the points where they started, as well as the locations they

traveled through. To illustrate, one student pointed out that the Minnesota River travels through big river valleys,

Yeah like how each river comes from like a different stem. Cause like the Minnesota River comes from like a big river valley where everything runs into it and the Mississippi gets a lot of stuff too, kind of where they start and where they travel through, any industrialization.

In order to understand what was really going on with these two rivers, students offered to look at the images captured from the different locations on both rivers, from the beginning to the end. Therefore, it would be easier to decide the factors negatively affecting the conditions of these two rivers,

it's be super interesting if they put this picture like they put a lot of sheets and they put like the source of the Minnesota and the source of the Mississippi, whether that be like they look the same at the beginning, but when they meet, what's happening to make that change from the beginning.

I mean I think it would be interesting to see different pictures of different points in the river where, like, the color may have changed and look around that area and see what could have affected it. If that's, if it's a different color all the way down and keeps changing or if it's like this exact color then there wouldn't be a point then.

In addition to addressing the starting points of the rivers, students also pointed out the Gulf of Mexico where the Mississippi River ends. Considering different rivers merging into the Mississippi river all the way down to New Orleans, students wondered how this affects the way it looks down there,

um, the first thing that comes to my mind when I see this is like what can I do to help, cause I don't really know but I wanna help make it cleaner. Um, I wanna know what the Mississippi River looks like all the way down the line, all the way down through Louisiana. I think it goes down to New Orleans down to the Gulf of Mexico. I wanna know if it looks really dirty down there, what's going on with it down there and then what it looks like at the start of it at Lake Itasca and if it looks really clean or not.

Use of the Image

As soon as they received the image, students immediately shared the possible uses of the image for different reasons. Most of the students stated that the image had big potential to be used as an eye opener for the people who were not aware of the issues around the rivers. Therefore, the image could help people understand the significance of the issue,

I think it might be an eye opener to some people like if that is part of our pollution then it would help people understand what's wrong with us.

Students also appreciated the fact that the image presented such a complex issue very simply. Therefore, they decided that it could cause a long lasting impact on people,

this picture you could show to a group of like second graders and understand like that the Minnesota looks bad and the Mississippi doesn't and with that like such a simple like impact that the picture makes it might leave a lasting impact on people that how bad it is cause like, it's an obvious problem. It's not something difficult to understand, and just the message needs to get out that it's bad. Whether that be, I don't know, how to fit it? But, It'll be a good way to get out the image and definitely leave an impact on people.

In addition, many students believed that the mainstream opinion in their community was that the Mississippi River was more polluted than the Minnesota River. That is why showing the image with no label on it would help people understand the truth,

I'd like to see what would happen if you took a bunch of people who lived in Minnesota and you took the labels off the rivers and then you asked them to point to which river they thought was theirs and to see which one they would choose.

Lastly, some students offered to use the image to raise awareness, as well as motivating people to take pro-environmental actions because they believed that the image carried out its message very strongly and effectively,

People after they see this will take action and start being more cautious of what they do to the lake and try to get people involved to help clean it up and everything and raise money to do it. Cause I feel like if you show people like harmful things it somehow makes them think about it more and more and wanna change it. Like if ah, people see those dogs on those commercials like looking like they're getting beat up at the pound and everything it'll make people want to donate to them and like even adopt a dog or something, so I think we can do the same with like showing people this image cause it'll make them wanna help out and make the river cleaner.

Social Impacts

In terms of the social consequences of the issue presented on the image, students addressed the changes on people's views about these two rivers. They believed that as people realized the significance of the pollution problem on the Minnesota River compared to the Mississippi River, their social habits around the river, including their choices of place for living, would change immediately,

I think from a social perspective it definitely sends a really bad connotation with the Minnesota River, like when people see this they're not going to want to go to the Minnesota River. Like, they're going to want to go to the Mississippi. Like, kind of the fact of if a person had a choice to live on the Mississippi or to live on the Minnesota this picture gives that, like, social impact that people are going to want to live next to the Mississippi and not Minnesota, just cause it's kind of, I would say disturbing and an appealing image.

Living in a state where recreational activities around the river were an important part of people's social lives, students also pointed out how those activities, such as fishing, would be impacted due to the pollution in the rivers.

um, socially this affects pretty much everyone who lives on or near the Minnesota or Mississippi River like in the towns that are all along side of them cause they probably like won't be able to go and do anything that they want to do like fishing and stuff. So it affects the people, too, that live around.

Different from the statements above, one student believed that the pro-environmental actions taken by the people living in her community was not enough to solve problem. Hence, despite the common view, these people were not environmentally savvy enough to prevent the issue,

I think it proves that, I mean a lot of people in Minnesota think that they're pretty good with the environment but this could prove that we're not as environmentally savvy as we thought we were. Like we, well we think that recycling and doing stuff like that is enough but it's not always enough.

Economy

Explaining the causes of the issues around the rivers, students often addressed the economical concerns of the people living in their communities. Students believed that those people chose to not to spend money for cleaning the river while making money by using these rivers,

from an economic aspect with it, I think that shows that we're not willing to spend the money on keeping it clean and, I mean we have a lot of buildings next to it, so that could be a factor that there's resources so we allow to be built so that, it makes money rather than spending to preserve it or keep it clean for that matter.

Based on what they observed, students listed the economical consequences of the issues around the rivers. Some students addressed the economical consequences for individuals, whereas others pointed out the companies negatively affected economically,

I feel like it could affect the economic too cause, um, I wonder if like they're limited economically on the Mississippi because of the Minnesota such as like fishing or different economical stuff they do with like the water and if that, um, Minnesota River water is polluting it could be hurting other companies economically.

Couple of the students argued that the issues around their local river would potentially impact the communities living downstream. They provided examples from the Gulf of Mexico where the economy has mainly been driven around the river,

I think it affects economically because all of the waste that comes from not only the Minnesota but all the feeder rivers kind of create a big dead zone down in the Gulf of Mexico where nothing, nothing can live and that takes away a lot of opportunities like shrimping and fishing and that hurts the people around those small towns that have fished for centuries to keep their families healthy and provide for them.

Ecological Impacts

Students frequently shared their concerns about the living systems directly affected by the health of the river. They reached the conclusion that any living creature in the river ecosystem could be affected negatively by the pollution in the river,

I think the obvious environmental perspective is the aquatic life being affected, other, um, water ways being affected, um, even maybe the, like the soil and land from like the Minnesota could be affected. I think there's many different things that could be affected in the environment.

In addition to the negative impacts on the river life, students also stated that the chemicals and other types of pollution indirectly impacts the health of the people living around the river because those people use the river for different reasons, such as fishing or swimming,

different chemicals that are being passed on to the Minnesota River to the Mississippi River and what those chemicals can do to harm like fish and other things in the river and then (clears throat) is it like safe to even eat, like fish that comes out of the Minnesota River or like even the Mississippi River down the stream? Can it be safe with all the chemicals that are going through it that the fish are swimming in?

Results and Discussion

This study investigated the ways secondary school students perceive a local controversial socioscientific issue through critical response pedagogies. In general, student's characterization and description of the rivers is mixed. These students make some very astute observations about the differences in appearance between the two rivers, but their descriptions display a level of ambiguity. Students describe the rivers as dirty and say that the rivers are polluted, but offer no explanation of what those terms mean or any expansion on how they arrived at such descriptions. On the other hand, students made explicit references to social, environmental, and economic aspects of the socioscientific issue presented on the image. Since the image presented a contrast between two rivers in terms of their pollution levels, students frequently listed different social and economic actions causing this significant difference between these two rivers. The fact that the Minnesota River was significantly more polluted than the Mississippi River on the location where the image was captured, students often examined the social, economic, and environmental reasons that makes their local river more polluted, as well as the consequences for the communities upstream and downstream in terms of these aspects. The literature in science education has highlighted the significant relationships among teacher beliefs, teaching practices, and student learning (Bryan & Atwater, 2002; King, Shumow, & Lietz, 2001; Lederman, 1992). As they made their explanations, students constantly made references to the social, environmental, and economic aspects of the issue. As it was mentioned before, the environmental ethics class was structured based on the triple bottom line idea that involves social, environmental, and economic perspectives. Hence, the findings of this study illustrated how teachers' practices in the classroom were reflected on students' statements. However, these statements consisted of not only what they learnt in the class, but also their personal opinions and beliefs derived from their experiences in their local communities.

In general, students addressed the consequences of the presented issue in both local (e.g. impacts on recreational activities in their town) and national scales (e.g. dead zone in the Gulf of Mexico). However, although both rivers captured in the image were in their backyard, students presented a stronger ownership for the Minnesota River while considering it as their local river. They often complained about the attention that the Mississippi River gets from the government and other organizations while even the local communities are not really concerned about the issues going on around the Minnesota River. The literature suggests that emotional involvement with environmental issues results in greater willingness to be involved in those issues (e.g. Bang et al., 2000). The statements of the students in the focus group sessions showed that students were more involved in the discussions about the Minnesota River than the Mississippi River, as well as being more motivated to suggest the necessary actions to prevent the issues around their local river. On the other hand, it may also indicate their lack of awareness about point and non-point source pollution with respect to their own place and space.

The findings revealed that the conversations in the focus group sessions were more personally meaningful and relevant because the image captured an area close to students' community. While expressing their opinions and beliefs about a local controversial issue, the students often shared their personal feelings, observations, and experiences to support their arguments. Pedagogical goals around these issues aim at engaging students in dialogue, discussion, debate, and argument (Zeidler, 2014) and personally meaningful and relevant discussions around socioscientific issues provide students opportunities to participate in the conversation around those issues (Burek & Zeidler, 2015). This study showed that a personally meaningful and relevant scenario presented with an image of a familiar location promoted both a quality and quantity of arguments. Science education literature indicates that students may not always feel comfortable in having conversations around SSI (Zeidler, 2014). This is especially the case when they are personally part of the controversy. Participants in these focus groups did not hesitate to share their opinions and positions about the issue because of the structure of the critical response protocol which started with an image and built the whole conversation around it, putting the participants at ease and making them non-hesitant in sharing their opinions and positions about the issue.

The nature of the critical response protocol in these focus groups created a democratic environment where participant students shared their knowledge, feelings, and experiences about socioscientific issues regardless of their status in their classroom. Therefore, a democratic environment based on dialogue among students occurred. Vandenberg (1999) pointed classroom disparities as "students who are members of the 'knowledge community' have higher status than those who are unfamiliar with the conventions of academic discourse" (p. 93). Asking students to identify what they notice and share their memories, experiences, feelings, and opinions about an image captured in a location where they were familiar to, these students were more comfortable to sharing their thoughts without any concern about being correct or incorrect. Using a critical response protocol to engage students in a conversation about a socioscientific issue created a dialogical environment where ideas were expected, not answers. Thus, the conversation shifted toward critical analysis of an issues rather than an under informed debate about perspectives.

Implications

There are some interesting things to note about secondary school student's ideas and understanding of social implications of a complex scientific issue as gleaned through critical response. Critical response pedagogy can be a non-threatening way to gauge students' knowledge and understanding of issues and identify possible misconceptions or knowledge gaps which would be useful in designing instruction. Further, the questions raised by students through critical response can serve as themes for instruction, ways to engage learners in the learning experience, and even primers to critical thinking for learners to probe deeper into issues. The ambiguity in the language used by students to describe scientific issue within their local context can also be helpful to teachers as they think about how to frame issues and choose language they use to discuss issues with students in class.

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