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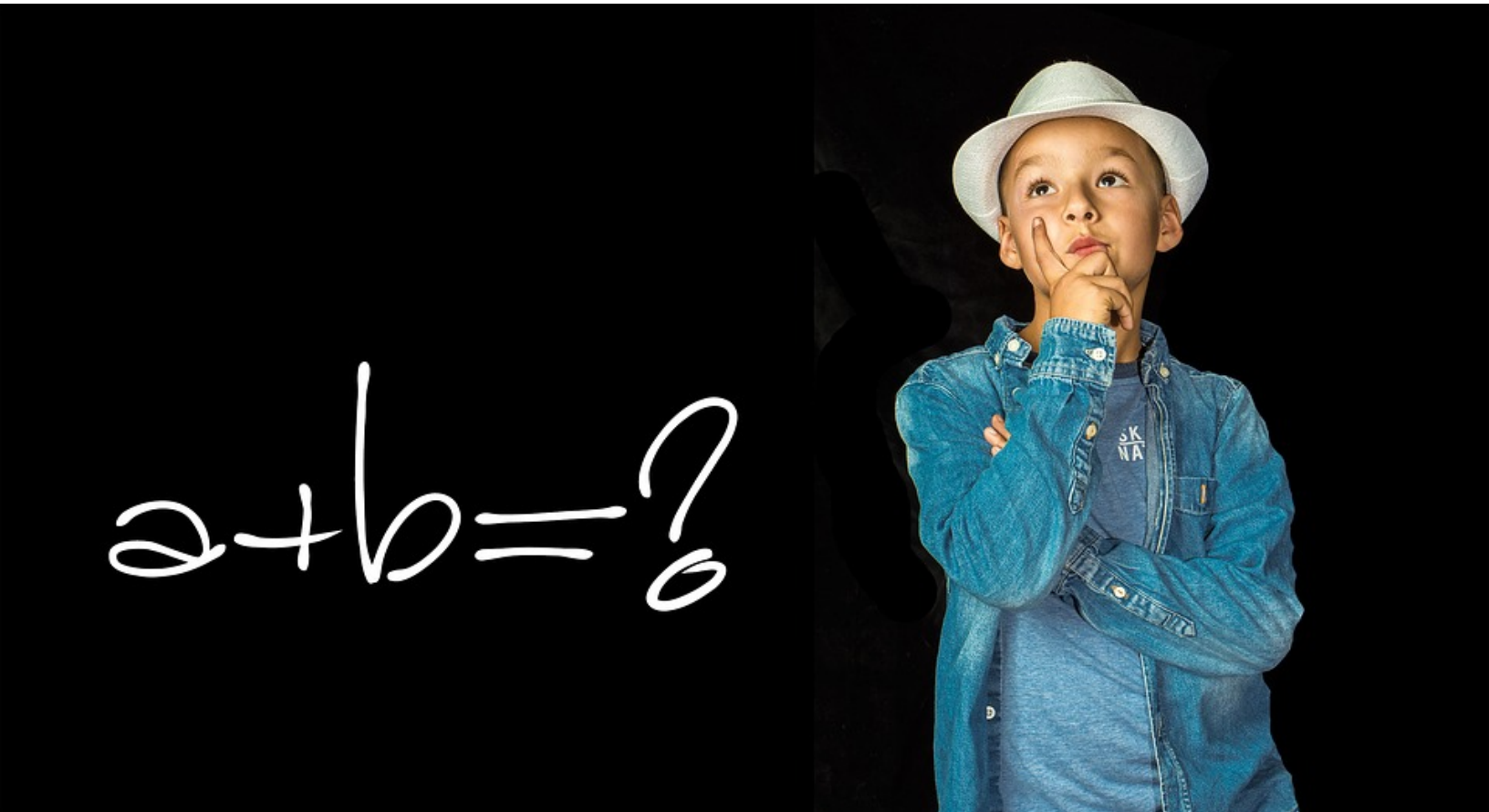
CEU's for Teachers and Educators

Using Math to Explore Social Issues



quantitative data there is less likely to be consensus about the need to change or maintain a policy.

Mathematics: An Insufficient Tool for Social Inquiry

Students indicated that mathematics is an inherently limited tool for social inquiry, even as it is a valuable tool as previously discussed. They proffered the following shortcomings of a mathematical inquiry about societal problems: (a) it is reductive and impersonal, (b) it provides inadequate explanations for problems, (c) it is irrelevant for moral arguments, and (d) it is inaccessible to the general public.

Reductive and Impersonal. In a mathematical inquiry, messy and complex societal issues are mathematized, transformed into simpler mathematical problems that can be solved. An issue is likely to be "oversimplified" (Alison) when mathematized. Therein lies an inquiry limitation. All students expressed doubt that a mathematical inquiry is capable of taking all relevant aspects of a social issue into account. In part, this is because, as Gabriel noted, "Not everything [about an issue] can be reduced to numbers."

Students acknowledged the difficulty of getting a mathematical inquiry right. For example, a rigorous examination of the fairness of the death penalty requires analyzing the complicated legal process that ensues between the commissions of murders and the executions of murderers. Students pointed out that the class's conclusions that the death penalty is a racially discriminatory practice would have been better substantiated had their inquiry incorporated additional factors. Students also acknowledged that a more comprehensive inquiry is likely to require more sophisticated mathematical tools than those taught in high school mathematics courses. Even so, students emphasized that it was unlikely that one inquiry could incorporate all relevant factors.

Additionally, many students (35%) indicated that a consequence of the application of mathematics to social problems is its simplification and objectification of human beings. An individual is reduced to a single statistic or a handful of attributes (e.g., race or gender) which William, among others, found worrisome: "People are so complicated. . . . You can't pick one thing to say represents a person. That's what makes it difficult for me."

Students (20%) indicated that the impersonal nature of mathematics can put us at a distance from social problems whereas personal stories help connect us to them. They spoke of the need to "leave the mathematics behind," as Zachariah put it, and reach out to individuals to hear their stories in order to better understand these problems.

Inadequate Explanations. For many students (approximately 38.3%), a mathematical inquiry about fairness lacks adequate explanatory power. Mathematics can help us identify social problems, but it cannot tell us why the problems exist, let alone what can be done to solve them. Noah made this point in reflecting on his investigation of the body image of students at his high school: "We found out that there is a positive trend of lots of dissatisfaction among girls, but that doesn't tell me why it is and that doesn't help me try to figure out how it could be reversed." In the following interview excerpt, Lauren indicated what other type of inquiry might be needed to help explain racial disparities in the special education classes in her town:

> *I really think that one of the things . . . would be to talk to a lot of people in that town . . . to try to understand what's going on behind that number. So while the statistics would still really be useful, it would just be a starting point.*

Irrelevance for Moral Arguments. Many students (46.7%) indicated that societal problems raise moral concerns and that mathematics is an irrelevant tool for addressing them. Some students challenged the implication of cost-benefit analyses that numbers should dictate actions commensurate with their magnitude or statistical significance. Why should some be denied care or resources because they are so few in number? Eric was one of these students:

> *When we were talking about [government-subsidized prenatal care], it would've been cheaper to just let the weak die, and then we wouldn't have to take care of 'em. But it's not very ethical. Math isn't ethical. It's just the hard facts . . . but as humans we're caring.*

Some students talked about the irrelevance of mathematics for what they perceived to be moral issues at the core of environmental policies and in social policies, such as the death penalty, which were the subject of their classroom inquiries. The following excerpt contains Noah's reflection on what he saw as an ethically questionable use of mathematics in the regulation of environmental hazards. He challenged the notion that the regulation of toxic substances is simply a matter of adopting levels pronounced safe by conventional scientific standards. In Noah's view, the risk of harm is too high.

> *The EPA has made this specific level, saying you can't have any more mercury than this. . . . If you're at 24 parts per million, you're OK, but if it's at 25 parts per million, you get arrested. . . . When you're talking about issues where morality is involved, if you use math, then it could become too easy to become disjointed from the subject and what's at stake. And if you do that then you can make mistakes that, while legally or mathematically sound, would be morally abhorrent.*

Students' reflections on the class's death penalty inquiry suggested that even if everyone agreed on the "facts" regarding the application of the death penalty in the United States (e.g., race is a factor in executions), the empirical evidence alone would not resolve the debate. One could always argue that the evidence suggests that the death penalty should be reformed, not abolished. Moreover, even if all the flaws in the administration of the death penalty were eliminated, one could still oppose or support the death penalty on other grounds, such as moral grounds. "None of the statistics would be relevant if you wanted to say, I think the death penalty is wrong because I just don't think you [the state] should kill people ever" (Blake). One could justify support of the death penalty on the grounds that "murderers deserve to die" (Sanjit) "to get justice for the murdered victims" (Emma), or

because "death is a less cruel form of punishment than life in prison" (Gabriel).

Inaccessibility. Some students (15%) noted that mathematical arguments about equity issues are unlikely to be widely understood by or potentially convincing to all citizens. As a result, mathematics serves to constrain the participation of individuals in deliberations about social issues where these arguments are advanced. Most people have no choice except to rely on the critiques of experts.

Judging Mathematics Applications

All students indicated that the conclusions of mathematical inquiries should not be accepted at "face value" (Madison). Rather, they ought to be accepted (or rejected) pursuant to one's "judgment" (Gerry) of the merits of the inquiry. Judgment is required because, in Elena's words, "there is not a set way to use mathematics to investigate a social problem." Furthermore, people can make choices that are self-serving, support their preconceived beliefs, or promote a political agenda.

Students identified the following five elements of mathematics applications as subjects for scrutiny. Representative comments about these elements and the percentage of students who mentioned an element are provided.

(a) Factors relevant to the social problem that are incorporated in the inquiry (100%).

Blake stated, "What things they were taking into account and what things they weren't taking into account. I think it's important to know these things."

(b) Definitions of concepts and their mathematical representations (approximately 71.7%).

A lesson learned from their inquiries was that opposite conclusions can be drawn from inquiries that incorporate different mathematical representations of concepts like fairness. Blake reflected on the class's death penalty inquiry:

> *You can conclude a situation is fair or not fair depending on how you define fair. . . . We showed that the death penalty was biased against African Americans when we compared the racial distribution of people on death row to that of the US population. However, we found that the death penalty was biased against Caucasians when we compared the racial distribution of people executed to that of people on death row. I find it interesting, and disturbing, that we could use two reasonable definitions of fairness to make radically different conclusions regarding the death penalty.*

(c) The data used and how it was collected and organized (approximately 78.3%).

In a joint interview, Adam and Matthew reflected on how data classification schemes can easily serve the agendas of those in power:

> *Because chi-square hypothesis testing and ANOVA statistics depend on the number of groups and the separation of numbers between groups, you can basically use the same number of people and classify them arbitrarily . . . to come up with whatever you want. (Adam)*
>
> *Historically, White people have been in power, and they classified people who weren't completely White as the "other" group. (Matthew)*

(d) The procedures used to analyze the data and their underlying assumptions (100%).

Brian noted that one needs to "make sure that the assumptions to use those methods are true." Milos reflected that "If you just change what you do with the data, that same data can be used to make sometimes even opposing arguments."

"There are definitely different ways of looking at the data and manipulating it to your argument," said Linh, who, like many of his peers, used words such as *manipulated* and *distorted* to describe the use of mathematics in this way.

(e) The conclusions and interpretations drawn by the inquirer (56.7%).

Students indicated that ignorance of mathematics or biases of the inquirer can influence the interpretation of inquiry results. Christopher reflected on how individuals could cherry-pick the findings of the class's mathematical inquiry about the death penalty to support the claim that there is no bias in its application:

> *White murderers were executed more often than Blacks. So, you could take that and say it's not really racist. But then when you look at the victims, it was the murderers of White victims who were more likely to be executed.*

Finally, all students indicated that mathematics can be used for good or ill. We hear from Ernesto on this point:

> *Some people are using their knowledge of math to inflict harm. They're creating weapons of mass destruction. Other people are saying, "I'm gonna use my knowledge to try to cure cancer." They're trying to use mathematics to do good. And it just shows that how math is used, all depends on the person.*

So, students argued, the motives and interests of developers or users of mathematics applications should be carefully examined to determine how (if at all) they stand to benefit from them and what we stand to benefit (or lose) from them.

A Critical Perspective on Students' Views of Mathematics

Critical mathematics education scholars argue that mathematics is an essential tool for exposing social injustice because of the relevance of quantitative information to justifications of social policies and practices in contemporary society. All students reported seeing the value of thinking mathematically about social justice issues as a result of their classroom inquiries. They indicated that their inquiries uncovered compelling evidence of the differential effects of social policies and practices on various social groups. Critical mathematics education scholars argue that such evidence

can indicate a systemic failure of our society to provide justice for all and that it implicates various forms of oppression as the underlying causes of these failures. Students largely agreed with this interpretation of group disparities revealed by their inquiries. Although they do not "prove" social injustice, students overwhelmingly (90%) said their inquiries clearly implicate racism, sexism, classicism and other forms of oppression as the causes of the disparities. Even students who did not agree with these implications indicated that their findings alert us to potential problems that ought to be investigated further.

Thinking critically about mathematics use as a tool for social inquiry entails thinking about mathematics in ways that challenge what Borba and Skovsmose (1997) referred to as an "ideology of certainty" (p. 17) about mathematics. Students' reflections on mathematics indicated that they contested many aspects of the dominant view of mathematics. Students challenged the belief that mathematics provides definitive answers to questions about the world. They noted that the certainty of conclusions of mathematical inquiries is frequently constrained by limits of confidence. They viewed their mathematical inquiries as an important beginning rather than an end to inquiry about the fairness of societal practices. While they expressed confidence in their conclusions, they saw them as provisional truths. They argued that because many social problems are very complex, they would probably need to weigh the evidence from several inquiries to obtain conclusive answers about them.

Students did not see mathematics as answering some important questions that might be asked about social practices. Although mathematics can tell us how the death penalty is working, it cannot in and of itself settle the larger question of whether we should have one, students said. Nor can mathematics tell us whether institutions should adopt affirmative action policies, whether wealth should be redistributed, or whether risks in the use of nuclear power are worth taking, and so forth. These students recognized that technical questions should not be conflated with sociopolitical and ethical questions in deliberations about societal problems.

Students problematized the objectivity of mathematics in its applications. They indicated that mathematical inquiries about social issues cannot be "entirely objective" (Gabriel) because people "put part of themselves in the math" (Matthew). All students reflected that there is often more than one way to mathematize problem situations. Furthermore, the transformation of many issues into a mathematics problem that can be solved is not unproblematic, as Dinesh reflected:

> *There's always an absolutely correct way to do things in math. That's what's really great about math. But then you have the problem of applying math to the world and then applying what you know about issues of fairness and social inequality to math. That's where things get muddled. . . . It's about that transition [between the real world and the math world] that you have to be careful of.*

His reflection embodies an element of Skovsmose's (1994b) rationale for reflecting on applications: the "problems and uncertainties connected with transitions" (p. 111) between the different languages involved in the processes used to develop the application.

Students demonstrated an awareness that mathematics applications incorporate the values and interests of their creators. As a result, they can be tailored to serve political or personal aims. A few students connected these aims to social groups and the larger sociopolitical context in which mathematics applications operate.

The questioning of mathematical knowledge and its uses is foundational to a mathematics literacy that is "critical." All students mentioned that their classroom experiences impressed upon them the importance of closely examining a mathematical inquiry before deciding whether to accept its claims as true. Alison's reflection was typical:

> *I never bothered to think about whether statistics I was told were accurate or not. You know, numbers can't lie. And now I realize that's not correct. You have to think about where these numbers are coming from and can we really trust them?*

In viewing people as the final judges of a social inquiry, students contested a dominant myth of mathematics as an "above-all referee . . . one that is above humans" (Borba & Skovsmose, 1997, p. 17). At the same time, they reflected that mathematical arguments are not likely to be understood by most citizens, echoing Skovsmose's concern that the use of mathematics limits the number of social critics of a mathematics application.

Conclusions

This study contributes to the research literature a rich description of high school students' views of mathematics as a tool for social inquiry. It evidences that students who have multiple experiences applying mathematics to social justice issues find mathematics to be a compelling tool for social critique, albeit one with limitations. It also shows that students develop a less mystified view of mathematics. Students neither outright reject nor uncritically accept applications of mathematics to societal problems and the notion of mathematics' utility as a social problem solving tool. They recognize the importance of scrutinizing mathematics applications and demonstrate an understanding of what scrutiny requires.

This study has implications for a high school mathematics curriculum that aspires to promote conceptions of mathematics that will benefit students and society. More opportunities for students to express their views of mathematics in the classroom are needed. The students in this study clearly had ideas about mathematics that were grounded in their classroom experiences. While the students articulated them eloquently during interviews, these ideas seldom received an airing in the classroom. This is the norm in mathematics classrooms: The nature of mathematics is typically not something U.S. high school students are asked to reflect upon (Kloosterman, 2002). Teachers need to know their students' epistemic assumptions about mathematics in order to design activities that enrich their conceptions of mathematics and challenge any mystified views they may have.

If schools are truly places where students are prepared for citizenship, then mathematics classrooms must be places where

students learn about the role of mathematics in society. Activities should engage them in reflection about the benefits and limitations of using mathematics to address societal problems and on the impact of mathematics applications on our lives. Engaging them in more activities where they experience the use of mathematics as an instrument of social change is another way to better prepare students for informed and active citizenship.

This study has limitations that suggest topics for future research. While it examined an important dimension of students' mathematics literacy—their views on mathematics as a tool for social inquiry—it did not examine other important aspects of mathematics literacy and their relationship to students' views. A topic for future research is whether socially relevant mathematics applications promote high mathematics achievement. This is an important question for secondary mathematics teachers who see the development of students' mathematics knowledge as their primary responsibility, particularly at a time of national concern about the underachievement of U.S. students. Another topic for research is a systematic examination of how socially relevant applications shape views of mathematics.

I believe that the classes in this study give us reason to be hopeful about the possibilities of socially relevant applications for mathematics education. So did the remarkable teacher participants in this study. I leave the last word to them.

> *I'm pleased with the extent to which . . . most of them would attempt to really understand what was going on in the problem as opposed to this pressure to just get the right answer, which is the pressure that they get from the test mentality everywhere else. I think they were genuinely curious about many of the things that we did during this year. (Ms. Jones)*

> *I think it made them a little bit more skeptical about reading an article or hearing a talking head on the radio . . . spouting off a statistic, that they are maybe a little more leery of accepting that. They began to ask questions about . . . why does it matter that this is unfair? What can be done about this injustice? Why doesn't somebody do something about it? I was pleased that they were doing that. (Mr. Smith)*