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"People Can Go Against the Government": Risk-Based Decision Making and High School Students' Concepts of Society

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Abstract: Research in mathematics education stresses the importance of content knowledge in solving authentic tasks in statistics and in risk-based decision making. Existing research supports the claim that students rely on content knowledge and context expertise to make sense of data. In this article, however, I present evidence that the relationship between content knowledge and statistical inference is bidirectional: it is true that students rely on content knowledge to make sense of data, but the converse also holds true. This claim is illustrated and supported by a case study of Grade 11 students (19 girls and 4 boys) as they determine the risk of nuclear power plant accidents. I present a conceptual model of society that emerges from the case study as students struggle to operationalize the concept of impact of nuclear power plant accidents. Findings suggest that the relationship between content knowledge and mathematical knowledge is complex. Finally, this research shows how authentic tasks in the mathematics classroom can be used to foster students' sense of citizenship.

Résumé: Dans le domaine de l'enseignement des mathématiques critiques, il est clairement nécessaire de créer des tâches authentiques pour habiliter les étudiants à utiliser les mathématiques. Cet article illustre comment on peut réaliser l'authenticité grâce à la prise de décision fondée sur le risque. Je présente une étude de cas portant sur des élèves de onzième année (19 filles et 4 garçons) qui tentent de déterminer le risque d'accident dans une usine nucléaire. Je présente un modèle conceptuel de société qui émerge de cette étude de cas où les élèves tentent de rendre opérationnel le concept d'impact d'un accident nucléaire en se fondant sur leurs connaissances des contenus. La relation entre la connaissance des contenus et l'inférence statistique est bidirectionnelle : s'il est vrai que les étudiants se fient à leur connaissance des contenus pour analyser et comprendre les données, l'inverse est également vrai. Enfin, cette recherche montre comment on peut se servir de tâches authentiques dans les cours de mathématiques pour encourager le sentiment de citoyenneté chez les étudiants.

Critical mathematics education requires authentic tasks in order to empower students with and through mathematics. This article illustrates how authenticity can be created using risk-based decision making. A case study of Grade 11 students (19 girls and 4 boys) is presented as they determine the risk of nuclear power plant accidents. I present a conceptual model of society that emerges from the case study as students struggle to operationalize the concept of impact of nuclear power plant accidents by relying on their content knowledge. The relationship between

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Color versions of one or more of the figures in the article can be found online at http://www.tandfonline.com/ucjs.

content knowledge and statistical inference is bidirectional: it is true that students rely on content knowledge to make sense of data, but the converse also holds true. Finally, this research shows how authentic tasks in the mathematics classroom can be used to foster students' sense of citizenship.

Within the field of mathematics education, there are many calls for authentic ways for empowering students (Freire, 1994; Skovsmose, 2011) and for conceptualizing "mathematics as a weapon in the struggle" (Gutstein, 2012, pp. 23–24). In this article, I explore the ways in which teaching about risk in the mathematics classroom can provide context for students' investigations about their world. I start by providing various definitions of risk found in diverse fields; I then explain why teaching risk is suitable for the critical mathematics education. After reviewing some studies on risk, I move to describing episodes from teaching risk that deal with students' conceptions of the society and their ethical concerns about risk.

WHAT IS RISK?

Risk is a concept that is prevalent in many disciplines and the term risk has been used in many distinct yet connected ways. Hansson (2009) distinguishes between five different definitions of risk:

1. Risk as an unwanted event that may or may not occur.
2. The cause of an unwanted event that may or may not occur.
3. The probability of an unwanted event that may or may not occur.
4. The fact that a decision is made under conditions of known probabilities.
5. The statistical expectation value of unwanted events that may or may not occur.

The third, fourth, and fifth definitions are the most common in mathematics. The third definition aligns with the view that a risk associated with an event is a quantifiable uncertainty (Gigerenzer, 2002), which is equivalent to the likelihood or probability of the event. This definition of risk is suitable when the events have similar consequences, but it becomes problematic if the impact of each event is different. For example, the likelihood of a person catching a cold is relatively large but its impact on the person's life is most likely to be minimal, whereas the likelihood of getting killed in a terrorist attack is relatively small but the impact is immense. In order to account for both likelihood and impact, proper understanding of risk requires the coordination between judgments of probability and impact (Pratt et al., 2011), which corresponds to the fifth definition, the statistical expectation. This coordination can be done informally but also formally using mathematical representations.

WHY TEACH RISK?

Decisions based on understanding of risk are made in all aspects of life, including health (e.g., whether to continue with the course of medication), finances (e.g., paying for extra insurance), and politics (choosing between preemptive strikes and political dialogue). These decisions are not only common but are also critical for individual and societal health and well-being. Some studies have shown, for example, that people are routinely exposed to medical risk information (e.g., prevalence rates of diseases) and that their understanding of this information can have serious implications for their health (Reyna, Nelson, Han, & Dieckmann, 2009; Rothman, Montori, Cherrington, & Pignone, 2008). Decision making in modern society is centered on the assessment and management of risk. Many issues, from the security of global financial markets to climate change, involve sophisticated arguments related to risk.

There is compelling empirical evidence suggesting that most individuals are not skilled in risk-based decision making (Kahneman & Frederick, 2002; Rothman et al., 2008). For example, Rothman et al. (2008) reported on the study of numeracy skills of 398 diabetes patients and found that many patients had difficulty on numeracy related tasks (e.g., understanding glucose meter readings and calculating carbohydrate intake). Furthermore, the authors found that the performance on the numeracy test was significantly correlated with diabetes knowledge and perceived self-efficacy.

PEDAGOGY OF RISK

For the purpose of exploring the pedagogy of risk, researchers involved in the Institute of Education's TURS Project (Promoting Teachers' Understanding of Risk in Socio-scientific Issues) developed a computer microworld called Deborah's Dilemma (Levinson, Kent, Pratt, Kapadia, & Yogui, 2011, 2012; Pratt et al., 2011). In Deborah's Dilemma, pairs of teachers were engaged in a narrative involving a fictitious person, Deborah, who suffers from a spinal cord condition. Based on the data about the side effects of a surgery and the consequences of not having the surgery, pairs of math and science teachers had to choose the best possible course of action for Deborah. One of the outcomes of the research program was the development of the pedagogic model of risk (Levinson et al., 2012).

According to this model, probabilistic judgments lead to the estimation of risk but the judgments are informed by values, experiences, personal and social commitments, as well as representations. This is in contrast with the utility model of risk, where values are separate from the probabilistic judgments and may only play a role in risk management (following an analysis of risk). Relevant findings from the study have been used throughout this literature review to outline the elements of the pedagogy of risk.

The Role of Values, Experiences, Personal, and Social Commitments in Risk-Based Decision Making

The collection, generation, and interpretation of data are influenced by social factors and are consequently value-laden (Pratt et al., 2011; Watson, 1997). In order to examine the social factors, students must be able to critically examine data (Gal, 2004b; Pratt et al., 2011). In addition, thinking about risk also involves decision making that can function on an individual level, societal level, and within the intersection of these levels (Pratt et al, 2011).

Students' perceptions of reliability of data are an important critical element. There is evidence that some individuals associate reliability with disinterestedness. For example, Pratt et al. (2011) found that two participants in their study (Linda and Adrian) were suspicious of the surgeon who they thought may be "drumming up the business" (p. 340).

Levinson et al. (2012) found that students "recognize the role of trust and authority in giving meaning to the data" (p. 224). The authors reported that a participant (Linda) found the spine doctor's recommendation reliable because he "knows more about it than the other people, and he's seen more of these people" (Levinson et al., 2012, p. 224). The notion of trust in groups that are involved in measurement is evident in Kolsto's (2001) study. Despite the fact that the students were sceptical of the power company's risk evaluation and the power company was marked as interested, the students accepted the company's claims concerning magnetic field strength from different sources.

In addition to the issues of reliability, there is an issue of content validity, which includes the questions of how the statement about data was derived, whether the claims are supported by the data, and whether additional information and interpretations are needed (Gal, 2004a). Kolsto (2001) provides evidence that students are quite vigorous in questioning the source of data but are less likely to question the validity, which requires students to analyze the content of the source and evaluate the arguments presented in the document.

The Role of Context and Content Knowledge in Pedagogy of Risk

Pratt et al. (2011) asked whether context may impede students' understandings of risk, drawing on examples from the previous studies that suggest that context may be detrimental to the mathematical understanding of risk. Pratt et al. (2011) concluded that the understanding of risk is closer to statistics than mathematics and that the context is crucial. If we strip away context and reduce the task of assessing risk to the mathematical coordination between likelihood and impact, we can see that the meaning is lost. In addition, the numbers (quantitative data) have to be viewed in context. Pratt et al. (2011) also considered the issue of who the decision maker is as an element of context. In other words, students will respond differently depending on whether they are making decisions about themselves or another person.

Pratt et al. (2011) conjectured and showed evidence that these three settings differ in the way participants use cognitive resources. They asserted that cognitive resources most readily used in the reading setting are affective (emotional) responses followed by the understanding of context. In the inquiry setting, understanding of the problem context takes precedence over mathematical and statistical knowledge, though this knowledge is also important. Finally, the authors conjecture that, in the pedagogic setting, which is intended to teach and assess particular ideas, statistical and mathematical ideas are prioritized, whereas affective resources are less likely to be drawn upon.

One of the prerequisites for understanding of risk is content knowledge (e.g., in order to be familiar with risk of nuclear power plants accidents, we should have relevant knowledge about nuclear power). However, possession of content knowledge does not guarantee that the knowledge will be used in risk assessment. For example, Levinson et al. (2012) stated that:

> there were many opportunities in the microworld for the teachers... to make use of relevant scientific knowledge in helping to evaluate risk, but none chose to do so, reflecting other accounts, where scientific knowledge and information are either marginal or irrelevant to lay decision making. (p. 228)

Teaching Risk in the Classroom

There is a lack of classroom studies of students' understanding of risk; the studies that do exist stress the importance of treating risk-based decision making as a complex enterprise. The importance of the complexity of decision making was highlighted by Monteiro and Ainley (2007) in their study of student teachers who drew on four distinct resources: mathematical knowledge, contextual knowledge, affective responses, and personal experiences. The authors found that "if attention is focused exclusively on one of these sources, then the judgment may be distorted" (as cited in Pratt et al., 2011, p. 338).

In order to create a classroom environment conducive to the complex view of risk, Kolsto (2006) suggested that students need "easy access to an appropriate range of information and viewpoints" (p. 1711). For example, in Kolsto's (2001) study of high school student decision making related to electrical power lines, many students were only drawing their conclusions based on research-related information. Kolsto (2006), citing Aikenhead (1985), suggested that if we want students to draw from wider domains (including values), we need to include tasks in which students are confronted with this information.

METHODS

I applied a qualitative case study approach as I explored the teaching of risk in a Grade 11 classroom using inquiry-based learning pedagogy. This research comes from my doctoral research and the details of the study are documented elsewhere (Radakovic, 2014).

Research Setting and Participants

The research setting was St. Hubertus Secondary School, a coeducational school with no direct access to laptops and no wireless Internet access. I did most of the teaching in the study—Clarissa, the classroom teacher, was there to help me plan the lessons, observe them, and assist me with the logistics and classroom management. Thus, the case study centers on the students and me, whereas the role of the classroom teacher was not explored in the study.

The Task: Safety of Nuclear Power Plants

Following the initial assessment, there were 3 hours and 45 minutes of instruction (over the three 75-minute periods) on determining the empirical probability of nuclear power plant accidents. The activity started with a 75-minute lecture that defined key terms: probability, theoretical probability, and empirical probability.

Following the introduction, there was a 75-minute group activity (full period) with the following objectives: to (a) critically evaluate the sources of data provided and (b) estimate the empirical probability. The students were given a worksheet in which they were presented with four websites to use as potential data sources. The websites contained nuclear power plant accident data and could be easily accessed with laptops. The websites were the World Nuclear Association, Greenpeace, Datablog, and Ecocentric. I chose to give students specific websites rather than having them freely explore the Internet because by selecting from a shared set of websites, I was able to gain insight into the reasons why they picked one over the other.

After deciding which website to draw data from, students were instructed to estimate the probability of a nuclear power plant accident. Following the activity, the groups presented their findings to the class; this took approximately 75 minutes (one full period).

Following the first activity, the second group activity (also 75 minutes) was completed and involved interpretation of data including likelihood and impact. The objective of the activity was to introduce students to the assessment of the impact, both qualitative and quantitative, and the coordination of the likelihood and impact and to present them with the idea that the assessment may be value laden. Throughout the group activities, I was a facilitator assisting in student learning and using direct instruction to clarify certain points—the direct instruction was given to either the groups or the whole class. This article reports on the Second Nuclear Activity. Preparation for the data collection at St. Hubertus Secondary School began in early September 2011. The second data collection, at St. Hubertus, began in October and ended in November of 2011 and had the same structure as the first data collection.

The Second Nuclear Power Plant Activity

I introduced the activity as a continuation of the previous day's activity. On this day, quite a few students were absent, so the groups were altered. There were four groups in total:

1. Priya, Iris, Maya, and Joseph.
2. Connie, Daniel, Karl, Andy, Lina, and Louvie.
3. Hiroko, Chloe, Dana, Mina, and Larissa.
4. Helen, Pouneh, Amira, and Talia.

The data source for all four groups is identical and consists of group video, presentation video, construction paper data, and handouts. The learning objective of the activity was to introduce students to the assessment of impact, coordination of the likelihood and impact, and the idea that the assessment may be value laden. The questions were written in such a way that they elicit student thinking about impact and coordination between likelihood and impact.

The first question on the worksheet asked what else besides impact should be considered in determining the risk of the power plant accident. I wanted students to think about impact; however, in most cases, examples involved different factors influencing risk (for example, location of power plant accident, age of the reactor).

Based on their knowledge of the safety of nuclear power plants, the students in Connie's group identified various factors influencing risk. Some of these factors can influence probability, some impact, and some both. Students disagreed on whether some factors were relevant, as the following conversation implies. Namely, in conversation with Louvie, Connie said that the type of nuclear power plant may matter. Louvie said that either way it would be the same considerations. Connie then agreed. From the discussion, we can see that the students conclude that the type of radioactive material is not a factor in the risk of a nuclear power plant accident. However, a couple of minutes later, Connie reiterated that the type of the material did matter:

> Connie: I think some power plants are more dangerous than other power plants based on the material they have.

Joao: Yeah, it should.

This time, Joao agreed with Connie that the type of material did matter. The conversation also shows that students sometimes reformulated their answer and what was said made more sense to their peers (“some power plants are more dangerous than other power plants based on the material they have” is more descriptive and clear than the statement “different types of radioactive material”).

Louvie and Connie agreed right away that the location of nuclear power plants is a factor (“if they are located in ‘natural disaster prone areas’”). The group also agreed that human factors influenced the risk of a nuclear power plant accident:

Connie: How skilled the people . . . are?
Louvie [enthusiastically]: Yeah! That’s true!
Joao: Yeah, mostly education. . . .
Louvie [Starts writing down and saying out loud while she writes]: How capable the workers are . . .
Joao: Like if you are in a third world country . . . obviously the technology . . . technology may be good enough . . . but obviously it won’t be as good as technology like from . . .
Connie: Canada!
Joao: Canada or the U.S. or the country that is developed and it has like universities or anything else like that.
Karl: Japan!
Joao: Japan . . . Shut up!

Based on my knowledge of the individuals in the group, Joao made the last comment because Karl’s family comes from Japan and Joao thought that Karl was boasting of the fact that Japan is considered developed. The episode illustrates how individuals’ beliefs and stereotypes about a certain group or a phenomenon also can influence their beliefs about risk.

Hiroko (Group 3) defined impact as any difference before and after the event, which is a very comprehensive definition of impact.

Hiroko: What was it? Impact is anything that makes slightest difference.
Chloe: Everything that makes difference to surrounding area. No, everything that makes difference.
Hiroko: Anything that makes a difference.

The students in Group 4 were not able to answer the second question, so they asked me for assistance. I explained the significance of impact. Pouneh then suggested: “Oh! Wouldn’t it affect money because the governments pass it on?” I agreed with the statement, and Helen then wrote: “financial impact.”

The group agreed that their answer to the first question could serve as the basis from which they could derive the impact of the accident. The group also agreed that they did not have concrete data available, but Amira suggested that they could use that “thing that happened in Japan.” Helen than asked how they could “fuse this information [from the first question] to determine the impact of an accident.” While posing this question, Helen placed her hands over the information written on the construction paper as if physically scooping all of the information and trying to turn it into impact (Figure 1). The examples show an importance of gestures in reasoning about risk—the gesture in this case represents the synthesis of all of the information into the assessment of impact.

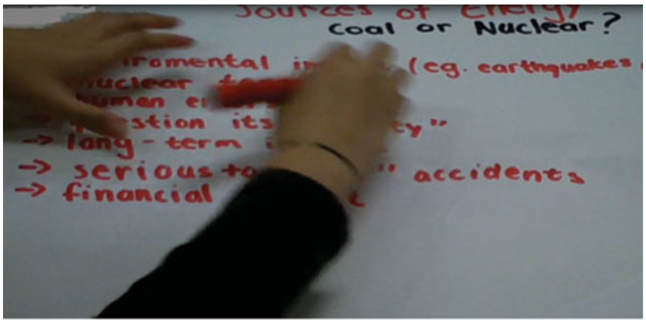

FIGURE 1 Helen Wants to Know How to Take This Information and Find the Data That Will Help Determine Impact (the Hands Are Blurry Because of the Movement).

They called on me to check on the work they were doing. I reiterated that they could look at financial cost and environmental cost. When I left, they were trying to make sense of what I had said:

Helen: What else? Is that it?
Pouneh: He said environmental, financial. And government. [On the recording, I never mention the government]
Helen: What? Like how? I don't understand that?
Pouneh: OK. When something happened, they go kabooie.
Helen: Yeah?
Pouneh: And there is a lot of stuff to fix.
Amira: It's going to take money to clean it up, it's going to take money to fix.
Helen: It's asking what data we can use to determine the impact of an accident, that's like finding the probability of an accident. What kind of data can we use?
Amira: Financial cost.

In this case, students visualize the scope of the impact by creating a scenario of the situation. Group 4 was trying to define the impact of a nuclear accident on the society.

Pouneh: It should be financial, environment, and government in brackets.
Helen: Oh yeah! [writing] Environment, what else?
Talia: Government? Who cares about the government? [laughs]
Amira [laughing]: Who cares about the government?
Pouneh: Put government, too.
Helen: Why does a government need to recover? People need to recover.
Pouneh: Because environment and government are different.
Talia: But government has responsibility for the environment.
Pouneh: Exactly!
Helen: Government does not need to recover.
Pouneh: Yeah, they do! They need to fix a problem.
Helen: Yeah, but that would be something different.
Amira: It has to be done by the people who own the plant.
Talia: But if there is pollution doesn't it have to be addressed by the government?
Helen: People can go against the government.

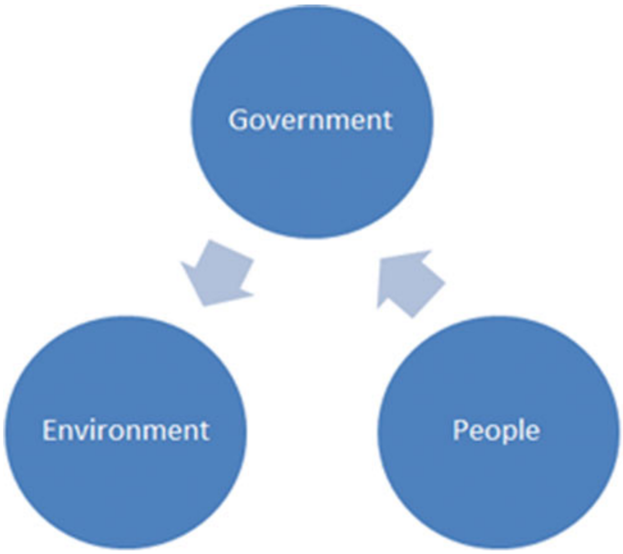

FIGURE 2 Representation of the Group's Model of the Society. Arrows Represent the Direction of Influence.

Pouneh [resolutely]: If the lives are being lost the government is involved!
Helen: Yeah, but how does that relate to the question?
Pouneh [loudly]: I don't know! He said something about the government that's all I remember.
Helen: No! If someone . . . ok . . . some [inaudible] people would be going against him. It would be . . . what is it called . . . when [inaudible] strikes again?
Amira: Protests!
Helen: Yeah. So, it could be social impact [taps first section where it says social impacts; places the arrow next to it and writes social]
Pouneh: Social uprising.
Helen: What do you mean by the government, though? I don't understand that.

In the above example, students are trying to define impact, but in order to do so, they are trying to make sense of the structure of the society. Based on their discussion, the model of the society they suggest can be represented by Figure 2, which can also be viewed as a mathematical object. The model of the society is important, because it lets students figure out the structure of the impact that an accident can have on the society. Notice how students started talking about impact and then tried to work out how different parts are connected. In addition, notice how students view environment, people, and government as separate but interacting with each other.

The following vignette from Group 4 illustrates the importance of values in determination of risk. The students read the working definition of impact as the number of accidents with fatalities greater than five. They spent a significant amount of time arguing whether the working definition was valid. A great part of the discussion was about whether it is right to ignore any deaths.

Helen: You guys, do you agree with this definition of impact? "number of accidents resulting in five or more immediate fatalities."
Pouneh: Where?

[Helen points at it]
Amira: It says more than five.
Helen: No!
Pouneh: I don't agree. If one person dies, they are not gonna care?
Helen: Exactly!
Pouneh: Everybody counts!
Amira: If you take this and multiply it by 5? I think that's what you have to.
Helen [writes with the black marker]: "Risk Assessment"

Helen agreed that ignoring the accidents with a number of deaths less than five may be problematic from an ethical point of view but insisted that it still valid:

Helen: I think, maybe that is a good definition—because, what is it called?—I am not being MEAN to the people who died, that are under four, but, like . . .
Amira: But, any death is considered something!
Helen: Yeah, but . . .

The fact that the students found ignoring death problematic was confirmed by the fact that Talia and Amira would consider ignoring injuries but drew the line at death:

Talia: But if this was an injury
Amira: Yeah if it was injury!
Talia: If this was an injury it would be a different thing, but it's death! People are dead!
Helen: So, what do I write?
Pouneh: That's OK. It's fine. Good enough
Helen: No. [writes] "No we don't agree; even one death . . ."

Helen stopped writing and started passionately arguing that the considerations of impact should be on a larger scale and that less than five deaths is a relatively small number:

Helen: Because the impact is defined in a bigger way.
Helen: I find this weird . . . because the impact [tapping the question with the marker]. . . . Impact is a bigger thing here. We are looking at the definition of impact. Who . . . cares about . . .

Helen reiterated that one death was not important to her but also realized that this was contingent on whether she knows the person or not:

Helen: One death . . . who cares? No offense! If one of my friends died . . .
I would care if one person died from the nuclear. . . . If I knew them. But honestly, if it's one person, it would not really affect anyone except for the one . . .
Christine: I say, everybody counts! [raising her voice] What if you are that one person that's gonna die?
Helen: Who cares! [laughs, they all laugh] Listen! Listen to me. An impact! One person dying off in the world is not a big deal. OK, guys?
Amira: That's true . . .
Christine: I understand that! But it still means . . .
Helen [banging her hands against the table in frustration; raising her voice]: It does not matter if it means or anything, the working definition. [gestures at the handout] What's an impact on the world?
Pouneh: Look how stern she is.
Pouneh: I would hit you Helen. [laughing]
Talia: This can't be the whole issue.

The lively discussion among the group members shows the importance of personal values on determination of risk and impact. It also shows the role of empathy in determining impact. The above argument also transformed into an ethical argument rather than a technical matter on calculating impact. As such, it is hard to argue that there is a right answer.

DISCUSSION

The Role of Context and the Content Knowledge

Pratt et al. (2011) discussed whether context may impede students' understanding of risk, drawing on examples from previous studies in which it was shown that context may be detrimental to mathematical understanding. The authors concluded that the understanding of risk is closer to statistics than to mathematics and that the context is crucial. If we strip away context and reduce the task to the mathematical coordination between likelihood and impact, we can see that the meaning is lost. The numbers have to be viewed in context.

Levinson et al. (2012) stated that

> there were many opportunities in the microworld for the teachers . . . to make use of relevant scientific knowledge in helping to evaluate risk, but none chose to do so, reflecting other accounts, where scientific knowledge and information are either marginal or irrelevant to lay decision making. (p. 228)

In my study, I found otherwise—the students' content knowledge interacted with their knowledge of risk, each at times elucidating the other. The students did seize the opportunity to use content knowledge, because the students seemed to understand that determination of risk and its various components depended on the context. For example, the knowledge about impact depended on students being able to recall the information about nuclear power plants. However, not only did the content knowledge influence the knowledge about risk—the converse was also true. For example, in order to determine the impact of the nuclear power plant accident, the students at St. Hubertus drew on their knowledge of the content; however, as they were trying to understand impact, they were also making sense of the society.

How the question was formed was also an important part of the context in which students reasoned about risk. If the question had been framed differently, that would have influenced the study. The way I posed the question was whether nuclear power plants were safe relative to other energy sources. In addition, the students understood the question to be whether "we" should have nuclear power plants. Some students made personal connections whereas others did not. This is consistent with Pratt et al.'s (2011) study in which the students said that they would react differently depending on whether they were making decisions about somebody else or about themselves.

The Role of Feelings, Beliefs, and Values

The affective factor is very important in individuals' risk-based reasoning. Slovic (2010) talks about the dread factor, which creates mental images about the hazards of interest (e.g., nuclear power plant accident). We can infer the feeling of dread in some imagery expressed by the St.

Hubertus students; for example, a student talking about the impact of nuclear power plants as "a barren landscape." Similarly, Gregory et al. (2012) have shown that beliefs and values have to be an integral part of risk assessment and that the choice of data and the presentation of data depend on values. This can be seen in my study when Christine's group encountered the table of fatalities and argued about whether it was valid to only consider the accidents that resulted in five immediate fatalities. One of the students had a stern belief that "every death should count," and the other one was more pragmatic. Finally, the student drew on her personal experience, saying that it would matter to her if she was the person or if she knew the person. The students did not draw as much on personal experience as did the students in Pratt et al.'s (2011) study. The reason is that the question was framed in terms of the logical statements: Are nuclear power plants safe? This can be compared to the decision statement: Should we have nuclear power plants or, more specifically, should we build more power plants in a certain area? Students did draw on their personal experiences, however. For example, a student at St. Hubertus stated that she would not like to live next to the nuclear power plant. However, because of how the question was construed, the students did not draw too much on personal experiences. Some students did show empathy (praying for Japan).

The students did not seem to shift their beliefs about nuclear power plants (except in Natasha's case). There were instances in which the exposition of quantitative data did cause students to question their beliefs. For example, some students were very surprised to find out that the fatalities for coal power plants were higher than those for nuclear plants. This is consistent with Kolsto's (2006) claim that students should be confronted with diverse information and viewpoints. However, students tended to include auxiliary information in order to "salvage" their beliefs.

CONCLUSION

Risk-based decision making is a complex process involving an interplay of highly contextualized quantitative reasoning and individuals' social commitments, beliefs, and values. As such, risk is a fertile ground for using mathematics. The article explores the connection between thinking about risk and students' views on society and ethics. Furthermore, the article is an invitation for researchers with the commitment to critical mathematics education to explore risk in their own practice.

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