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Gale L. Russell

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Risk Education

A Worldview Analysis of What is Present and Could Be

Gale L. Russell

University of Regina, Canada

Abstract: Risk, risk analysis, risk management and risk-based decision-making are ubiquitous ideas in the modern world. Consequently, risk education is emerging as a new field of research. However, just as the defining of risk and what it entails is a contested topic, so too is the field of risk education research open to many possible approaches. In this paper notions of risk, particularly as they play out in research on risk education, are analyzed (within an ethical space) using a theoretical framework based on the Traditional Western and an Indigenous worldview. Through this analysis, along with the identification of the kinds of knowledge and ways of knowing currently being valued in the research, other kinds of knowledge and ways of knowing that may prove just as important emerge.

Keywords: decision-making, ethical space, indigenous, risk, risk Education, western, worldview.

Introduction

No matter how dominant a worldview is, there are always other ways of interpreting the world. Different ways of interpreting the world are manifest through different cultures, which are often in opposition to one another. One of the problems with colonialism is that it tries to maintain a singular social order by means of force and law, suppressing the diversity of human worldviews (Little Bear, 2000 p. 77).

Risk, risk analysis, risk management and risk-based decision-making are ubiquitous ideas and terms in the modern world; however, what is meant by risk and how one can analyze, manage, or make decisions based upon risk remains, if not contended, then inconclusive. Borovcnik and Kapadia (2011), define risk as “a situation with inherent uncertainty about the (future) outcomes, which are related to impact (cost, damage, benefit)” (p. 5503), a definition which will work for the purpose of this paper. Within much of risk research, there is general agreement that “there are two levels of criteria for making decisions: personally preferred ones and rationally bound ones” (p. 5503). There even is agreement as to the origins of the knowledge held in relation to each of the criteria (affective/emotional responses and scientific methods, respectively); however, the perceived worth of each of these criteria by researchers is not so clear cut. Further, as with other emerging and prominent features of the modern world, like technology, there is a proclaimed need for the study of risk to be part of students’ educational experiences. Hence, the need to consider risk education: where does it belong, what should it look like, and how can it happen – researchers have begun to investigate this proposition.

Concurrently, within another emerging area of research, it has been theorized that the grounding of the teaching and learning of mathematics within an Indigenous worldview (the transreform approach) has the potential to bring about changes that grounding within the Traditional Western worldview might not (Russell & Chernoff, 2011, 2012, 2013a, 2013b). Particularly, it has been proposed that such a change in worldview could result in the end of the Math Wars (Russell & Chernoff, 2013b); the

acceptance and implementation of research-supported approaches to the teaching and learning of mathematics, such as those related to constructivist learning theory (Russell & Chernoff, 2012); and to diminish, even eliminate, the marginalization of students (Indigenous and non-Indigenous alike) with respect to mathematics (Russell & Chernoff, 2012, 2013b). The goal of this paper is to provide an analysis as well as examples, which illustrate the importance of extending the current boundaries of risk education research to include considerations that emerge, yet untapped, through the analysis. The purpose of this paper is to use this same theoretical framework to analyze the existing risk education research in order to provide new insights into what has been considered and what has not. Further, through the use of particular examples of situations involving risk, an argument is made for how risk education could be strengthened in relation to this analysis.

This paper begins with a brief discussion of key areas and ideas related to risk and risk education. Then, the aforementioned theoretical framework and an explanation of how it will be applied are described. From that point, the theoretical framework is used to analyze current research in risk education, highlighting what kinds of knowledge and ways of knowing are being valued, which are not being valued, and which remain hidden. Finally, two examples of recent incidents and the risk knowledges that were valued and not valued within them are presented to demonstrate the importance, the possibilities, and the consequences of the analysis results.

Risk in the Literature

Existing research and theories about risk are abundant and variable. Within different fields (psychology, science, finance, politics, and medicine, to name but a few), much has been researched and written in relation to risk, risk analysis, risk management, and risk-based decision-making. As this paper is about risk education, it is fitting to present a synopsis of significant research studies investigating what risk education should include and how it should be carried out. Before such a discussion however, three other topics will be explored: the communicating of risk information, prominent theories about risk analysis and decision-making, and how risk is currently being incorporated into curricular (standards) documents. Whereas an understanding of what exists within theories of risk analysis and decision-making provides a reference for what may be occurring pedagogically in risk education, a curricular analysis helps to provide a contextual perspective for how risk education is being related to curriculum content. The discussion of the communicating of risk information, which will be considered first, sheds light on what understandings students need to “survive” in our “risk-driven” world.

Communicating about Risk

Today, the assessment and management of risk, as well as the making of decisions with respect to risks involved, is found in nearly every facet of our lives, making the communication of risk-based information omnipresent. In relation to communication about risk, three aspects will be considered here: language issues, relative and absolute risk, and representational formats.

Often, in an effort to clarify risk information, complex probabilistic relationships, calculations, and values are communicated instead through the use of adjectives: “probabilities can be described fluidly with words, using language that appeals to people’s intuition and emotion” (Spiegelhalter, Pearson, & Short, 2011, p. 1394). For example, in a Rapid Risk Assessment for the Ebola virus disease (EVD) in West Africa released by the European Centre for Disease Prevention on January 30, 2015 the following communication of a risk assessment was given: “The risk of EVD being imported into the EU or the risk of transmission occurring within the EU remains low or very low due to the range of risk

reduction measures that have been put in place by the Member States and the affected countries” (p. 2). Likewise, on February 11, 2015, Public Health England released a Risk Assessment of the Ebola virus disease outbreak in West Africa stating: “Despite the recent confirmation of the first Ebola virus disease (EVD) case diagnosed in the United Kingdom (UK), there is no change in the overall EVD risk assessment for the UK. While the risk of further EVD cases being imported into the UK is currently considered to be low, the risk of transmission occurring within the community in the UK is, and is expected to remain, very low due to the range of robust measures that have been put in place. There is still an expectation that a handful of cases may occur in the UK over the coming months” (p. 1). It is important to note that although both risk assessments are addressing the same two risks, EVD entering a region from elsewhere and the spread of EVD within a region, there are differences in how the assessment of risk(s) is presented, and quite possibly how those risks are determined. In the case of the Public Health of England assessment, the risk of importing EVD into the UK and the risk of transmission of EVD within the UK are considered separately, giving two definitive appearing risk ratings of low and very low, respectively. Alternatively, the European Centre for Disease Prevention’s assessment considers the two forms of risk, the importing and the transmission of EVD, as a single overall risk, which provides a similar, but seemingly less definitive risk rating of low to very low. The choice of which way to evaluate and present the two official risk assessments is not justified or clarified in either document; moreover, what constitutes low or very low risk (in either case) is not elucidated (beyond the notion of a “handful of cases of EVD over the coming months” – a vague statement in and of itself), leaving interpretation of this risk assessment up to the individual. These two reports, coming from similar organizations give an example of Spiegelhalter, et. al.’s (2011) claim: “the attractive ambiguity of language becomes a failing when we wish to convey precise information, because words such as ‘doubtful,’ ‘probable,’ and ‘likely’ are inconsistently interpreted” (p. 1394). If the use of such language is not deemed advisable in communicating in general about risk, consideration needs to be given to how to otherwise communicate the information, and how to educate people to interpret such communications.

Also related to language is the concern raised by some researchers (e.g., Martignon & Krauss, 2009; Pratt, Ainley, Kent, Levinson, Yogui, & Kapadia, 2011; Till, 2014) over the deceptive (intentional or otherwise) use of relative (perceived) risk, rather than absolute risk, within communications. Relative risk, which is a comparative statement of the change in risk or a comparison of two different risks, can lead to grievous misunderstandings. Consider, for example, a dog food commercial that advertises that their new product has 50% more protein than that of their old product. For many pet owners, a higher protein diet is desirable and the relative risk (positive, in this case) of 50% can easily be interpreted as a significant increase, but in fact, the absolute risk, or how significant the increase really is, depends upon how much protein was in the original product.

In considering the communication of risk information, a final focus of research is of importance in this discussion: how individuals understand (or misunderstand) different representations of information related to risk. Till (2014) notes: “Findings of cognitive psychologists reveal evidence that the format of representation is crucial for understanding the real harm or chance of different options in situations of uncertainty ... Frequency formats are much better processed by the human mind than ratios” (p. 84). Till also argues that “Since risk-related data may be emotionally loaded, it is convenient to use representation formats that are objective, unbiased and easy to grasp for a wider public” (84); however, he also warns that “mathematical formats like ratios, fractions, percentages or decimals” can be misunderstood despite the visual or graphical representation used. Likewise, Spiegelhalter, et. al. (2011) discuss similar issues arising from the formatting and representational model of risk-related data and information. Clearly, the issue of how to represent risk information is a complex one, with further

research in how to clarify such representations both in terms of format and public awareness and understanding being needed.

Theories Related to Risk: Analysis and Decision-Making

Much discussion about risk analysis and decision-making starts with the emergence of the term ‘economic man’ in the early 20th century. In the late 19th century, ‘economic man’ was a derogatory term used by those in opposition to John Stewart Mill’s assertion that in political economy, man seeks to gain as much as possible with the least effort or loss (Persky, 1995). Moving into the 1900s, ‘economic man’ became re-envisioned as describing man as a being aware of all possibilities and choices in a situation and therefore capable of making decisions that maximize his advantages, minimize his disadvantages, or both. The theory of the ‘economic man’ soon led to the development of the ‘subjective expected utility’ (SEU) model. This model proposes that for any possible plan of action, there exists a set of hazards to which numerical values representing the impact of each particular hazard can be assigned. The product of the probability of a hazard occurring and the assigned value of impact for the hazard is defined as the risk of the hazard. The risk of a plan is the sum of the risks of the hazards within the plan, and the plan with the lowest risk is the best decision to be made. By the 1940s, doubts about the ‘economic man’ and of the SEU model were well known: the complexities involved in any one risk-based decision-making task would prevent either theory being fully realized (Kent, Pratt, Levinson, Yogui, & Kapadia, 2010). In response, researchers (such as Kahneman, Simon, Slovic, and Tversky) proposed instead that man works within a ‘bounded rationality’, a reality in which not all is known, and even what is known need not always be considered. Simon (1959), shifted the focus from maximizing (minimizing) to satisfying (i.e., ‘economic’ man to ‘satisficing’ man), wherein acceptable or adequate choices are made based upon limited knowledge of the full reality of a situation. From that point, researchers (such as Kahneman, Slovic, and Tversky) undertook defining and investigating different heuristics and biases “which reduce the complex tasks of assessing probabilities and predicting values to simpler judgemental operations. In general, these heuristics are quite useful, but sometimes they lead to severe and systematic errors” (Tversky, & Kahneman, 1974, p. 1124). The heuristics and biases proposed were seen as the mechanisms used by the ‘satisficing man’. As will become evident shortly, in many ways the reasoning behind the ‘economic man’ and the ‘satisficing man’ and the associated theories, can also be seen to play out within recent theories and perspectives on risk education, including where risk should be housed within curricula and how it should be approached pedagogically.

Other Data and Modelling Concerns

With all the different types and styles of risk assessments being made, guidelines are often determined to define “acceptable” risk, but as with the Ebola virus example above, what is to be considered within one establishment as acceptable risk is not likely to be consistent with another, even in the same field. One need only to consider the current issues of water use, transportation of gas and oil, or fracking to realize that it is very possible that one person’s acceptable risk is another’s unacceptable risk. Throw “big data” into the mix, and the determination of risk becomes more complex. As Spiegelhalter (2104) states, “Big data means that we can get more precise answers... But this apparent precision will delude us if issues such as selection bias, regression to the mean, multiple testing, and overinterpretation of associations as causation are not properly taken into account... Serious statistical skill is required to avoid being misled” (p. 265). Tim Palmer, a physicist specializing in weather prediction and climate change, adds more uncertainty to the power of big data in risk assessment: “The truth is that the level of detail in the models isn’t really determined by scientific constraints... It is determined entirely by the size of the computers” (Macilwain, 2014, p. 1222). Unlike Palmer’s concern about our ability to use big data meaningfully within technological constraints, Smith, an economist,

referring to climate change models based upon past mean-temperature changes over 1-10 years, argues: “The question is, when will we have significantly better quality information than we have today? I think we may have our answer from the climate before we get it from the physics” (Macilwain, 2014, p. 1223). Thus, questions about risk related to big data need to take into account more than the issues that Spiegelhalter (2014) noted: the capacity of computers and the ability for meaningful and relevant data to be collected for analysis must also be scrutinized. Meanwhile, risk assessments and management strategies are in constant demand for those seeking to make well-informed decisions.

Current Curricular Inclusion of Risk and Risk-related Concepts

Since risk impacts our lives in so many ways, it is not surprising that many educational systems and researchers are looking for ways to embed risk assessment and management and risk-based decision-making into the K-12 school system. Speaking about the UK, Pratt, Levinson, Kent, & Yogui (2011) comment: “In modern society, risk permeates decision-making at both personal and policy levels, a fact now being recognized in curricula” (p.1), including “Personal, Social, Health and Economic (PSHE) Education, Citizenship, Science and to a lesser extent in Mathematics” (Pratt & Yogui, 2010, p. 1). The word “risk” appears in at least one of the key stages for the above-mentioned curricula, except, that is, Mathematics (hence “to a lesser extent”), where ‘risk’ is not explicitly stated, but is implicitly connected to some of the content outlined.

PSHE is different from the other courses mentioned because it is a non-statutory course. Instead of a curriculum (or standards), PSHE has a guidance document that outlines the intent of the various key stages, which is meant to guide the development of school-based curricula for the courses. Within this guidance document, the following statement is made: “we expect schools to use their PSHE education program to equip pupils with a sound understanding of risk and with the knowledge and skills necessary to make safe and informed decisions” (Department of Education, Sept. 11, 2013). Consequently, as a non-statutory course, the defining of risk and what knowledge and skills are necessary to make safe and informed decisions is left in the hands, for the most part, of individual schools.

The remaining courses cited by Pratt and Yogui (2010) are statutory courses and thus have specific curricula (standards) for the different key stages or key stage pairings. For example, in Citizenship, at key stage 3, pupils are to be taught about “the functions and uses of money, the importance and practice of budgeting, and managing risk” (Department of Education, September, 2013, p. 2). This is a much narrower focus on the type of risk (specifically, financial) than given in PSHE, but as noted about the PSHE course, how such risks are to be determined or managed is not discussed. Similarly, in key stage 3 Science, pupils are to be taught attitudes towards working scientifically, including to “evaluate risks” (Department of Education, 2013, p. 4), yet there is no indication of what risk and its evaluation entails. The same is true in key stage 4 Science, where it states that as part of their development of scientific thinking, “students should be taught so that they develop understanding and first hand experience of evaluating risks both in practical science and the wider societal context, including perception of risk” (Department of Education, 2014, p. 5). It is likely that such notions are addressed in approved resources, raising the question, what should the resources include about these topics?

As noted previously, risk, by name, is not mentioned in any of the key stages of the Mathematics curriculum within the National Curriculum in England. There is, of course, much content related to probability and statistics, which inherently would seem to connect itself to risk assessment and management as well as risk-based decision-making. This content, taught (as described in the document) through the pupils learning about working mathematically, such as selecting “appropriate concepts,

methods and techniques to apply to unfamiliar and ‘non-routine problems’ interpret their solution in the context of the given problem” (Department of Education, 2014, p. 6), could quite reasonably be interpreted as including risk-related learnings.

A search of the Common Core State Standards Initiative (2015) finds two standards in which risk-related analyses and decision-making are the focus: CCS.Math.Content.HSS.MD.B.5 -- “Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values” and CCS.Math.Content.HSS.MD.B.7 -- “Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game)”. In both instances, the risk assessment being considered is grounded in probability and probabilistic reasoning. As only Mathematics and English Language Arts have Common Core State Standards, the concept of risk within other subject areas will vary according to the curricula or standards adopted in a particular state or region.

As just one example of what is happening in the United States within the other subject areas, consider the Content Standards for California Public Schools (California State Board of Education, 2014), which mentions risk in all but 7 of the documents posted on the site (specifically, English Language Arts, Building and Construction; Energy, Environment, and Utilities; Engineering and Architecture; Fashion and Interior Design; Manufacturing and Product Development; and World Languages). In many cases, “risk” in the content standards is used in a discussion of at-risk students; however, specific references to risk assessment and management, as well as risk-based decision-making, are given. For example, the *Health Education Content Standards for California Public Schools, Kindergarten Through Grade Twelve* (California Department of Education, 2009) document includes, in the rationale for Standard 4: Interpersonal Communication, the statement: “The ability to appropriately convey and receive information, beliefs, and emotions is a skill that enables students to manage risk, conflict, and differences and to promote health” (California Department of Education, 2009, p. viii) and Standard 7: Practicing Health-Enhancing Behaviors states: “All students will demonstrate the ability to practice behaviors that reduce risk and promote health” (p. viii). Through all grades, the Health standards frequently reference students learning about ways to reduce particular risks and to avoid risky behaviors. Alternatively stated, the focus is mainly on identifying risk factors and options related to risky situations or the awareness of and management of risk. In addition, decision-making related to risk is also considered (mainly from the perspective of reducing risk). Analysis of risk does not appear to be a primary focus; however, the focus on knowing about risks would be a primary step towards analysis of them. Within the *Grades 9 – 12 by Disciplinary Core Ideas* (Schweingruber, Keller, & Quinn, 2012) document for Grades 9-12 Science, learning related to ideas of risk considers the “limitations on the precision of data (e.g., number of trials, cost, risk, time), and refine the design accordingly” (p. 47). This statement harkens back to some of the concerns expressed by Spiegelhalter (2014), and Palmer and Smith (Macilwain, 2014) and it is likely that such a consideration would include an analysis of the risk involved in the identification and collection of data and decisions being made upon that analysis.

Like the United States, Canada also does not have a single unified set of curricula; however, the four Western provinces, the three territories, and some of the Atlantic provinces are all using the Western and Northern Canadian Protocol (WNCP) Common Curriculum Frameworks for K-9 and 10-12 Mathematics (CCF) as the foundation for their respective provincial and territorial mathematics curricula. For some of these jurisdictions, the curricula documents used are identical to the WNCP CCFs (save the cover page), while in other jurisdictions, the same mathematical content is presented in different ways in order to better communicate the specific initiatives and priorities of that jurisdiction. In

some (rare) cases, content is added or deleted from the WNCP CCFs at the jurisdictional level; however, the overall agreement between the different curriculum documents is still very high.

Within the WNCP documents, risk is specifically mentioned in upfront matter, which gives a brief synopsis of the pedagogical and mathematical beliefs and processes that the document is grounded upon. These references to risk all relate to the importance of encouraging and supporting intellectual risk taking within mathematics: “Creating an environment where students openly look for, and engage in, finding a variety of strategies for solving problems empowers students to explore alternative and developed confident, cognitive mathematical risk-takers” (WNCP, 2008, p. 8). However, this is not to say that risk analysis and risk-based decision-making does not get consideration within the curricular documents. Consider, for example, the first outcome in Grade 12 Workplace and Apprenticeship Mathematics (Saskatchewan Ministry of Education, 2013b): “Analyze and interpret problems that involve probability”, and specifically, indicator 1.6 for this outcome: “Explain, using examples, how decisions may be based on a combination of theoretical probability calculations, experimental results and subjective judgments” (p. 26). It can be easily argued that such decisions may well, in fact likely would, be in relation to situations involving risk. A similar outcome, in the course Grade 12 Foundations of Mathematics (Saskatchewan Ministry of Education, 2013a), “ Interpret and assess the validity of odds and probability statements” has the indicator “1.5 Explain, using examples, how decisions may be based on probability or odds and on subjective judgement” (p. 71), which is also easily connected to risk assessment and management, as well as risk-based decision-making. Thus, within these two courses, students should be engaging in risk analysis and risk-based decision-making through the consideration of both objective and subjective knowledge. It can be argued that these two indicators give a bit more direction towards what students might learn when reasoning about risk than what was found in previously discussed curricular documents, namely probability, odds, and subjective judgments in decision-making; however, where it is obvious what objective knowledge the students are to consider, i.e., probabilities and odds, what kinds of subjective knowledge to be considered (or if it is open-ended) remains undefined.

Risk Education

With the above insights into some of the more common ways that risk, risk analysis, risk management, and risk-based decision-making have been incorporated into a selection of (Western) curricular and standards documents, thoughts now turn to what is being said and researched about in relation to risk pedagogy. Until recently, when risk started to impact people’s daily lives in a myriad of ways, risk education, particularly at the K-12 levels, was generally not being considered, and thus, was not a focus of research either. In the field of risk education, links between existing theories and research on risk and decision-making in other domains are often forged along with considerations of new ideas and relationships. Within this paper, two particular aspects will be emphasized: the assumptions, beliefs, and theories supporting the approaches taken, and the approaches themselves. Given primary focus herein is the work of two sets of researchers: Krauss and Martignon; and Ainley, Kapdia, Kent, Levison, Pratt, and Yogui.

Research by Krauss and Martignon. The research in risk education by Martignon and Krauss (2009) focused on developing within students a “chain of competencies that make up good decision making for informed consent in basic domains of modern life like those of medical and investment decisions” (p. 229). Further, recognizing that “while most of the mathematical training of secondary school tends to be soon forgotten by those who do not pursue a career requiring further mathematical tools, mathematical competencies acquired until the ninth or tenth year of age appear to remain robust and unaltered during subsequent life” (p. 228), grade four students were selected to be participants in the

study. In carrying out their study of the grade four students' development of the particular competencies, Martignon and Krauss turned to research findings demonstrating that hands-on activities and tools can strengthen learning and sought ways to incorporate such strategies into their pedagogical design.

Martignon and Krauss (2009) also provide an explanation of the major assumptions behind their intent of the study, and in particular, underlying the chain of competencies ultimately investigated:

Stochastic literacy is a necessary condition for enlightened decision making in an information-based society. Becoming conscious that judgments about our fellow human beings and about nature should often be based on probabilistic rather than strict logical implications can reduce the impact of prejudices and stereotypes. Moreover, an understanding of probabilities can shape our decisions allowing us to assess possible risks associated with our actions. In fact, good modelling of risky situations can sustain our cognitive and emotional perspective on personal and collective affairs, reducing our anxieties and guiding our informed consent (p. 227).

A number of key ideas emerge from this statement, the first of which is the claim that enlightened decision-making is dependent upon a significant understanding of stochastics. Second, the claim is made that probability-based reasoning can reduce the impact of prejudices and stereotypes. A third assertion is that probabilistic knowledge can support risk assessment, and finally, that probabilistic modelling, done well, can mitigate the impact of otherwise held cognitive and emotional perspectives by moderating anxiety and providing support for strong decisions. In other words, probabilistic and statistical knowledge and reasoning are being centered as a (if not the) key player in risk education; moreover, such learnings can reduce (perhaps even eliminate) negative results of more affective responses, such as anxiety, prejudices and stereotypes. As such, the focus of the study is on the development of rational competencies and indirectly, the diminishing of the impact of affective reasoning.

The series of competencies that this study investigated are intended to act as a “tool box for decision heuristics in the bounded rationality paradigm” (Martignon, & Krauss, 2009, p. 229) for students in the classroom and in their future lives. Within this bounded rationality paradigm, Martignon and Krauss argue that, like the satisficing man, people “combine elements of basic Bayesian reasoning with effective decision heuristics” (p. 229) that they have selected to be of importance. The purpose of the play-based activities in the study are thus to give the students the tools necessary to make rational appraisals and decisions that are both effective and efficient (within a bounded rationality paradigm).

In the study, through the use of cards and tinker cubes, the teaching of the grade four students begins with the investigation of making logical inferences within the context of if-then statements. However, “Preparing children for decision-making practices requires training in making inferences, not just strictly logical but also, most importantly, probabilistic ones” (Martignon, & Krauss, 2009, p. 231), and so the students move next onto activities involving “conditional implications” (p. 232) as a consequence of the inclusion of conditional probabilities. From there, the students engage in activities that involve the comparing of proportions. The researchers explain: “[students] need to understand conditional probabilities for determining the validities of features and they need to make comparisons between different validities of features for establishing rankings among features... These competencies are at the core of risk assessment” (p. 231). Further, Martignon and Krauss explain: “The comparison of proportions is essential in comparing feature validities and for assessing risks” (p. 232). The research, and the experimental teaching, for this study ends with the students playing a game in which comparing of risks can be used to determine which of a number of possible moves is the least risky. Overall, the

ordering of the activities is described as “a ‘historic trajectory’... from logic to probability” (p. 238), giving the students a historically accelerated experiential learning of decision-making and reasoning with risk.

Research by Ainley, Kapdia, Kent, Levinson, Pratt, and Yogui. Foundational to their study of risk education, Kent, Pratt, Levinson, Yogui, and Kapadia, (2010) explain that: “Going beyond the idea of risk in statistical theory, we are trying to understand how personal values and models influence thinking about risk and the process of decision-making, and the implications of this for classroom practice” (p. 1). Thus, different from Martignon and Krauss (2009), this group of researchers considers the role of affective (emotional) knowledge and responses in decision-making and risk by making “An initial assumption ... that decision-making involves the coordination of different kinds of information, based on quantitative models and personal value systems and judgements” (p. 1). This study also differs from the one previously described in that it is focused on a different category of research participants: mathematics and science teachers with an extension to one group of high school students. The selection of mathematics and science teachers as participants is related to the previous discussion of risk within curricular (standards) documents, as well as a recognition that often the socio-scientific aspects of risk and decision making are seen as part of science education, while the stochastic aspects are seen as part of mathematics education. The participants were paired (one mathematics teacher with one science teacher) in the study to shed light on this assumption, but also to see the result of having both approaches working together as an attempt to inform where and how risk might best be brought into curricula in general. Overall, it was hoped that the participants would come to a better understanding of risk and decision-making processes and features through their involvement in the study; an understanding which might then be taken back into the respective teachers classrooms. A final part of the purpose of their study was to investigate how the results of the study aligned with existing research and theories about risk and decision-making. In particular, a focus was given to investigating the prevalence and strength of the application of the priority heuristic by the participant teachers (see Pratt, Levinson, et. al., 2011); however, in this paper the focus will remain on the reasoning behind the design of the decision-making software tool that was developed and implemented and on the choice of participants.

Reflecting upon the various theories and research of risk, Kent et. al. (2010) argue: “we think it is clear that students cannot be educated to think about risk only from a heuristic basis. There is a need for a systematic quantified analysis of some kind” (p. 2), which the team decides to attempt through the creation of a set of software tools entitled Deborah’s Dilemma. The first characteristic that should be identified about Deborah’s Dilemma is that the researchers attempted to create the tools to deal with a particular real-world (like) situation. This decision is supported by the work of Gal (2012) who argues that, with respect to risk education, “The content of instructional tasks should not be limited to traditional examples taken from games of chance or based on artificial problems, but the kinds of everyday contexts where probability plays a role and where adults encounter uncertainty and risk” (p. 6). Deborah’s dilemma is she has been told by a doctor that she needs to have back surgery. The user of the software tools is provided contextual information regarding minor and major hazards related to the surgery, and aspects of Deborah’s life that are impacted by the health of her back. Based on this information, the participants are asked to recommend to Deborah whether or not she should go ahead with the surgery. As is often the case in real life, the information provided is at times inconsistent and incomplete, as well as from a variety of sources.

The software package developed has three tools for the user to engage with: the ‘Operation Outcomes’ tool, the ‘Painometer’ tool, and the ‘Risk Mapping’ tool. The Operation Outcomes tool

allows the user to input various probabilities obtained from the information provided regarding the possible outcomes of having the surgery (successful to death, inclusively). The tool uses the probabilities entered by the user to run simulations of the surgery occurring. The user then requests the tool to carry out single or multiple runs (surgeries) and an outcome (or set of outcomes) is generated by the program. Because the participants chose which hazards to consider in the use of this tool, their affective responses were necessarily part of their decision-making.

The Painometer tool allows the teachers to “control Deborah’s level of pain tolerance, the amount of work and domestic/leisure/sport activity that Deborah does and the pain intensiveness of each, assuming that some types of work and sport would worsen the pain and others would relieve” (Pratt, Ainley, Kent, Levinson, Yogui, & Kapadia, 2011, p. 330). In addition, the participants could add activities to the painometer to explore “whether a balance could be achieved between pain-inducing and pain-relieving activities, so that Deborah might manage her pain within tolerable limits from day to day” (Pratt, Ainley, et. al., 2011, pp. 330-331). Because the participants controlled the level of pain assigned to each activity (compared to a standardized tolerance level), the Painometer tool allowed additional aspects of their affective responses to be accounted for.

An important confirmation for the researchers from an initial trial of the study, where only the Operation Outcomes and Painometer tools were used by the participants, was that the participants were struggling with bringing the two aspects influencing their decisions (the possible outcomes of the operation and the levels of pain associated with daily tasks without the operation) because their analyses were taking place in two disconnected tools. As a result, the researchers implemented the ‘Risk Mapping’ tool – a graphical modeling tool of decision boxes and hazard boxes. Colour coding of the boxes allowed the participants to represent the level of risk associated with the various decisions and hazards (as opposed to numerical probabilities). The researchers explain: “Whilst the mapping tool does enforce the association of impact and likelihood with each hazard, we did not enforce any model for how these relate to ‘level of risk’. It was exactly at this point where we hoped users would express their personal models for the situation, providing us with a window on their thinking about risk” (Kent, et. al., 2010, p. 4), once again assuring the possibility for both rational and affective reasoning to emerge. With this third tool, the participants were found to be able to better coordinate their thinking about the hazards and their thinking about the impacts.

With this brief overview of pertinent literature and research related to risk, risk analysis, risk management and risk-based decision-making, the stage is now set for the introduction of the theoretical framework for this paper. As mentioned previously, this theoretical framework is based upon two distinct worldviews, an Indigenous worldview and the Traditional Western worldview, and analysis occurs within an ethical space. The introduction to the theoretical framework begins with a discussion of broad understandings and considerations necessary when working within a worldview framework.

Theoretical Framework

To carry out a theoretical analysis of risk education from the perspective of the two aforementioned worldviews, it is important to acknowledge the definition of worldview being used in this paper and to clarify with whom each of the worldviews are associated. Worldview is a term that has been defined in many ways, depending upon the context and resulting purposes in which it is to be used. For example, when considering worldviews within the context of different religions, one might define alternate religious worldviews according to answers and approaches to the big questions of life (e.g., what is the purpose of life, where did life come from) and how and where the answers to those questions

can be sought or found. Regardless of the context (religious, economic, political...) however, all worldview descriptions ultimately consider (and answer) two questions: “what kinds of knowledge are of value” and “what ways of knowing are valued”. It is this less context dependent and more holistic way of defining individual worldviews that is used in this article.

Equally important to understand about the worldviews and their descriptions is that the particular names of the worldviews should not be thought to mandate inclusion or exclusion of any individual from said worldviews on the basis that he/she is or is not considered a(n) ‘Western’ or ‘Indigenous’ person. The names of these two worldviews comes from observed commonalities within the named group in general, but it is not to be concluded that an individual holds said worldview solely on the basis of their membership in the larger group (e.g., a person who identifies as being of ‘Western’ heritage need not be grounded within the Traditional Western worldview). Conversely, holding a particular worldview is not restricted by what group one is a member of (e.g., a person identifying as ‘Indigenous’ may hold the Traditional Western, or any other worldview).

Some concern may also arise over the use of different articles (‘the’ and ‘an’) proceeding the two worldview names (‘the’ Traditional Western worldview and ‘an’ Indigenous worldview); however, this is done with purpose. As will become evident shortly, the Traditional Western worldview is one in which little (or no) variation is possible because of the emphasis on singularity of truth, knowledge, and ways of knowing. As a result, it is distinguishable from other possible Western worldviews. Hence, ‘the’ Traditional Western worldview is ‘a’ Western worldview – one of many possibilities. ‘An’ Indigenous worldview, as again will become evident shortly, does not preclude variability within the worldview. An Indigenous worldview, as presented, is not representative of any one particular Indigenous group’s worldview. Rather, it is an overarching worldview comprised of commonalities amongst the ways of knowing and kinds of knowledge valued by different Indigenous groups and peoples around the globe. This worldview has within it the flexibility to fit the variance of specific worldviews found amongst Indigenous groups and peoples, thus it is really one of a range of Indigenous worldviews, hence ‘an’. With these broad understandings and considerations in hand, brief introductions to the Traditional Western worldview and an Indigenous worldview, as understood for the theoretical framework for this paper, will now be provided.

The Traditional Western worldview

The Traditional Western worldview has its own “ontological, epistemological, sociological, and ideological ways of thinking and being” (Kovach, 2009, p. 21) that can be distinguished from those of other worldviews, such as an Indigenous worldview. The Traditional Western worldview has as its foundation at least five defining characteristics, which, in a rational way, confirm and strengthen each other (Absolon and Willett, 2005; Kovach, 2009; Ermine, 2007; Little Bear, 2000; Meyer, 2003; Schelbert, 2003). Perhaps most important to the Traditional Western worldview is the belief that knowledge of value is “linear and singular, static, and objective” (Little Bear, 2000, p. 82) in nature, resulting in the valuing of one correct answer to any problem or question; further, this answer cannot be proven false or replaced by alternative answers. In effect, this characteristic of the Traditional Western worldview places an emphasis upon the defining of dichotomous relationships. In addition, the Traditional Western worldview holds that there is one correct way to achieve these answers (at least within each category of context considered). The valuing of the linearity of knowledge naturally gives rise to the defining and perceiving of hierarchies of knowledge, giving rise to specialization and superiority and authority of both knowledge and knower. Seeking of more knowledge, then, is a way to become more specialized, more superior, and more authoritative. Within the traditional worldview, new knowledge is sought for the sake of the knowledge itself. These hierarchies, based upon linearity, help to

eliminate the possibility of alternative answers or solution strategies – as one moves up a knowledge ladder, the newest knowledge level is given authority over all previous levels. The Traditional Western worldview holds rational thought and the scientific method as crucial in the obtaining of new knowledge, or stated more explicitly, knowledge of value comes from observation that is done in total isolation of all other factors and is based upon measurable data. The result is that the notion of truth being linked to measurability, and knowledge of value being related to physical objects and processes that are external to the individual and that are in isolation of other intruding influences. Directly related to the scientific method and rational thinking are the notions of the compartmentalization and categorization of knowledge into small components which are also important within the Traditional Western worldview. Through compartmentalization and categorization, knowledge is believed to not only be emerging in an isolated way (not interfered with by extraneous factors), but it is also easier to accurately measure. Together, these processes confirm not only validity, but absolute truth; further, that absolute truth is known by experts who are attributed with absolute authority. Another consequence of the rationality, measurability, compartmentalization, and categorization of knowledge of value is that it is also abstract knowledge – void of context and dissected into small parcels of truth. Finally, as a consequence of the truth of the valued knowledge never changing, the Traditional Western worldview values the preservation of this knowledge in written, an abstract (symbolic) and permanent form in which the truth is captured for perpetuity.

An Indigenous Worldview

In an Indigenous worldview there are number of defining characteristics, all explicitly and implicitly linked to one main characteristic: relationships (Absolon 2010, Barnhart & Kawagly, 2005; Canadian Council on Learning, 2007; Ermine, 1995; Hogan, 2000; Kovach, 2009; Leavitt, 1995; Little Bear, 2000; Meyer, 2003; Youngblood Henderson, 2000). The main encompassing characteristic of this worldview, the establishment and maintenance of relationships with all of creation (including people, the earth, the spirit world, and the cosmos), is foundational to all knowledge of value and ways of knowing. It is through the establishment and maintaining of relationships that knowledge worth knowing emerges. As a result, knowledge of value in an Indigenous worldview also contributes towards the perpetuation and strengthening of relationships. Moreover, the relationships that are gained and maintained in the seeking of knowledge come from all ways in which a relationship can exist: physical, emotional, spiritual, and intellectual. In an Indigenous worldview it is important that knowledge is intrinsically and extrinsically connected to the place from which it came – the knowledge is in relationship to place. Knowledge that only exists in abstraction where it is decontextualized and disassembled into its constituent parts no longer carries with it the connection to the relationship(s) for which and through which it was created and, as a consequence, such knowledge becomes less valuable. In addition, since knowledge is created and shared through relationships that are not just intellectual in nature (but also emotional, physical, and spiritual), the restriction that knowledge of value comes from objective sources and rational processes is not found within an Indigenous worldview, rather subjective knowledge is often viewed as just as valuable, or even more valuable, than objective knowledge. Personal experience and intuition (from the past, present, and future) are also considered valid sources of knowledge. Moreover, within an Indigenous worldview, valuable knowledge is understood to be different for different people, and the diverse ways in which these different knowledges can be created are also of value. This appreciation for diversity in knowledge and ways of knowing also derives from the importance of relationships, where getting to know and appreciate the uniqueness of who or what one is in a relationship with is crucial for the relationship to be authentic, meaningful, and productive. It is as a result of this characteristic of an Indigenous worldview that the knowledge that is created and valued is able to remove the sense of dichotomy between what might otherwise seem to be diametrically opposed

ideas, such as good and evil. Instead of being polar opposites, the two states become two parts of the totality of being. This means that within the Indigenous worldview, alternate answers and alternate solutions (and strategies) to a problem are not only recognized, but valued for the wisdom that they bring to relationships. As a significant part of any relationship is seen to be the act of giving back, sharing is also an important part of an Indigenous worldview, as is the use of the knowledge gained through relationships to strengthen those relationships and create new ones. Knowledge is not sought for the sake of knowledge, but for the sake of how it can contribute to the wellbeing of the whole (including self, family, community, the earth, the universe and the cosmos). Since knowledge varies as relationships change and emerge, knowledge of value is most often kept and shared through oral traditions, allowing the sharer of the knowledge the flexibility to adjust the knowledge for the relationships into which it is being brought; sharing of knowledge and giving back through knowledge is therefore sensitive to relationships, keeping relationship central to the valuing of knowledge. This oral tradition and the knowledge contained therein contribute to the traditional (cultural) knowledge of the Indigenous people and the place and story in which the knowledge originated is considered part (the story) of the knowledge. Without place, and thus story, the knowledge has no value.

The Meeting of the Two Worldviews: Ethical Spaces

Much tension can (and historically, has) easily formed between the two worldviews described. For this reason, the analysis that follows will be considered from within an ethical space, that is, the space that exists between two different knowledge systems. Ermine (2007) explains that such a space “is initially conceptualized by the unwavering construction of difference and diversity between human communities” (p. 194), just as the descriptions of the Traditional Western worldview and an Indigenous worldview has. By considering these differences – which define the uniqueness of each worldview resulting from “distinct history, knowledge tradition, philosophy, and social and political reality” (p. 194) – and then contrasting the worldviews in a non-judgmental way that creates and allows for engagement in the ethical space between the two cultures. Therefore, analysis using the theoretical framework of the two worldviews carried out within an ethical space is not meant to evaluate or rank the two worldviews; rather, it is an opportunity to better understand what is currently under consideration in research pertaining to risk education and to hypothesize where else the research might head.

In order to engage in such an ethical space, Ermine (2007) holds two criteria must be met: the context under consideration must be unethical, and there needs to be cross-cultural concerns. With respect to ethical spaces, Ermine defines ethics as “the capacity to know what harms or enhances the well-being of sentient creatures” (p. 195), so an unethical issue would be one that has caused, or has the real potential to cause harm, to which it is contended in this paper, that risk education is focused on the potential for harm, and that risk education has the potential to influence (positively, negatively, or not at all), students’ ability to negotiate situations and events involving risk. Therefore, risk education can be considered an unethical issue.

The second criteria of the meaningful entrance into an ethical space is that there needs to be cross-cultural concerns related to the issue of interest. Of course, risk is a topic or issue, which knows no cultural bounds in the broadest connotations; however, feminist theory, critical race theory, theories of decolonization, and other post-modern and post-structural theories acknowledge a multitude of cross-cultural concerns that relate to risks and disparities in risk with respect to culture. For example, currently in Canada, the risk-based cross-cultural concern of missing and murdered Indigenous women (see Kappo, 2014 for a brief overview of the cultural nature of this issue) is a prominent issue of interest for many.

With an understanding of the two worldviews and of an ethical space in which they can be used to analyze risk education, the stage is set to consider what aspects of the research of risk education align with aspects of either of the worldviews. Further, consideration can also be given to those aspects of either worldview which, so far, have not entered into the investigation of and theorizing about risk education. These ideas can then be removed from the ethical space to see if they might be meaningful and plausible within risk education itself.

Analysis

The theoretical framework of the two worldviews (the Traditional Western and an Indigenous) is now brought to bare, within an ethical space, upon the aspects of risk and risk education discussed in the literature synopsis above. It cannot be overstated that the purpose of this analysis is not to judge what has been done within existing research, but to present a new way of thinking about that research in light of the kinds of knowledge and ways of knowing that are being promoted or highlighted, and thus valued. Likewise, it provides an opportunity to identify other possible kinds of knowledge and ways of knowing that have been either overlooked, ignored, or denied. Neither of these analyses is a judgment on choices made or not made, but rather a framing of what is and what else might be possible or considered. The analysis begins by considering what ways of knowing and kinds of knowledge are already being valued, both implicitly and explicitly, within the existing research, then turns to what is not present.

Valued Knowledge and Ways of Knowing In Communications and Risk Research and Theories

Both the topics of communicating about risk, and theories of risk analysis and decision-making are inconclusive regarding how or if they align with aspects of either of the two worldviews in relation to the kinds of knowledge and ways of knowing being valued. In many communications about risk, the kind of knowledge and ways of knowing that are considered of value are not typically presented, only the conclusions made as a result of the particular positioning. For example, the two EVD risk assessment communications do not indicate what information the risk assessments are based upon, nor is the way in which that knowledge is known described. Assumptions, based upon past experiences and possibly even gut feelings, might cause one to lean towards a particular conclusion (e.g., this is rational knowledge based on scientific methods), but in reality only in-depth research of each particular circumstance could say for sure. The use of adjectives in risk communications is equally disagreeable towards the undertaken analysis. Although one might be positive that the risk that is being communicated about is based upon scientifically backed rational thinking, along with the hierarchical and compartmentalizing nature (e.g., very low, low, moderate, and so on) of their use (thereby aligning with the Traditional Western worldview); the subjective possibilities for interpretation of the terms would seem to lean more towards the kinds of knowledge and ways of knowing that are valued within an Indigenous worldview. Likewise, the mathematically theoretical nature of the SEU model would seem to indicate that linear, static, authoritative, and objective knowledge and ways of knowing are being emphasized, yet it also inherently must involve subjective reasoning related to what features of the risk are or are not considered (or identified). It is within the more applied aspects of the literature synopsis (i.e., risk in curricular/standards documents and risk education) that the theoretical analysis proposed above takes on more relevance and less ambiguity.

Valued Knowledge and Ways of Knowing In Curricular (Standards) Documents

Like above, in some of the examples provided regarding inclusion of risk and decision-making within curricular (standards) documents, the ways of knowing and the kind of knowledge being valued

are not always evident; however, in some there are more easily identifiable indications. For example, the UK's Citizenship document, managing risk is tied to very factual and procedural ideas: functions and uses of money and budgeting. It would seem then, that likewise it would be expected that the way students should know about managing risk would also be in a routine-oriented, hierarchical and rational-based way. Consequently, the emphasis would also appear to be on knowing of facts and procedures. Thus, both the ways of knowing and the kinds of knowledge valued by this inclusion of risk within Citizenship could be said to align closely with the kinds of knowledge and ways of knowing valued within the Traditional Western worldview. Similarly, within California's standards document for health education, there are also (likely) indications of valuing rational and scientific knowledge and ways of knowing, such as in the practicing of risk-reducing behaviours. In so saying, the assumption is that the preferred risk-reducing behaviours would be presented to the students as rational and factual knowledge by an authority figure (the teacher), all of which is in direct alignment with the valuing of the Traditional Western worldview. However, the rationale for Standard 4 document what is valued shifts from strictly static and objective knowledge to knowledge that includes beliefs and emotions which are of value within an Indigenous worldview. Moreover, by including beliefs and emotions, not only is what kinds of knowledge valued expanded – so too are the possible ways of knowing expanded to include emotional ways of knowing and possibly others (such as spiritual, physical, intuitional, or experiential). The two examples from mathematics curricula from Saskatchewan add another twist to the analysis since despite the absence of the word risk within the indicators or outcomes, it is reasonable to assume that risk would be a consideration within the decision-making, if only on the basis that the decision-making is within the context of probability education. In these two examples, both objective and subjective forms of knowledge are to be considered. In the Workplace and Apprenticeship Mathematics course it is made clear that the objective knowledge might originate from theoretical calculations or from experiments, while in the Foundations of Mathematics course no such clarification is made. With respect to the kinds of objective knowledge and subjective knowledge that are to be considered, neither course offers further clarification. Thus, it can be contended that these two examples of outcome indicators are specifying that both rational and scientific knowledge and ways of knowing as well as subjective knowledge and ways of knowing are to be considered within decision-making, and thus valued. Consequently, the ways of knowing and kinds of knowledge valued aligns with the Traditional Western worldview and at least some of an Indigenous worldview.

Valued Knowledge and Ways of Knowing in Risk Education – Martignon and Krauss

The discussion of risk education, because of greater breadth and depth of information available, will allow for the most comprehensive analysis of the valuing of kinds of knowledge and ways of knowing. For example, consider the stated assumptions for Martignon and Krauss' (2009) study. First, "Stochastic literacy is a necessary condition for enlightened decision making" (p. 227) is a statement demonstrating the valuing rational knowledge and ways of knowing. Likewise, the implication of stating that probabilistic reasoning can impact prejudices and stereotypes is also conveying a strong message about the importance of rational knowledge and ways of knowing over prejudices and stereotypes, which are often argued to be the products of emotional rather than rational knowledge. Of course, the reverse argument can be made that many prejudices and stereotypes are proposed and defended through what, at least on the surface, appears to be rational and scientific evidence. Finally, as informed consent is being couched within good modeling (undoubtedly based upon probabilities) the implication would be that such informed consent also comes from rational and scientifically produced knowledge. Thus, the kinds of knowledge and ways of knowing supported by the assumptions of Martignon and Krauss' (2009) would best align with those of the Traditional Western worldview.

Considering the design of Martignon and Krauss' (2009) study there are a number of ways in which the valued knowledge and ways of knowing can be directly related to those of the Traditional Western worldview, starting with the ordering of the activities. First, the order is described as *the* series of competencies rather than *a* series of competencies. There is an assumed correctness to the order in this choice of article (whether consciously intended or not), a hierarchy of learning through which one must progress in order to achieve the intended goal of giving the students a toolbox of decision heuristics. This assumption of a correctness of order is further confirmed in the explanation that the design is following the "historic trajectory ... from logic to probability" (p. 238). The strictness of defining and the authority of following the series of competencies given are representative of the valuing of rational and scientific knowledge and ways of knowing, with no consideration made of alternative kinds of knowledge or ways of knowing. The design of the activities also is grounded in rational and scientific knowledges and ways of knowing. For example, derivation of specific heuristics implies that these heuristics are most important, or singularly best, for considering risk and decision-making. These are not just any heuristics; however, they are heuristics that are bounded in rationality. In fact, rationality and scientific methods dominate this study's intended learnings, with categorizations of the kinds of activities with very specific and singular connections being made between them. Overall, Martignon and Krauss' study is well grounded within the kinds of knowledges and ways of knowing valued within the Traditional Western worldview, and in some ways, it supports the devaluation of other ways of knowing and kinds of knowledge, such as beliefs and emotional knowledge.

Valued Knowledge and Ways of Knowing in Risk Education – Ainley, Kapdia, Kent, Levinson, Pratt, and Yogui.

As noted earlier, the primary difference between the study done by Ainley, Kapdia, Kent, Levinson, Pratt, and Yogui and the study done by Martignon and Krauss is the former's acknowledgement and incorporation of affective or emotional responses and data. As such, in the areas of overlap, it will be assumed that the research of Kapadia, et. al. also values the ways of knowing and kinds of knowledge that are foundational to the Traditional Western worldview. Other kinds of knowledge and ways of knowing, however, can also be seen as valued within this research. First, the assumption held by the researchers regarding the importance of personal value systems and judgments (as noted by Kent et. al., 2010) while making decisions aligns with the valuing of emotional and possibly experiential knowledge and ways of knowing, which are valued within an Indigenous worldview. This assumption is further realized within the study proper through both the Painometer and Risk Mapping tools. The Painometer is explicitly about incorporating the emotional responses and knowledge of the participants into the study, and the Risk Mapping tool is an attempt to create a model detailing relationships between emotional responses and knowledge together with the rational and scientific knowledge captured within the Operation Outcomes. Even the specific design of the Operation Outcomes tool allows for emotional responses and knowledge to (implicitly) enter into the decision-making experience as the participants choose which outcomes to focus on while using the tool. One can easily assume that some, if not all, of these choices are subjectively determined based upon emotional and relationship-based knowledge. This emphasis on emotional and relationship-based knowledge and ways of knowing is representative of some of the kinds of knowledge and ways of knowing valued within an Indigenous worldview. Additionally, relationship-based knowledge and ways of knowing are also being encouraged by the design of the study, stepping beyond the typical boundaries (or compartments) of science and mathematics, inviting the mathematics teachers to consider the socio-scientific aspects of risk in the given dilemma, while encouraging the science teachers to consider the mathematical properties of probability at the same time. Finally, because the design of the study is such that no one kind of knowledge or way of knowing is overtly presumed to be of greater importance, the

valuing of rational and scientific knowledge within the study can also be seen to align with an Indigenous worldview's consideration and acceptance of diverse ways of knowing and diverse knowledge depending upon the relationships sought and created within that context and at that time.

Unrecognized or Devalued Kinds of Knowledge and Ways of Knowing

As was stated previously, but warrants revisiting, when working within an ethical space, the above analyses and the ones to follow are not intended to serve as statements of judgments; rather, they are meant to give a different perspective, a new set of lenses through which risk, decision-making, and risk education can be contemplated and explored. For the same reasons as no identification of what kinds of knowledge and ways of knowing are being valued within different forms of communications about risk or within theories of risk and decision-making, the same two portions of the literature review will not be analyzed. Instead, the reader is invited to, at their leisure, reflect upon the possibilities from within their own knowledge and ethical spaces and experiences.

In reflecting upon the positioning of risk within curricular (standards) documents, the compartmentalization of risk into specific subjects is consistently present. As a result, the message (intended or not) conveyed is that risk, as mentioned in a particular place in a particular document, should be studied within the isolated conditions therein. As such, the possibility of building relationships within the learning is bounded to particular kinds of knowledge and ways of knowing. What is not being explicitly recognized (hence valued) is the many ways in which risk crosses the artificial boundaries of subject areas within everyday life. Situations of risk that one encounters in their personal life rarely are restricted to one field only. Financial risk is not just risky in relation to money, but to every aspect of life, just as what is involved in a health risk is never only medical in nature. Thus, there is an opportunity to investigate the possibility of risk education without specific subject boundaries. To an extent, Ainley et. al.'s study has done so, but the possibilities of relationship-based knowledge can extend further. Perhaps risk and decision-making could be considered as guiding principles behind education, as competencies, which are common to, and integrative of, all subject areas; risk literacy could be seen as foundational across all curricula

There are also other kinds of knowledge and ways of knowing that have yet to be valued (or acknowledged, even if to be dismissed) within risk education research including intuitional, spiritual, physical, experiential, traditional, and cultural knowledge. There is an opportunity for reflection upon, and possible inclusion of one or more of these kinds of knowledge and their associated ways of knowing within risk education, and such possibilities deserve candid consideration. Next, a small hint of what such considerations might include is given.

Why Consider the Unconsidered?

Some might dismiss, at this point, everything that has proceeded in this paper as over-exuberant and self-indulgent theorizing. Without any hint at why one might even consider any of the additional knowledges and ways of knowing mentioned, the whole idea can seem irrelevant and impossible to realize. For this reason, two real-life situations steeped in risk and decision-making are presented and reflected upon: the destructive tsunami of 2004, and the so-called "Navajo plague" of 1993. Each of these events took many lives, but each also reveals how some knowledges and ways of knowing that were ignored at the time may have changed the final outcomes.

Boxing Day, 2004

On Dec. 26, 2004, a magnitude 9.0 earthquake centered near the west coast of Sumatra and under the Indian Ocean occurred. The energy released by this earthquake has been estimated to be equivalent to 23 000 atomic equal to those of Hiroshima. The resulting tsunami a few hours later had waves that moved at the speed of a jet. (National Geographic News, January 5, 2005). Pictures and videos of homes, people, animals, and all kinds of belongings being swept into the ocean went viral across all forms of media. More than 150 000 people were killed, with some estimates being placed at 250 000 and higher, and millions lost everything they had. Despite all of the technology and scientific models available to predict and communicate risks of earthquakes and tsunamis, scientists were unable to provide adequate warning for the event. Yet, a number of indigenous groups, frequently ignored or seen as inferior to other non-indigenous inhabitants, survived en masse. Unfortunately, the same was not true for the non-Indigenous people inhabiting the same islands and communities. The mass survival of these indigenous peoples is now recognized to be the result of their “in-depth knowledge of the environment” (Mercer, Dominey-Howes, Kelman, & Lloyd, 2007, p. 251). As an example, the Moken (or sea gypsies), an Indigenous group from Thailand who live on the Indian islands of Andaman and Nicobar, “managed to anticipate the tsunami danger. Their knowledge of wind, tides, and the animals, which had been passed down from generation to generation, prepared them to deal with the natural disaster” (Perez, n. d., p. 1). Part of this knowledge included the silence of the cicadas, which was understood to tell the people to run for higher ground, and they did. When interviewers asked a Moken man why the tsunami had happened, he responded “The big wave had not eaten anyone for a long time, and it wanted to taste them again” (p. 2). Such knowledge would not, at least in Traditional Western worldview terms, be considered rational or scientific knowledge. Nor is it emotional knowledge. It is the traditional knowledge of the people, the knowledge which has been preserved and carried forward through generations of oral traditions. It is spiritual knowledge, intuitional knowledge, physical knowledge, and possibly experiential knowledge. No testing, isolation, compartmentalization, or abstraction of the knowledge was done. Similar examples from onslaught of the tsunami can be found throughout the region’s Indigenous peoples, including those who live on Nias Island where, not only did the Indigenous people survive, but so too did their homes that were nearly 100 years old, while the new modern homes on the island were destroyed. These examples are filled with a kind of knowledge and a way of knowing that has been “increasingly recognized in the international arena, yet is frequently overlooked in practice” (Mercer, et. al., 2007, p. 247). Will the same be true in risk education?

The Navajo Plague

In the spring of 1993, a healthy, newly engaged, Navajo woman of 24 became sick one day with “a stuffy nose, a dry cough, aches, and little else. It looked like an ordinary case of the flu” (Arviso, & Cohen, 1999, p. 117). The following day, the woman “showed up in Crownpoint in severe respiratory distress and hypoxic ... She’d died a few hours later” (p. 118). On the day of her funeral, her 19 year old fiancé became similarly ill, was “brought to the GIMC emergency room in full respiratory and cardiac arrest and died shortly thereafter” (p. 120). These were the two patients of a soon to be epidemic that was spreading through the Four Corners – the name given to a region within Arizona, New Mexico, Colorado, and Utah in which a number of Navajo reservations are located. Although the as yet unidentified disease was seemingly targeting only Navajo people (hence the name ‘Navajo Plague’), restaurants and businesses in communities adjoining the reservations began refusing to serve anyone who appeared to be Navajo in descent; people began cancelling vacation reservations in the south; and “the national media jumped to the conclusion that it was *because they were Navajo* that these individuals had contracted” (pp. 121-122) this acute respiratory distress syndrome. Local doctors and health care

workers were dumbfounded as to the underlying cause for the disease, and so the Centre for Disease Control (CDC) was called in to solve the mystery. The CDC carried out a series of laboratory tests that “failed to identify any of the deaths as caused by a known disease such as bubonic plague” (Centers for Disease Control and Prevention, 2012). As additional testing continued, physicians and researchers repeatedly found that “The particular mixture of symptoms and clinical findings pointed... away from possible causes, such as exposure to a herbicide or a new type of influenza, and toward some type of virus”. Tissue samples were analyzed by virologists at the CDC, ultimately leading to the identification of a previously undocumented type of hantavirus. The species of mouse (the deer mouse) known to carry and transmit this virus through its fecal matter and urine is not considered endemic to the Four Corners environment, and for this reason, hantavirus had not been considered in the original testing. Had hantavirus been included within the possible underlying diseases that were originally tested for, many people may not have died.

However, at least one of the healers within the Navajo reservations knew that a change in climate could result in the deer mouse being, at least temporarily, endemic to the Four Corners. In fact, a worker from the CDC, who was of Navajo decent had gone, to see the healer to ask about the disease. The healer replied by showing the CDC worker a photograph of a sand painting with a mouse in it, and he also told the worker that “many years ago such a sickness had occurred and that the sand painting had been used to treat it” (Arviso, & Cohen, 1999, p. 122). In reality, the sand painting did more than identify the particular breed of mouse responsible for the illness. It also explained why the population size of that particular kind of mouse would increase: three or more years of excessive rain leads to increased production of the seeds of the dwarf pine trees in the area, and those seeds are one of the best food sources for the deer mouse. When finishing his sharing of the story of the sand painting, the healer told the worker to share this knowledge with the CDC, and more specifically, to “Look to the mouse” (p. 122). Sadly, in all of the documented knowledge about this outbreak, there is no mention of anyone else (not even the Navajos living on the reservations) approaching the healer for information. Like the scientists, most Navajo people believed that this outbreak must be something new, beyond and foreign to their traditional knowledge. The CDC has officially acknowledged that: “Navajo Indians... recognize a similar disease in their medical traditions, and actually associate its occurrence with mice. As strikingly, Navajo medical beliefs concur with public health recommendations for preventing the disease” (Centers for Disease Control and Prevention, 2012). Perhaps, if the traditional knowledge and ways of knowing had been valued by the scientific practitioners and, dishearteningly, by the Navajo people themselves, the hantavirus diagnosis would have occurred sooner, and fewer young and promising lives would have been lost. Perhaps research into risk education would benefit from acknowledging the value of asking and listening to learn from traditional knowledge keepers.

In both the case of the 2004 tsunami and the 1993 hantavirus epidemic, the traditional knowledges of indigenous peoples, neither based in rational scientific knowledge and ways of knowing or in emotional and affective knowledge and ways of knowing, could have reduced the risk to the people in those situations. However, to acknowledge and value such knowledge and ways of knowing, and to incorporate them into our understanding of risk, risk understanding, risk management, and risk-based decision-making, we need to come to terms with the limitations imposed by beliefs such as significant stochastic understanding being necessary for decision-making. Undoubtedly, there are times when such stochastic knowledge is of huge benefit in decision-making, but as the two previous examples demonstrate, stochastic knowledge (at least as understood within Western knowledge and mathematics) is not the only way in which one can make enlightened decisions. How this understanding will inform risk education remains to be seen.

Final Words

At this point, the relevance of including the discussion of research on communicating about risk and theories of risk and decision-making within the review of the literature can be elucidated. Specifically, the consideration of alternative kinds of knowledge and ways of knowing could also be considered within the areas of communicating about risk and theorizing about risk and decision-making. It is a discussion which might not only result in significant consequences to the research being done, but it also could help in the processes of decolonizing stereotypical and prejudicial ideas held about Indigenous peoples and their knowledge as well as the resulting oppression and marginalization.

Most of the research related to risk education and decision-making has been, for the most part, unaware (or possibly dismissive) of many of the ways of knowing and kinds of knowledge valued within an Indigenous worldview. Perhaps this is due to the Traditional Western worldview's (which arguably has grounded much of academic research) unquestioning belief in absolute truth and rationality; perhaps it is due to the need to create the 'other' to find self-worth (another consequence of the underpinnings of the Traditional Western worldview and processes of colonization and oppression); or, perhaps it is due to the failure of an education system and its supporting research to include considerations of alternative ways of knowing and kinds of knowledge. The reason why is not of greatest importance; rather what is important is what will be done about this realization.

The emerging field of risk education has within its reach an opportunity that has been missed or ignored by so many other fields of study: the valuing of alternative ways of knowing and kinds of knowledge beyond those that are rationally and scientifically-based and the emerging valuing of emotions and emotional responses. Perhaps this time, it will not be that "western science remains firmly entrenched in its traditional methods. An entrenchment from colonial times... when our ignorance of the 'other' contributed to an increased divide between them (the developing world) and us (the Western world)" (Mercer, et. al, 2007, p. 246). Perhaps risk education will help break through these, often unspoken, boundaries.

As a final note, if the decision is made to embark upon the consideration and possible inclusion of other kinds of knowledges and ways of knowing, care must be taken to not appropriate and commodify those kinds of knowledges and ways of knowing (Smith, 2000). In the valuing of new kinds of knowledges and ways of knowing, then so must the keepers of those knowledges and ways of knowing be acknowledged, valued and respected. Perhaps, risk education will not only venture into new worlds of knowing — it is possible that it could contribute to the processes of decolonization for the good of all peoples.

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In keeping with the sentiments expressed in the final words above, I would like to acknowledge the contributions of the Indigenous scholars, elders, knowledge keepers, and ancestors, who despite the challenges of colonization, have managed to preserve their worldviews. Further, I thank them for sharing their worldviews with everyone, despite the condemnation and oppression they have so often experienced as a result of holding such worldviews.

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