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ORIGINAL PAPER

Exploring risk perceptions: a new perspective on analysis

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Abstract
When secondary school students were asked about the socioscientific issue of using sodium fluoroacetate (1080) poison to control New Zealand's possum pests, they provided a wide range of responses. Their responses showed that they considered this method of control to be risky and contentious. Such contentious issues are an example of the complexity involved in using a socioscientific approach to investigate an aspect of post-normal science. This paper provides the background to and development of a new risk perceptions analysis framework that was employed to qualitatively interpret these diverse viewpoints. Four Cultural Types (*Nature Benign, Nature Tolerant, Nature Ephemeral* and *Nature Capricious)* are accommodated within this framework. Each Cultural Type has a particular view of risk that is defined using common characteristics and is differentiated by unique individual attributes. It is proposed that this framework has the potential to analyse students' responses to this contentious issue of 1080 use. The framework could be used as an educative tool in classrooms to investigate the range of views within society about issues that involve risk. Additionally, it could be used to assist students to gain awareness of their own view as well as develop an appreciation about the differing views of risk held by other people when discussing contentious issues.

Keywords Risk education · Socioscientific issues · Post-normal science

If a goal of science education is teaching for citizenship and improving scientific literacy, then knowing about risk is important. Everyone needs to have some awareness of how perceptions of risk influence their understanding of issues, as well as the implications of that understanding on what Marvin Berkowitz and Patricia Simmons describe as the "global village" (2003, p. 117) in which we now live. But a focus on risk within science education

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is new territory for science teachers as traditionally science programmes have focussed on decontextualised, fixed content with known and predictable outcomes. Consequently, in Clare Christensen's (2009) view, teachers often avoid using content that emphasizes risk where knowledge is uncertain and in dispute. To add to the complexity of this issue within science education, students may be unaware of how culture can influence risk perceptions. It is argued that without this awareness, students' confidence to participate in decision-making about risk issues now, as well as in their future, may be compromised (Christensen). This paper proposes the use of a new risk perceptions framework, using a viewpoint Jerome Ravetz describes as "post-normal science" (2006, p. 71). It is argued that such a framework could assist in the teaching of controversial issues, by unravelling the complexity of how people view risk. This risk analysis framework was developed to analyse students' perceptions of the risks involved in the contentious use of a poison to control pest species in a New Zealand environment. The framework has its origins in the Grid/group Cultural Theory work of Mary Douglas (1978, 1999, 2003a, b, c, 2007).

Scientific literacy and the teaching of risk within socioscientific issues

Jack Holbrook and Miia Rannikmae (2009) propose that the concept of scientific literacy has been debated for decades. They believe this is because there has been confusion about the exact meaning of scientific literacy and it has been difficult to define. To address this situation, Douglas Roberts created a framework to describe the various views of scientific literacy in 2007, which contained two components he named as Vision I and Vision II. Vision I component teaches scientist-centred science, focusing on decontextualized subject matter. Robert's Vision II science is student-centred and context-driven, focusing on the development of citizens who can make informed decisions about science-related issues in their lives. A more recent development by Jesper Sjöström and Ingo Eilks (2018) is the conception of a Vision III scientific literacy that involves building the capacity of citizens to use their understanding of scientific knowledge and practices to solve socioscientific issues in their everyday lives.

Alongside this recent addition of a new vision of scientific literacy, Douglas Roberts and Rodger Bybee (2014) argue that there is a need to revitalise school science education as levels of young people's interest in science decline. Additionally, Britt Lindahl et al. (2011) support the need to improve interest in science in schools and report that levels of scientific knowledge in the general populace have diminished.

Vital to the goal of revitalising school science education is setting learning in contexts relevant to learners (Olivier Morin, Laurence Simonneaux, Jean Simonneaux and Russell Tytler, 2013). One example that highlights the importance of a relevant context was Yeung Chung Lee and Marcus Grace's (2010) study. They researched 15–16-year-old students' opinions about bat conservation in Hong Kong and concluded that "students are better motivated to learn new concepts from authentic contexts than from textbooks" (p.164). Lee and Grace also believe the teaching of science through this locally based context provided a platform for students to "develop their decision-making skills to handle controversial ecological issues" (p.164). They assert this method of teaching contributed to developing these students' scientific literacy skills. The authors of this paper believe the use of 1080 in New Zealand is another example of a relevant, controversial issue invoking a complexity of views, that has the potential to contribute to students' scientific literacy skills and could

support Roberts' (2007) Vision I and II forms of scientific literacy and possibly Vision III if action is taken.

Furthermore, Christensen (2009) argues part of the revitalisation of school science should be promoting awareness that science is surrounded by uncertainties, including risks, and that scientific knowledge and related technologies are rapidly changing, consequently setting science in a sociocultural context. By setting science in such a context, Dana Zeidler and Jennifer Lewis (2003) believe that students can then learn to recognise that although humans have always faced uncertainties and risks, the risks facing people today are more complex. This complexity arises because many socioscientific issues that we are facing involve multiple, interacting variables, for example the use of 1080 to control predator mammals in New Zealand.

Many such risks have global implications, for example growing pollution from plastic debris. By incorporating risk into science education, students can learn to work with knowledge uncertainty (Christensen 2009). Julia Hansen and Marcus Hammann (2017) also support the inclusion of risk in educational programmes. They assert that students need to develop risk competence to assist them to navigate and participate in social debate on risk-related issues.

However, Mary Ratcliffe and Marcus Grace (2003) found that teachers report concerns about these programmes taking more time to teach, covering less content and would require a change in delivery. Additionally, Ralph Levinson, Phillip Kent, David Pratt, Ramesh Kapadia and Cristina Yogui (2011) believe that risk is challenging to teach because the concepts are contested, the topic is situated and incorporates epistemic and non-epistemic values, and often involves mathematical ideas such as statistics. Furthermore, in their study, Linda Schenk, Karim Hamza, Leena Arvanitis, Iann Lundegård, Andrzej Wojcik, and Karin Haglund (2021) describe how teachers can be concerned about imposing political views on their students or are unwilling to express their own values about risk issues.

Despite these difficulties, Ravetz (2006) argues for a "post-normal" (p. 71) approach to science, recommending that teachers should include uncertain science knowledge involving risk within science education. A post-normal approach acknowledges that in today's world, rapidly evolving global issues increasingly involve "facts [that] are uncertain, values [being] in dispute, [where] stakes are high and decisions urgent" (p. 70) and science-based outcomes are contentious, for example the effects of climate change. Ravetz asserts that using a "what-if" (p. 75) approach will develop students' appreciation of these novel science-based situations and their inherent risk issues.

Recommending the teaching of risk in schools has also been proposed by Troy Sadler and Dana Zeidler (2004) using a socioscientific issues (SSI) approach. They describe SSIs as "social dilemmas with conceptual ties to science" (p. 387) and argue that this focus would illustrate the interdependence of science and society to students.

Ratcliffe and Grace (2003) also support SSIs being taught in schools, describing the general characteristics of SSIs as those that have a basis in science, involve risk ideas, deal with incomplete information, include forming opinions, and embrace local, national, or global dimensions. Additionally, Schenk et al. (2021) argue that risk should be a more central part of SSI teaching as it often includes decision-making skills. This approach would also provide contexts that embody Ravetz's (2006) notion of 'post-normal' science where risk is central.

Moreover, Kathryn Stevenson, M. Nils Peterson, Howard Bondell, Susan Moore, and Sarah Carrier (2014) assert that it is important to teach contentious topics in teenage years as adolescents represent a group whose worldviews are still forming and therefore, they may be more open to new views. These authors propose the teaching of risk, which is an

inherent component of post-normal science and part of an SSI approach, is essential when teaching science that examines differing points of view. However, despite these recommendations, Lindahl, Rosberg, Ekborg, Ideland, Malmberg, Rehn, Ottander, Silfver, and Winberg (2011) found that incorporating risk when using an SSI approach can be problematic. They found that students can be distracted when working with complex SSIs because the outcomes are unclear, which challenges their rational, emotional, and social skills.

Another approach to teaching risk is put forward by Schenk, Hamza, Enghag, Lundegård, Arvanitis, Haglund and Wojcik (2019). Although they assert that the concept of risk is difficult to define because it has technical as well as everyday meanings, describing it as "polysemous" (p. 1273), they propose teachers use a seven-element, two level model to aid the understanding of the multidimensional concept of risk. The outer elements contained in the model are knowledge (about risk decisions), values (judgements that need to be made) and activity (that generates risk), while the inner level contains the four elements of uncertainty, probability, severity, and consequence all of which could promote understanding and discussion about risk.

The authors of this paper assert that this while this seven-element model illustrates how risk is a complex concept and highlights the different elements contained in a risk issue, it does not provide students with an appreciation for why people feel the way they do about these issues. We propose that our risk analysis framework may develop students' understandings in this area.

Developing the risk perceptions analysis framework

People's perceptions of risk are socially constructed. These perceptions are formed by quantitative assessments of, for example hazards in the environment (Bernd Rohrmann 2008), which are then filtered through their personal values and experiences (Grant Gardner, Gail Jones, Amy Taylor, Jennifer Forrester and Laura Robertson 2010) in order to determine the relevance of the risk to their own lives. Culture, race, gender, and personal worldviews shape the way a risk is viewed (Dryhurst, Schneider, Kerr, Freeman, Recchia, Van Der Bles, Spiegelhalter and Van Der Linden 2022). Assessments of people's risk perceptions seem to be predominantly contextually bound and quantitative. For example, Gardner, Jones, Taylor, Forrester and Robertson (2010) who explored undergraduate students' risk perceptions of nanotechnology applications, Fangnan Cui, Yaolong Liu, Yuanyuan Chang, Jin Duan and Jizu Li (2016) who investigated tourism risk perceptions and Dryhurst, Schneider, Kerr, Freeman, Recchia, Van Der Bles, Spiegelhalter and Van Der Linden (2022) who explored public risk perceptions of COVID-19 and willingness to adopt preventative public health behaviours. However, there is a paucity of studies investigating the risk perceptions of students engaged in formal education (Gardner, Jones, Taylor, Forrester and Robertson 2010).

There appear to be some risk perception analysis frameworks, but similarly these appear to employ quantitative data. For instance, the Risk Perception Attitudes (RPA) Framework developed by Rajiv Rimal and Kevin Real (2003) is used to assess people's motivation in relation to personal health behaviours. By quantitatively measuring risk perception attitudes using this framework, four different health-related behaviours can be identified. These groups of behaviours categorise a person's motivation level to actively manage their health and the likelihood of them taking action to do so (personal efficacy). One group of behaviours is responsive (highly motivated and able to translate motivations in action),

and another is avoidance where people's motivations to act are reduced by weak efficacy beliefs. Another group is indifferent and is the least motivated to act, and the last group, the proactive group, is able to take action but less motivated because of their low-risk perceptions. This framework has been used to inform health campaigns, for example prevention of breast cancer (Rajiv Rimal and Hee-Soon Juon 2010). The RPA was extended by Jie Wang, Bingjie Liu-Lustres, Brent Ritchie and Dong-Zi Pan (2019) into assessing risk perceptions involved in adventure tourism. However, this framework relies on a quantitative, broad-brush approach, with little detail about reasoning for an individual's categorisation. Therefore, the authors of this paper looked to the work of Mary Douglas (1978, 1997, 1999, 2003a, b, c, 2007) to develop a framework that would enable a more fine-grained analysis.

Mary Douglas is regarded as a seminal risk theorist (Deborah Lupton 2013). While Douglas's work has been criticized by some researchers for developing a less-than fully formed analysis typology (Åsa Boholm 1996) nor providing empirically validated evidence (Sander van der Linden 2016), her ideas have remained influential when analysing risk (Branden Johnson and Brendon Swedlow 2021). Douglas was influenced by Emile Durkheim who believed that any society displayed a "common consciousness" (Durkheim 1984, p. 38) that is, shared beliefs that operate as a unifying force within any society. Because Douglas's work focussed on the identification of and interaction between different cultural groups within a society, the authors believe it could potentially provide a way to investigate the collective or 'common consciousness' of the participants in this research.

Unlike Ulrich Beck (1994), who believed better communication between scientists and the public would improve the public perception of risk, Douglas (1999) stressed the importance of culture when analysing risk. She asserted that in any culture citizens hold deep-seated views about risk situations and providing additional information will not persuade them to change their minds. Douglas asserted that when examining risk, there is a need to identify different social groups within any society and argued that there were four groups who shared a similar point of view, or cultural bias, about any specific issue. She developed a typology of social relationships to categorise these four groups, which became known as the Cultural Theory of Risk (Douglas 1997) and asserted that such a typology was both "parsimonious and … comprehensive" (Douglas 2007, p. 8). She believed that while it might be argued that there could be multiple cultural biases in any community, for explanatory value, identifying four types of social environment that generated four distinct cosmologies kept the concepts of social relationships understandable and uncomplicated. The two dimensions identifying these four differing views within this typology were named by Douglas (1997) as grid and group. The grid dimension indicates the increasing influence of laws or rules within a society, and the group dimension indicates the belief of being increasingly unified into bounded groups. Douglas argued that each of the four groups was defined by these two dimensions and could be identified by multiple distinctive characteristics. She identified the grid/group typology a "polythetic method" of classification (1997, p.15) which means that rather than requiring all these characteristics to be present in every member of any group, only some characteristics were necessary to define its members. This feature has been implemented in the framework developed for this study.

Douglas's work is fundamental to the development of this new risk perceptions analysis framework shown in Fig. 1, and her ideas are centrally placed.

Over the past 40 years, the Grid-Group Cultural Theory has evolved to become an important structure to assist in the understanding of risk (Lupton 2013). Adding to this evolution was the research conducted by Michael Thompson, Richard Ellis and Aaron Wildavsky (1990) who argued that the four groups in this Cultural Theory are interdependent

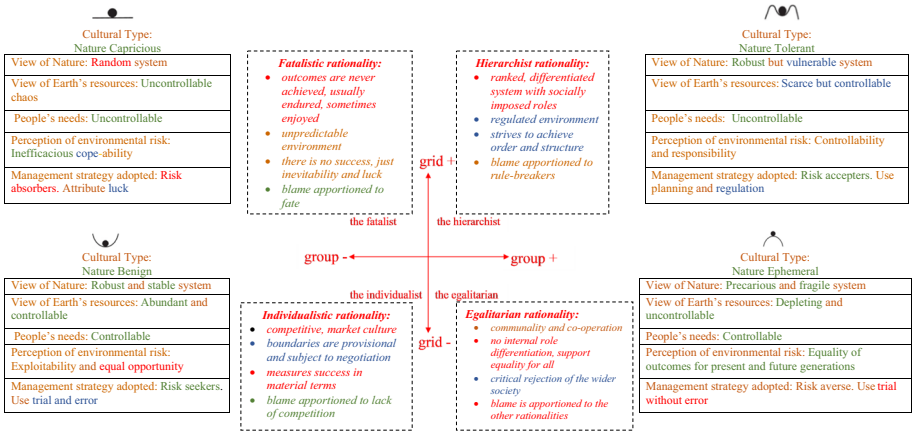


Fig. 1 The Risk Perceptions Analysis Framework, centrally displaying Douglas's Grid-Group Cultural Theory, supported by specific rationalities and bordered by five common characteristics and individual attributes for the four Cultural Types (synthesised from Douglas 1997; Schwarz and Thompson 1990; Steg and Sievers 2000, Thompson, Ellis and Wildavsky 1990, and augmented by the first author's interpretation of theoretical research about Cultural Theory)

and in constant dis-equilibrium. They posited that each of the four groups is not equally represented within a society at any given time and there is a "perpetual dynamic imbalance" (p. 4) between them that changes depending on the situation or social context being discussed. These four groups (*Nature Capricious, Nature Tolerant, Nature Ephemeral* and *Nature Benign*) are given equal space in the new risk framework shown in Fig. 1.

The Myths of Nature work of Michiel Schwarz and Michael Thompson (1990) and Crawford Holling (1979) were also employed, by adapting and augmenting their research to support the new risk framework. The risk analysis framework incorporates their Myths of Nature as a component, which represent each group's beliefs about how risk to ecosystems should be managed (Schwarz and Thompson). These Myths of Nature, depicted diagrammatically and integrated within the new framework, are represented by a ball in a landscape, where the ball represents environmentally risky behaviour, and the landscape represents the vulnerability of nature. At the top left of the framework shown in Fig. 1, the ball is positioned on a flat landscape to represent that any risk can result in the ball being able to move uncontrollably. The diagram on the top right represents a ball at the bottom of a basin, and its risky movement is controllable if it is not knocked over the edge. At the bottom right, the ball sits precariously on top of the landscape, here there is the risk that it could be knocked off its position at any time. Finally, at the lower left the ball is depicted in a controllable and low-risk position within a large basin.

An additional feature of this new framework is the specific rationalities that the four groups employ when justifying their opinions (Schwarz and Thompson 1990). These rationalities have been modified and augmented by the first author, using comparable language to assist analysis, and are positioned beside the original grid-group ideas that Douglas (1999) identified. Finally, there are five common characteristics listed in the left-hand side of the four outer boxes in the framework. These characteristics were initially identified by Linda Steg and Inge Sievers's (2000) when they investigated environmental risks in the Netherlands, where they identified between two and five characteristics for each of their groups within their research. To ensure a standardized format, the first author expanded

these characteristics so that the four groups within the analysis framework each have five common characteristics. Furthermore, while each Cultural Type shares these common characteristics, each Type has unique attributes that result from their specific rationalities. These unique attributes then provide a way to differentiate between the four Cultural Types.

Describing the four cultural types

There are four Cultural Types in this framework. In the top left of Fig. 1 is *Nature Capricious*, whose supporters are risk absorbers, meaning they have a belief that risk must be acknowledged and prioritized in their lives as there is no success in society, only inevitability and luck. They display a fatalistic rationality, which is depicted diagrammatically as an uncontrollable ecosystem for their view of the Myth of Nature. This group is situated in a **weak group and strong grid** position on the framework to show that these supporters have weak affiliations to any group culture and firmly believe that rules are imposed on them. Douglas (2003a) described this Cultural Type as believing that there was little they could do about anything in their lives and they could only cope. Consequently, they preferred not to be involved in societal issues. For *Nature Capricious* supporters, blame is apportioned to fate, and they have a conviction that outcomes are to be endured, never achieved.

In the top right of Fig. 1 is the *Nature Tolerant* Cultural Type where supporters display a hierarchist rationality which is situated in a **strong group and a strong grid** position. They believe in a regulated environment, a need for responsibility, order, planning, and structure. This group has a long-term view of risk, believing that issues can take time to resolve. Supporters apportion blame to rule breakers, and this rationality is illustrated by the diagram of the Myth of Nature as a manageable ecosystem, but only if rules are followed. Douglas (1999) opined that within any society these people have a stalwart affiliation with a group, and they strongly follow rules around issues in which they believe. She asserted that people with *Nature Tolerant* values accept the importance of ranked roles and a division of labour in society. Douglas (2003a) believed that proponents of the *Nature Tolerant* Cultural Type were needed for the maintenance of a society because of their hierarchical and bureaucratic beliefs.

Beneath the *Nature Tolerant* group is the Cultural Type *Nature Ephemeral*, positioned in a **strong group, weak grid** situation in the framework (bottom right). These supporters demonstrate an egalitarian rationality of communality and co-operation. They have an equality of outcomes belief for all living things and an aversion to any risk they could encounter. Supporters of this Cultural Type express a strong sense of belonging to a group about issues that they believe in unfalteringly, but a weak sense of following regulations when they believe these rules do not align with their ideas. Consequently, they apportion blame to other rationalities. Douglas (1997) argued that within any society people with egalitarian views were essentially the radical conscience of a community.

Finally, in the lower left of Fig. 1 is the *Nature Benign* Cultural Type, holding a **weak group, weak grid** position. They rationalise that boundaries and rules are subject to negotiation and the diagrammatical version of their Myth of Nature depicts this rationality. They believe that ecosystems are an exploitable low-risk resource. Supporters display a low sense of belonging to a group and do not place importance on following established rules. They display an individualistic rationality where success is measured in material terms in a competitive, market-driven culture and blame is apportioned to a lack of competition. Douglas (1997) argued that people with individualistic values were the entrepreneurially

inclined members of society, who come up with the new ideas, compete for esteem and income and describe their risk views using procedural terms and meanings.

The issue of using 1080 in New Zealand—the context for this study

While New Zealand is one of the most biologically diverse and unique areas of life on Earth, its biodiversity is also one of the most vulnerable. Gerard Hutching and Carl Walrond (2017) identified that 37% of New Zealand's endemic birds and 34% of New Zealand's plants are endangered.

The Organisation for Economic Cooperation and Development (OECD) have recognized this unique biodiversity by stating in their *Environmental Performance Review* (2007) that New Zealand has a "special responsibility for biodiversity conservation, since a high percentage of its 90,000-native species are endemic and unique" (OECD 2007, p.5). These ideas are similarly supported by many New Zealand citizens who believe that conserving New Zealand's unique biodiversity is important as well as expressing a desire to "ensure the experience of New Zealand's natural environment remains a part of the Kiwi way of life" (Department of Conservation [DOC] 2006, p.3). In 2000, a twenty-year New Zealand Biodiversity Strategy was developed that established national goals "to halt the decline of New Zealand's indigenous biodiversity" (Ministry for the Environment [MfE] 2000, p. 2) and focused on developing strategies involving both community and individual action. However, despite the establishment of these national goals, the OECD's 2007 environmental performance review was critical of New Zealand's biodiversity rescue attempts, stating:

> Biodiversity conservation still faces major challenges in New Zealand. Despite sizable decreases in the numbers of certain pests (e.g. rats, possums, rabbits) in some areas, invasive species continue to pose serious risks to indigenous ecosystems and species. (OECD 2007, p. 5)

To background this issue, the introduction of the Australian brush-tailed possum (*Trichosurus vulpecula*) causes a significant threat to New Zealand's natural biodiversity. Possums feed on native flora and fauna, compete with native species for habitats and, as they lack natural predators, their numbers have exploded. This population explosion also poses an economic threat as possums transmit bovine tuberculosis (bTB) to cattle, deer, and pigs. James Russell (2014) asserts that while over 90% of New Zealanders agree that possums need to be eliminated, methods for doing so are highly controversial and are perceived as risky. One method of control is poisoning with sodium fluoroacetate (1080) pellets that disrupt mammalian cellular respiration pathways. The pellets are dyed green to deter birds from eating them and are also flavoured with cinnamon which attracts possums.

Research carried out by Charles Eason, Aroha Miller, Shaun Ogilvie, and Alastair Fairweather in 2010 identified New Zealand as the world's largest user of 1080 pellets. It has been used since the mid-1950s and Wren Green (2004) states that it is the only poison registered for aerial application. TBfree New Zealand and DOC are the main organisations distributing 1080 (Green). TBfree is the New Zealand agency responsible for managing bTB eradication by controlling the possum reservoirs of the disease (Operational Solutions for Primary Industries[OSPRI] n.d.). Green describes how DOC manages conservation land to improve the health of natural ecosystems and in easily reached forested areas the methods of control include trapping, shooting and the use of repellents to deter possum

browsing. He asserts that these methods are inadequate to control pests in remote and inaccessible forested locations. Instead, in these areas 1080 is dispersed by helicopters fitted with global positioning systems to facilitate this dispersal and reduce secondary poisoning of native wildlife. While regular reviewing of bird populations following aerial 1080 drops has been implemented, Green accepts that some bird species have died; for example the predatory native Ruru (*Ninox novaeseelandiae*).

Concerns about 1080 entering waterways have been raised (NIWA 2011) even though 1080 is not deposited within 20 m of major waterways (Green 2004). Indeed, regular testing by the Environmental Protection Authority (EPA 2019) in New Zealand has never detected 1080 in New Zealand drinking water supplies. Additionally, the public are notified by DOC and OSPRI before any aerial distribution of 1080.

However, many Māori (indigenous people of New Zealand) have expressed concerns about the risks of aerial distribution of 1080 in forests. They hold a holistic view of the natural world and a belief of them being part of ecosystems. This holistic view integrates understandings about *kaitiakitanga* (environmental guardianship), *whakapapa* (ancestral lineage) and *tikanga* (customary practice). The 1840 Treaty of Waitangi protects New Zealand's bicultural heritage, and as Garth Harmsworth and Shaun Awatere (2013) argue, Māori concerns about these risks must be considered by the government and their agencies.

Many individual New Zealanders (like nature ramblers and photographers) believe that the use of 1080 is justified (Russell 2014). Often, this belief is held because they consider the risks to the country's unique biodiversity by introduced pests is overwhelming and the adverse effects of 1080 on native species are minimal (Green 2004). Additionally, the environmental organisations World Wildlife Fund (n.d.) and the Royal Forest and Bird Protection Society of New Zealand (2018) support 1080's use. Alongside this approval, there is the cautionary view that this poison needs careful management so that mammals, both commercial and domestic, are not affected.

However, Wren Green and Maheswaran Rohan (2012) state that despite over 60 years of research and practical experience, the use of 1080 in New Zealand is still embroiled in controversy. Russell (2014) carried out a national survey (800 participants) of attitudes towards introduced wildlife comparing data collected in 1994 and again in 2012. His analysis reveals that participants' support for the use of 1080 as a control method had dropped by 9% between the two surveys. Russell argues that recent 1080 debate in New Zealand has largely focussed on two issues. The first issue is the perceived risk associated with the aerial application of 1080. Additionally, some citizens believe that this application method contaminates the environment and adversely affects national waterways. Moreover, these citizens argue that the pilots delivering the 1080 could mis-calculate and consider that fences holding farm animals could be breached allowing these animals access to the poison.

The second issue described by Russell is that a number of citizens are concerned about the perceived cruelty of a 1080-induced death. Save Animals From Exploitation (SAFE) is an example of a group within New Zealand who are opposed to the use of 1080, advocating for the safety of all animals. SAFE support the view that all animals that die from 1080 poisoning have an "extremely cruel and protracted" death (n.d.), believing 1080 should be banned from use. Another group opposing 1080 are the Deerstalkers' Association (New Zealand Deerstalkers' Association n.d.) who consider hunting mammals, such as wild deer and pigs, important as a food source as well as a way of life. The New Zealand Wildlands Biodiversity Management Society (n.d.) acknowledge that these animals are susceptible to the risk of accidental or secondary 1080 poisoning while grazing. Another adverse viewpoint is described by Jo Pollard (2011) who argues that many dog owners are opposed to

1080 use. Pollard states that 1.75 mg of 1080 is a lethal dose for a 25 kg dog. Ingestion leads to convulsions and death often occurs within 6–48 h (Eason, Miller, Ogilvie and Fairweather 2010). Currently, there is no known antidote (Green 2004).

These accounts illustrate the range of opinions about 1080 use in New Zealand and many of its citizens actively participate in discussions and the risks involved with its use. These issues are multifaceted, complicated, controversial and illustrate the effects of decisions made and reflect the intricacies of post-normal science.

Method

Purpose and research question

The purpose of this study was to investigate the complexity of students' views about the use of 1080 to control predator mammals using a risk analysis framework populated with qualitative data. An interpretive-qualitative mode of inquiry framed the study (Sharan Merriam 1998).

The research question that guided this study was:

> How can a risk analysis framework based on the work of Mary Douglas categorise students' perceptions of the risks involved with using 1080 poison?

Selection and sampling of students

Forty secondary students (16–17-year-olds) were chosen from two similar-sized, state-run, multicultural and co-educational schools—one rural and one urban. These different locations were purposively selected to represent the views of different communities in New Zealand. Additionally, the sample of students was purposively selected because they were all enrolled in a Year 12 biology course and because the research question was about a conservation issue that is related to the curriculum being studied. Additionally, these students were all entered in a National Certificate of Educational Achievement (NCEA) biology level 2 course and were engaged in an assessment that aligned directly with the research question (New Zealand Qualifications Authority 2017). This meant that the collection of data could be included as part of this assessment, therefore minimizing the intrusion into the students' learning time. It should be noted that this is one of two instances where socio-scientific issues are specifically mentioned for assessment. This assessment can be linked to references in the Participating and Contributing sub-strand in the Nature of Science strand in *The New Zealand Curriculum* at Levels 5–8 (Ministry of Education 2007).

Data gathering tools

The data gathering tools involved a questionnaire and individual semi-structured interviews. At the beginning of the teaching, the students were given access to two resources. The first resource contained material supporting the use of 1080 (Battle for our Birds 2016), a resource produced by a government department based on scientific evidence. The second resource, which opposed the use of 1080, was a video produced by two brothers Clyde and Steve Graf, known as The Graf Boys, based on their personal beliefs (Graf and Graf 2013).

Data were generated from a questionnaire booklet containing five images relating to the risks of 1080 use. The five images in the questionnaire were: a bucket suspended below a helicopter flying over a forest; a possum sitting in a tree; a stoat in a forest; a dead deer lying on a forest floor and a sign displaying information about 1080 pellet release in a specific area. Students were asked to look at the photographs and then, respond to these open-ended questions for each of the images:

- What do you first think of?
- Why did you think that? (Justify your answer)

The questionnaire construction provided a simple and consistent format between the five images. It was decided to keep the format uncomplicated, meaning the language would be familiar, appropriate, and unambiguous to Year 12 students. Moreover, the use of words of a general nature within the questions was deliberate in an effort to ensure the students were not directed when giving their responses, while providing a format capable of measuring their opinions, attitudes, and perceptions about the risk issue.

Additionally, 29 students from within the two schools were individually interviewed for 20 min, using a semi-structured format. The intent of this format was to give freedom to the students to express their ideas. Another objective of this format was to give the interviewer the flexibility to further probe these students' views that might emerge during the interview and so gain a deeper understanding of their reasoning. The interviewer's questions focused on why a particular response had been given, or what had made the student think that way. These 29 students were purposively selected by their individual teachers, over two days based on them being present and the teacher's agreement to release them from their timetabled class, again with the goal of minimizing the intrusion into the students' learning time.

Data analysis

The risk perceptions analysis framework showed in Fig. 1 was used to analyse the empirical, qualitative data generated by these students' responses. Thematic analysis was employed to identify characteristics of the four Cultural Types (Merriam 1998). A summary of the characteristics and individual attributes for each of the Cultural Types is shown in Table 1.

These data were used to populate and then, test the newly developed risk perceptions analysis framework's efficacy. Initially, the students' responses were read, re-read, and similar responses grouped together. Then, mutually exclusive themes or categories were constructed using the characteristics and rationalities of the four Cultural Types identified within the framework by continuously comparing similar student responses to identify what Merriam describes as "recurring regularities" (p.180). Each of the specific attributes of the four Cultural Types had unique identifying words and phrases. These were then used to classify responses as belonging to one of the four groups within the risk analysis framework. During this step, an indicative word list consisting of commonly used words was developed for each of the five images. Using an iterative process, all the student responses were included. Examples of these responses are displayed in Figs. 2, 3, 4, 5 and 6 in this paper.

While the first author led this thematic analysis, peer scrutiny and regular de-briefing strategies with the co-authors were employed to ensure credibility (Andrew Shenton, 2004). The two co-authors also coded samples of students' responses to authenticate the

Table 1 A summary of the common characteristics and individual attributes for the four Cultural Types

Common Characteristics	Individual Attributes of the Four Cultural Types			
	Nature Tolerant	Nature Capricious	Nature Ephemeral	Nature Benign
View of nature	Robust but vulnerable	Random system	Precarious and fragile	Robust and stable
View of Earth's resources	Scarce but controllable	Uncontrollable chaos	Depleting	Abundant and controllable
People's needs	Uncontrollable	Uncontrollable	Controllable	Controllable
Risk perception	Controllability and responsibility	Just cope	Equality of outcomes for all	Exploitability
Risk management strategy	Use planning and regulation	Attribute luck	Risk averse	Use trial and error

category construction and the indicative word lists. Where disagreement was encountered, each example was discussed, and agreement reached. During the de-briefing sessions, clarification of ideas and themes were also discussed.

Results

The following analyses demonstrate the capacity and versatility of the risk perceptions analysis framework (Fig. 1). By following an iterative analysis process, based on the ideas of Merriam (1998), indicative words and phrases within all the students' responses were identified. The indicative words and phrases are identified and discussed in the following sections.

Capacity of the risk perceptions analysis framework

To illustrate the capacity of the risk perceptions analysis framework, Fig. 2 demonstrates that the framework can be used to provide an individual analysis of a student's perceptions of a risk issue. This example provides a detailed analysis of one of the five images within the questionnaire. Within the figure, the left-hand side displays the five common characteristics from the risk analysis framework (Fig. 1) and the centre column displays the specific attributes of the Cultural Type *Nature Ephemeral*. The right-hand column displays this student's questionnaire and interview responses.

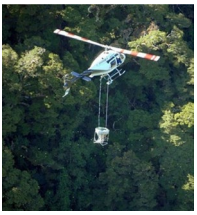
Figure 2 presents the analysis of Student R11's response, which is characteristic of those students holding the *Nature Ephemeral* Cultural Type who display an egalitarian rationality of communality and are risk averse. Using the polythetic approach (Douglas, 1997), this student described their risk ideas about 1080 using three attributes within this Cultural Type. The indicative words and phrases used are displayed in different colours representing each of the attributes and are italicised in the following analysis. When identifying their *View of nature,* Student R11 displayed an emotional response to the 1080 poster image in their description of this chemical's effects on the environment by using the word "*dangerous*". Using this word implies their belief that nature is a precarious and fragile system that

Common Characteristics	Specific Attributes for Cultural Type:Nature Ephemeral	Student R11's response
View of nature	**Precious and fragile system**	Questionnaire image:  ***Dangerous. Animal cruelty. Death. Pain. Poison. Animal cruelty. Death to innocent animals. Long cruel drawn out deaths. This is a deadly poison that shouldn't be put down. Pests should be culled not forced into horrible death. More than just the pests are being killed. Dangerous.*** ***The dogs, that's why I thought it was cruel. Because, you know, if dogs are to wander and eat bait or eat carcasses that is it for them. (Interview)***
View of Earth's resources	Depleting and uncontrollable	
People's needs	Controllable	
Perception of environmental risk	**Equality of outcomes for present and future generations**	
Risk management strategy adopted	**Risk averse. Use trial without error (Egalitarian)**	

Fig. 2 Analysis of individual attributes within the Nature Ephemeral Cultural Type, exemplified by Student R11's response. Indicative words and phrases used to describe the poster are identified by colour-coding: View of Nature, brown; Perception of environmental risk, blue; Risk management strategy, green

Common Characteristic	Nature Tolerant specific attributes and U09's Response	Nature Benign specific attributes and R08's Response	Nature Ephemeral specific attributes and U14's Response	Nature Capricious specific attributes and U18's Response
Perception of environmental risk: for questionnaire image of a brushtail possum. 	**Controllability and responsibility** ***They are harm [sic]to our natives. Because they are pests. Reason for using 1080.*** ***Yeah. (Interview)***	**Exploitability and equal opportunity** ***Going possum shooting at my sisters [sic]place. My sisters[sic]husband is a shepherd on a farm and when we go there we can shoot possums. And he collects the possum fur to sell afterwards.*** *(Student not interviewed)*	**Equality of outcomes for present and future generations** ***Is it around 1080? Because he looks like he may be in a forest.*** ***Yeah, it doesn't deserve it. (Interview)***	**Inefficacious cope-ability** ***I don't know. Ugly.*** *(Student not interviewed)*

Fig. 3 Four students' responses displaying their differing rationalities to justify their Perceptions of environmental risk when viewing the image of a possum. Indicative words are colour-coded blue



Cultural Type	Specific attributes for the Common Characteristic: *Risk management strategy*	Student responses, using their specific rationalities to demonstrate their common consciousness
Nature Tolerant	Risk accepters: Use planning and regulation.	*Student U08: Even though it is dropping poison, it is the best option. Other options are less effective.* *Student R16: Helicopter dropping pellets of 1080, because it is used in hard to reach zones.*
Nature Benign	Risk seekers: Use trial and error.	*Student U07: 1080 being thrown into forests.* *Student U06: I can say the helicopter is dropping 1080.*
Nature Ephemeral	Risk averse: Use trial without error.	*Student R02: A helicopter carrying something unnatural. Creates controversy. Many controversy[sic], over whether they should do it or not.* *Student U17: 1080 poison. Pesticide.*
Nature Capricious	Risk absorbers Attribute luck.	*Student U18: Spraying some kinda [sic] spray.* *Student U22:* Response left blank.

Fig. 4 Figure illustrating a common consciousness using specific rationalities for the common characteristic Risk management strategy between the four Cultural Types when analysing students' responses to the image of a helicopter flying over a forest. Pertinent Nature Tolerant responses are coloured pale green; Nature Benign brown; Nature Ephemeral red and Nature Capricious are mauve

Questionnaire Images	R12 responses displaying the common characteristics and specific *Nature Tolerant* attributes			
	View of Nature: *Robust but vulnerable.*	**View of Earth's resources:** *Scarce but controllable.*	**Perception of environmental risk:** *Controllability and responsibility.*	**Risk management strategy:** *Risk accepter. Use planning and regulation.*
	*A helicopter ariel [sic] spreading 1080 so it can cover more land and is cost effective. Because it's easy to get the 1080 to all locations quicker and more effective* *After doing research about 1080 then I saw it was in bushland, so yeah. (Interview)*			
	*Possum. Scary. Because possums aren't friendly and are scary. They are pests-damage nature. A pest being targeted by 1080. Because possums carry TB which can be passed onto the biggest industry-dairy farming.* *Well, if there's heaps of possums around like dairy farming is one of the biggest things in New Zealand, so obviously that's going to be put at risk. Because they can't do anything to hurt you, but they could hurt like the industry of New Zealand. (Interview)*			
	*A deer that has been accidently poisoned by 1080. Because the 1080 can't of had deer repellent meaning at that stage many unnecessary animals were dying until it was changed.* *Yeah, it is more informed about it. (Interview)*			
	*A stoat trying to prey on native bird nests. Because the stoats are preying on the native species, so 1080 is targeted at them.* *Once I looked at my research about what they do. (Interview)*			
	*Danger. Be careful. Because the sign says warning of poison. Warning about the deadly 1080 that has been dropped and its effects. Because the sign is showing the effects on humans and native species.* *Informative. (Interview)*			

Fig. 5 Analysis of R12's responses to demonstrate a stability of views. View of nature responses are displayed in brown, view of Earth's resources in red, perception of environmental risk in blue and risk management strategies in green

has the potential to become unbalanced by any change because "*more than just the pests are being killed"* in the ecosystem, which may not recover. Additionally, R11's repeated use of the word "*dangerous*" at the beginning and the end of their response, emphasises these ideas and indicates their aversion to 1080.

The second attribute Student R11 described could also be identified as emotional, when they expressed their view of equal rights and unfair death, or equality of outcomes related to their *Perception of environmental risk* of using 1080. Although Student R11

U12's responses displaying their Cultural Types		
Three *Nature Benign* attributes to: *View of nature: Robust and stable.* *Perception of environmental risk: Exploitability.* *View of Earth's resources: Abundant and controllable.*	One *Nature Tolerant* attribute to: *Perception of environmental risk: Controllability and responsibility.*	Three *Nature Ephemeral* attributes to: *View of nature: Precarious and fragile.* *Perception of environmental risk: Equality of outcomes for present and future generations.* *Risk management strategy: Risk averse.*
Response to questionnaire image of helicopter: *They're bombing the forest. Bombs are projectiles that kill when deployed. Same with this toxin.* *I put in toxins, like I described it as bombs. That concept came to me as I said here, bombs are projectiles that kill when deployed. Toxins work the same and is deployed in the same way, well relatively same way. So that is why I said bombing. (Interview)* **Response to questionnaire image of possum:** *It might be a rodent. Looks like one.* *So, a pest here and they are not doing anything positive, well they might as well be exterminated. (Interview)* **Response to questionnaire image of stoat:** *They must be exterminated. They're rodents and I don't see any downsides to exterminating them.* *Yes. They must be exterminated since as I said we had a class about rodents and what they do here, and I felt they must be exterminated since we learned that these things are not native, so it doesn't matter if they die out here in New Zealand. So, yeah. Because they can be killed or like shipped off to another country because they are not ours. (Interview)*	**Response to questionnaire image of 1080 poster:** *IDK.* *I was tired, so I couldn't exactly think of a more proper response. It is necessary. It doesn't matter if it frightens people, they are better off frightened rather than dead or in the hospital. (Interview)*	**Response to questionnaire image of dead deer**: *The neck. It looks like something broke it back. It must have died painful. 1080 is a slow killer, so it probably felt himself die.* *The second one just showed how wrong it was when I took a better, longer look at it. Like un-natural I mean. Yes, because like most people, when people die I mean real painfully, they tend to die with their eyes open if they don't have enough time to like close it. So, I said painful. (Interview)*

Fig. 6 Analysis of U12's responses exemplifying their Cultural Types for the five questionnaire images. Responses are displayed in brown, their view of Earth's resources is red, their perception of environmental risk is blue and their risk management strategies are green

acknowledged that New Zealand has a pest problem and wrote "*pests should be culled*" in their questionnaire response, they did not agree with the use of 1080 to solve this pest problem. Rather, they seemed to believe that instead of using 1080 where the risk is high and that animals would have "*pain"*-filled death, these pest species should be carefully removed from the forest, but not killed. It is possible that Student R11 may have witnessed culling and this experience has been used to illustrate a way of removing pest species without harming them, so they would not in their view be "*forced*" into "*drawn out deaths*." Student R11's use of word "*innocent"* when describing their ideas about the types of deaths could demonstrate a belief that animals should be treated compassionately, deserving to live their lives unharmed, ensuring equality of outcomes for all.

Student R11's view of *Risk management* illustrated the third attribute. This student seemed to demonstrate their aversion to risk by repeating the terms "*cruelty*" and "*cruel*" four times within the questionnaire response and during the interview. Their repetitive use of this emotional term suggested Student R11's belief that 1080 is a merciless method of pest control. Their risk aversion to 1080 was also conveyed by their belief that the *"deadly poison*" … *"shouldn't be put down",* demonstrating their view that 1080 should not be used as a method of pest control at all, that it caused *"pain"* and so indicating a strong egalitarian rationality. During their interview, Student R11 continued to express their concern and risk aversion to using 1080. They commented that any dogs near the 1080 distribution area may be harmed or killed, saying if dogs either ate bait directly or any carcasses poisoned by 1080 (secondary poisoning), "*that is it for them."*

The versatility of the framework

As well as providing an analysis of individual students' responses, the risk perceptions analysis framework can also be used to demonstrate the range of views expressed when students respond to the same image but display different Cultural Types. For simplicity, one common characteristic, *Perceptions of environmental risk,* is used to illustrate the

individual attributes of four students when responding differently to the image of the possum and are displayed in Fig. 3. As with the first example, indicative words are coloured in each response.

In the first example, Student U09's response reflects a *Nature Tolerant* hierarchist rationality with a belief in responsibility and order when they wrote "*They are harm [sic] to our natives.*" Student U09 could also be displaying some measure of acceptance of the risks involved, supporting their view of the need for a controlled environment when they described how possums are "*pests"* and are the "[*r]eason for using 1080."* Student U09's views potentially were reiterated when they were interviewed and after re-reading their questionnaire response, chose not to change or elaborate on it, just saying "*Yeah"*. In addition, this student's use of words such as "*our*" and "*native*" denote ownership of the pest problem in New Zealand, possibly showing their sense of belonging to a group. The use of these words is characteristic of a *Nature Tolerant* Cultural Type and reinforces Douglas's (1997) ideas about people holding this risk perception exhibiting strong group affiliations.

The second example, Student R08's response, signals a *Nature Benign* rationality when explaining their *Perception of environmental risk*. Responses within this Cultural Type commonly included factual accounts and demonstrated a low sense of risk around the use of 1080. They often included personal experiences and procedural accounts in their responses, and as shown in this example, used words like *"me*" or "*my.*" For example, Student R08 described an encounter of "*Going possum shooting at my sisters [sic] place"*. Their description reflects an individualistic and market-driven rationality, because they imply that possums are an exploitable resource and that it is acceptable to "*shoot possums.*" Also, Student R08 described how they experienced their *"sisters[sic]husband"* collecting "*the possum fur to sell afterwards",* which indicates a further expression of a market-driven *Nature Benign* rationale. Student R08's *Perception of environmental risk* supports the view of equal opportunity for all users of the forest and a *Nature Benign* view of living with risk, with a belief that these activities were acceptable. Additionally, they justified using the possum fur for profit, possibly because they were aware of the income to be made through such sales where the possum fibre is often mixed with merino wool to make clothing (Hutching 2015). In New Zealand, possum hunting by shooting or trapping is a common rural recreational activity in which anyone can participate. Hunting and shooting pests for profit were common themes displayed within this Cultural Type**.** Consequently, this group believes that the risks involved with having a possum population were compensated by viewing it as a resource they could harvest.

Students displaying the *Nature Ephemeral* Cultural Type rationalise an equality of outcomes for all living things. In this example, Student U14's view about the use of 1080 to control pest species indicates that they have a *Nature Ephemeral* view towards *Environmental risk* and are risk averse. During the interview, U14's *Nature Ephemeral* views became even clearer when they expressed their belief that animals deserve to live without the danger of 1080 poison and should not be killed by people's deliberate actions describing their ideas about the possum image as, *"Yeah, it doesn't deserve it."* This response could demonstrate that U14's views of the environmental risk that possums cause must be tolerated in society despite their pest status. Additionally, their questionnaire response possibly showed that they felt concern for the animal's wellbeing by writing, "*Is it around 1080?"*, indicating their awareness of the danger of 1080 for possums. Moreover, they potentially expressed an anthropomorphic view by sometimes naming the possum "*he.*" Furthermore, rather than describing the possum as a pest, Student U14 chose just to focus on describing the possum as a living organism in its habitat saying, "*he looks like he may be in a forest",* which could be seen as supporting an egalitarian rationality.

Finally, Student U18's response is reflective of a student displaying a *Nature Capricious* Cultural Type with a perception of having to cope with and absorb risky situations that are always present. This student wrote, *"I don't know. Ugly."* This limited response was typical of many of the *Nature Capricious* responses within this study. Douglas opined that people in society holding *Nature Capricious* views were the ones who responded by saying little, were unsure, or did not respond at all. The authors agree with Douglas's views when she argued that the response "Don't know, is very instructive" (Douglas 2003b, p. 1357) as she believed that it reveals the strength of the preference of a fatalistic outlook where there is little hope of human control over the environment and situations are just left to fate.

Common consciousness within each rationality revealed

This risk framework can also reveal the differences between Cultural Types when focusing on one common characteristic. Figure 4 displays the analysis of students' responses to an image of the risks involved of a helicopter spreading 1080. This helicopter image is displayed on the left, outside the figure. The four Cultural Types are displayed, each with their specific attributes for the common characteristic of *Risk management*. The students' responses are located on the right, and indicative words are colour-coded differently for each Cultural Type.

Figure 4 shows how students within each of the four Cultural Types demonstrate their common consciousness by using a similar language to reveal their perceptions of risk when discussing their risk management views. Two analysed examples are provided for each Cultural Type to illustrate this phenomenon. Supporters of the *Nature Tolerant* Cultural Type indicated a hierarchist rationality by justifying their risk management strategy of being risk accepting, with an understanding of the risks involved in the use of 1080. This rationality is suggested in Student U08's response when they described the application of 1080 by helicopter being the *"best option"* while recognizing that there is some risk in its use, by saying "*even though it is dropping poison.*" Similarly, Student R16 described the image of the aerial application as "*used in hard to reach zones.*" Despite not mentioning the suitability of the method of application in their response, Student R16's rationality is potentially based on their acknowledgment that risks can be controlled if rules are followed, reflecting their Myth of Nature belief in an ecosystem that could be managed. Both their responses also suggest a belief in the usefulness of the control method in protecting New Zealand's biodiversity and support of a *Nature Tolerant* rationality.

The examples of the *Nature Benign* Cultural Type, signalling a rationality of being aware, but unconcerned about living with risk is reflected in Student U07's seemingly dispassionate explanation that 1080 is simply "*dropped"* or "*thrown"* into a forest with no additional discussion about the benefits or harm to the forest, or the wider ecosystem. This potentially reflects their Myth of Nature rationality of low risk to the ecosystem, as both students' responses describe the image of the helicopter and the spreading of 1080 either procedurally, or in terms of how it impacts on them individually. Thus, their responses appear to demonstrate an individualistic rationality and a minimal sense of belonging to a group.

In the examples displaying a *Nature Ephemeral* Cultural Type, both students exhibited an egalitarian rationality with a risk management strategy of being risk averse, aligned with a Myth of Nature belief in the constantly perilous position of the ecosystem. Firstly, Student R02's response concentrates on the *"controversy*" they believed that 1080 causes because people disagree with its use, and that 1080 is an "*unnatural"* material, whereas Student U17's response focuses on the negative aspects of 1080, describing it as *"poison"* and "*pesticide*".

Both their justifications appear to be based on an abhorrence of causing harm to living things or generally contaminating the environment.

The *Nature Capricious* Cultural Type risk management strategy is being a risk absorber. Supporters display a fatalistic rationality and a belief in inevitability which is reflected in their Myth of Nature view of an ecosystem where change could happen uncontrollably at any time. Followers describe a positive outcome to risk situations as just being lucky. The two examples within the figure indicate this rationality as the first student (U18) describes the image passively and minimally, as an example of spraying using a helicopter and the second student (U22) did not respond at all. While both responses are limited and therefore difficult to analyse, they do support Douglas (2003a) ideas who designated people with this Cultural Type as believing that there was little they could do about anything in their lives and opined that these supporters may not respond at all, use minimal words in their response, or state they did not know.

These examples display how the framework has the capacity to identify a common consciousness to the same image, specific to their individual Cultural Type and corresponding rationality. Furthermore, the risk perceptions analysis framework can also demonstrate that a Cultural Type rationality can remain constant as shown in the following section.

Same response—differing images

Analysis using this new framework was able to provide data to substantiate the "*stability hypothesis*" proposed by Douglas who argued that when an individual exhibited a cultural bias, they remained within that Cultural Type (Steve Rayner 1992, p. 107, italics in original). This hypothesis is illustrated in Fig. 5 and shows that R12's responses to all five images demonstrated consistent attributes of the Cultural Type *Nature Tolerant.* This figure is set out in the same manner as previous ones.

Analysis of this student's responses demonstrated a hierarchist rationality of striving to achieve order and structure and four different attributes were found within their responses. R12 described the process of aerial spreading of 1080 in forested areas within the helicopter image as an acceptable, "*cost effective*" method and an efficient technique as it could "*cover more land,"* as the helicopter could travel *"to all locations quicker."* This implies a *Nature Tolerant* perception about *Environmental risk* as being one of controllability and responsibility in their belief that the use of 1080 being the best way of poisoning pest animals in this situation. Their view seems to have been reiterated during the interview when they described how once they realised that the helicopter was spreading 1080 over "*bushland*," their idea about the effectiveness of this method did not change but was strengthened. This view may be the result of R12 living rurally, thus having previous knowledge about the method of spreading 1080 throughout inaccessible areas by DOC in New Zealand (Royal Forest and Bird Protection Society of New Zealand 2017).

The possum image inspired three different *Nature Tolerant* response attributes. Firstly, R12 described possums as animals that "*damage nature*" possibly illustrating a rationality of striving to regain the natural order within the New Zealand forest ecosystem by viewing nature as being vulnerable to the damage that possums cause. Secondly, R12's description of Earth's *resources* as scarce but controllable was implied in their description of possums as a "*pest"* being *"targeted by 1080"* to protect "*nature*" from being damaged. The third *Nature Tolerant* attribute seemed to be evident when R12 described their *Perception of environmental risk,* because they explained that while possums were not a threat to people, they did pose a threat to the dairy industry by carrying bTB. Student R12 viewed this risk

as "*scary.*" During their interview, the student provided additional information about the importance of the New Zealand dairy industry.

Student R12's response to the deer image also indicated a *Nature Tolerant* rationality with a risk-accepting *Management strategy,* believing that the deer died from secondary poisoning by writing it had been "*accidently poisoned by 1080*." They also commented on the introduction of deer repellents to some baits to reduce such accidental poisonings and explained that "*many unnecessary animals were dying until it was changed*". These views remained resolute during the interview, despite being more informed about the issue of secondary poisoning.

Two *Nature Tolerant* attributes were implied in R12's response to the stoat image. Firstly, they described how they believed that stoats *"prey on native bird nests,"* which could be seen as demonstrating a hierarchical rationality of responsibility about *Environmental risk*. Secondly, R12 agreed that 1080 should be *"targeted at them,"* potentially signaling their *View of Earth's resources*, that stoats need controlling. This response seems to acknowledge the importance of achieving order within the forest ecosystem by removing these pest species, which was reinforced during their interview.

The final image to which R12 responded was the 1080 poster image. By using the words "*warning*" and "*danger*", they appear to display an *Environmental risk perception* demonstrating a belief in the controllability of people's actions regarding the distribution and use of 1080 poison. The concept of responsibility was implied when they wrote that humans need to "*be careful"* and heed warnings. Their interview response reiterated these *Nature Tolerant* attributes and a hierarchist rationality of responsibility because they described the poster as "*informative*".

However, not all students displayed such stability of views and opinions which will be discussed in the next section.

Are risk perceptions context dependent?

Rayner (1992) believed that when an individual discussed risk within a specific context, a particular cultural bias was displayed. He argued that specific contexts created the cultural bias within each individual and that their views could change between each context, exhibiting a fluidity of Cultural Types. Rayner named this idea the "*mobility hypothesis*" (p.107 italics in original). For example, as shown in Fig. 6, Student U12 appears to display *Nature Benign* attributes when responding to three of the images (helicopter, possum and stoat). However, they seem to show *Nature Tolerant* views when responding to the image of the 1080 poster and *Nature Ephemeral* views when responding to the image of the dead deer.

When responding to the image of the helicopter, U12's responses signalled a *Nature Benign* Cultural Type, an individualistic rationality, and a robust and stable *View of nature* when they said, "*They're bombing the forest."* During the interview, U12 expanded on their view and said, "*I put toxins, like I described it as bombs"* when describing how 1080 is distributed over forest areas. This seems to reflect a *Nature Benign* view that nature is a robust and stable system that can withstand "*bombing*." During their interview, U12 mentioned that they played video games and that the image of the 1080 poster reminded them of a menu screen. It is possible that this helicopter image reminded them of projectiles in a video game because they did not mention whether distributing 1080 using this method was right or wrong, just the method used, a procedural description.

The possum image provoked a *Nature Benig*n Cultural Type response with two attributes identified. Student U12 wrote "*It might be a rodent, looks like one*." Although no

identifying words were found within this response, their ideas were clarified during their interview when they explained "*So a pest here"* potentially displaying a *Perception of environmental risk* that supported exploitability and eradication of possums because they simply described the possum as a pest. Adding support to this idea during their interview, U12 exclaimed that possums were *"not doing anything positive."* U12 then added that possums *"might as well be exterminated.*" Here, U12 may be displaying a second *Nature Benign* view towards this animal, suggesting that it had little value to them. This implies that U12 believed that *Earth's resources*, of which the possum is one, were controllable.

The stoat image inspired a response that was a *Nature Benign View of Earth's resources*. While U12 wrongly identified the stoat as a rodent rather than a mustelid, they believed that stoats were an issue. They also believed that killing them by any means or removing them by being "*shipped off to another country"* to control their numbers was acceptable. This point was reiterated when they said "*I don't see any downsides*" to their removal since they viewed stoats as a problem pest species that was introduced to New Zealand. This explanation signals individualistic characteristics with a weak group and weak grid culture, by frequent use of the words *"I," "them"* and "*they*." Additionally, the information U12 provided was relayed factually, not emotionally, reflecting strong support for the elimination of stoats in New Zealand in both their written response and the interview. In both responses, U12 used the words "*exterminated," "exterminating"* and "*can be killed*" to describe ways of removing these abundant but controllable pest species. Interestingly, this description was similar to how they had described the possum image. Their strong response to exterminate these pests may have resulted from the fact that stoats are common pests in New Zealand.

When they responded to the poster image of the 1080 information, U12 seemed to display *Nature Tolerant* views. Although writing "*IDK*" (I don't know) as their response to the questionnaire, during their interview, they explained this by saying, "*I was tired, so I couldn't exactly think of a more proper response. It is necessary."* Within their interview, the word "*necessary*" was identified as exhibiting a *Nature Tolerant Perception of environmental risk*. This response appears to demonstrate a feeling of responsibility about use of 1080 and that citizens needed to be informed, regardless of whether they were "*frightened*" by the information or not. Therefore, it can be said that U12 exhibited a *Nature Tolerant* Cultural Type which involves using regulations to achieve order and control about the environmental risk of using 1080.

Three *Nature Ephemeral* attributes were displayed by U12 when responding to the dead deer image. Firstly, they gave an emotional *View of nature* response. When they focussed on the angle of the neck and explained how they believed that someone or "*something"* had caused this unusual angle, U12 implied their *View of nature* as a precarious and fragile system, which is easily unbalanced. They described how they believed the deer's life had ended because its neck had been deliberately broken, resulting in the "*un-natural*" angle of the deer's neck. Also, U12 indicated a Nature Ephemeral view of *Perception of environmental risk* about the dead deer when they wrote the words "*painful*" or "*painfully*" repeatedly. This repetition appears to emphasise the idea that all living things should have the right to dignity in life and in death and that death should be pain-free. Moreover, they wrote that they believed that the deer *"probably felt himself die."*, possibly displaying a *Perception of environmental risk* that supports an equality of outcomes by anthropomorphising the deer as male ("*himself"*) and that it could feel the pain of his death. Another *Nature Ephemeral* attribute was their *Risk management strategy.* Student U12 seemed to display their aversion to the risk of using 1080 in forests by writing *"1080 is a slow killer."* During the interview, U12 compared the deer's death to that of a person by again

anthropomorphising the deer's death. Furthermore, they described the use of 1080 to kill as "*wrong*." This description of how 1080 kills slowly could be seen as revealing their distaste about the risk of using this poison and demonstrates a *Nature Ephemeral* view, supporting a *risk management* strategy of being risk averse.

Because some students' Cultural Types remained stable, while others, like U12's variety of responses, were more fluid, we assert that both the stability and the mobility hypotheses were demonstrated by these students and support both Douglas's and Rayner's hypotheses. Within the data set, eleven students' risk perceptions were analysed as being only one Cultural Type, while 29 students displayed a combination of two or three Cultural Types. This finding demonstrates that some students' perceptions of risk can vary both within one context/image as well as between contexts/images. (see Garthwaite, 2019).

Analysis of the data set identified that all four Cultural Types were present. Table 1 shows that 28 students expressed *Nature Tolerant,* hierarchist rationalities and 23 provided *Nature Benign* responses that displayed individualistic rationalities (Table 2).

A smaller number of students gave responses that demonstrated a *Nature Ephemeral* egalitarian rationality (16 responses). Only four students responses could be categorised as a *Nature Capricious* rationality; however, the authors recognize that their limited responses potentially made their analysis difficult. Moreover, there was little difference in the variety or types of responses between the urban and rural students, apart from the *Nature Capricious* Cultural Type. This may have resulted from the urban students having limited personal experience about 1080.

These examples have demonstrated the versatility and capacity of the risk perceptions analysis framework (Fig. 1) in that it is able to analyse responses individually, by image, by rationality and by stability or mobility of view. Furthermore, it is argued that this framework could be used to assist students to unravel both their own as well as other people's views of risk.

Discussion, educational implications, and limitations of the framework

This study investigated the versatility and capacity of a newly developed analysis framework to analyse students' perceptions of the risks involved with the use of 1080 to control possums in New Zealand. The authors assert that this framework is able to explain "why people perceive the world the way they do" (Thompson, Ellis and Wildavsky 1990, p. 2).

Critics of Cultural Theory, such as Boholm, (1996) and van der Linden (2016), argue that there have only been meagre empirical results produced by proponents of Cultural Theory. The empirical data from this study add to the number of empirical studies underpinned by Douglas's work. A second criticism by Boholm (1996) is that there exists confusion and a lack of clarity between the four Cultural Types within the original Cultural Theory typology. However, this lack of clarity was acknowledged by Thompson, Ellis and Wildavsky (1990) during the early phases of the theory's development, when they stated that the typology was a "deliberately rough-and-ready frame…sketching a broad picture" (p. 272). Despite this criticism of Cultural Theory, the authors assert that the newly developed analysis framework used in this study did enable the identification of all four Cultural Types within the students' responses. Each of the Types were able to be readily identified through the use of indicative words and phrases. Furthermore, unlike some previous studies (Steg and Sievers 2000) each of these Cultural Types was afforded equivalent status within this risk perceptions analysis framework, which is consistent with Douglas's Grid-Group

Table 2 Total number of student responses to the five images within the Cultural Types

	The four Cultural Types			
	Nature Tolerant (Hierarchical Rationality)	*Nature Benign* (Individualistic Rationality)	*Nature Ephemeral* (Egalitarian Rationality)	*Nature Capricious* (Fatalistic Rationality)
Number of responses to the five images	28	23	16	4

Theory (1978) of the equal importance of each type within a community and of keeping the analysis simple and uncomplicated. Moreover, the findings of this study support Douglas's (2003b) assertion that the two Cultural Types, *Nature Tolerant* (28/71 responses) and *Nature Benign* (23/71 responses), will always be the most represented within any society and that they are both "allies and rivals at the same time" (p. 1358). The other two Cultural Types, she asserts, will always be in the minority and were defined by their dissent from the majority, as was also found in this study (See Table 1).

Five common characteristics that all members of society utilize when discussing environmental risk, but are justified by employing specific attributes, were identified using the framework. Indeed, the framework was able to analyse data about risk perceptions in an in-depth and fine-grained manner. Firstly, an analysis of individual responses was provided to illustrate the capacity of the framework to identify different Cultural Types (see Fig. 2). The framework was then used to reveal that some students perceive risk in different ways when viewing the same image (Fig. 3). This example illustrates that within society, risk is perceived differently, and each person's response depends on their Cultural Type and corresponding rationality, to justify their individual position. This analysis of empirical data provides evidence to support Douglas's (1999) theoretical stance. She asserts that within any society it was as if there was "a struggle is going on, [where] members of one culture are giving each other reasons for contesting everything that is preferred by the others" (p. 411). Furthermore, an individual's views are embedded in their cultural bias and their social groupings within society and "[w]hen faced with estimating probability and credibility, they come already primed with culturally learned assumptions and weightings" (Douglas 2003a, p. 58). In fact, Douglas believes that discussions between members of the four groups result in irreconcilable conflict, or what she refers to as the "dialogue of the deaf" (2007, p. 9), where citizens talk at, not to each other.

The framework also revealed that when people are justifying their beliefs, they display specific rationalities related to their Cultural Type that reveal a 'common consciousness' (Durkheim 1984). This means that supporters within each Cultural Type use similar language to justify their shared beliefs and positions when discussing a risk situation (see Fig. 4).

Finally, analysis using the framework showed that some students had stable views (Fig. 5), while others held a mobility of views, thus supporting both Douglas and Rayner's (1992) hypotheses about risk ideas within society.

Educational implications

The educational implications of these findings are potentially significant, and the authors assert that this study provides three points of value to the field of risk education. Firstly, this new framework has a straightforward design, displaying a complex concept in a simple manner, and its simplicity means that it could be used in classrooms. The framework could be used to provide an uncomplicated pathway for teachers to introduce and discuss the complexity of controversial risk issues using a SSI approach to provide an illustration of the complexity of post-normal science. Moreover, we believe that the introduction of this framework could be carried out in a timely manner, so alleviating teachers' concerns about time constraints reported by Ratcliffe and Grace (2003).

A second point of value is that this framework could create opportunities for students to explore their own ideas about risk and those of their classmates. Students could use the framework to analyse their responses to a risk issue, explore the reasons why they have these views, their personal position about a specific risk issue within a community and therefore recognise their own Cultural Type. According to Mark Newton and Dana Zeidler (2020), being able to consider different viewpoints is a critical skill when working towards a resolution of a socioscientific issue. Not only does the ability to appreciate multiple perspectives enhance students' scientific literacy, it can also develop students' empathy and critical thinking skills. Furthermore, students could use this framework to discuss their views with others in the classroom to assist them to understand different viewpoints about a risk issue and overcome their resistance to considering perspectives that differ from their own (Newton and Zeidler 2020).

Thirdly, previous research has shown that teachers can be reluctant to introduce risk topics because they may not wish to reveal their own opinions (Schenk et al. 2021), or because they believe they lack strategies to work with topics that require argumentation skills (Lindahl et al. 2011). We argue that this analysis framework provides a suitable approach to justify why people have differing opinions. Furthermore, it could allow teachers to comfortably reveal their position within the framework alongside their students, as they are part of the classroom community, so diminishing their potential feelings of anxiety and may encourage them to include risk issues in their teaching programs in the future.

Ravetz (2006) asserts that post-normal science provides an avenue to illustrate that as a society, we are increasingly facing risk issues, for which routine scientific methods and traditional methods of teaching certain scientific knowledge are inadequate. We argue that a way of implementing a SSI approach, using a post-normal science viewpoint could occur by teachers discussing the concept of risk, then demonstrating and describing Douglas's Cultural Theory (1978) ideas, using a copy of the analysis framework to guide this understanding, perhaps giving other relevant risk issues as examples (such as the effects of climate change). This activity could then be followed by teachers providing a background to the issue and risks involved in 1080 as a method of pest control in New Zealand, using the framework to initiate discussion about the range of views found about the issue. Such an introduction could enhance understandings of the complexity of risk views held within society and of the roles that each Cultural Type plays, so enriching the development of further, critical discussions about the issue, possibly leading to increased interest in science.

Additionally, to encourage an understanding of the complexity of views held within a complex risk issue, students could carry out such activities as role-play, debates, or forming on-line groups to enrich their discussions about a relevant risk issue. Alternatively, students could participate in an "extended peer community" (Ravetz 2006, p. 76), where a

variety of people with differing points of view representing the different Cultural Types about a particular risk issue are invited into the classroom to discuss their ideas. Ravetz asserts that such discussions are vital for appreciating other members in the community's views and assist in the understanding of the complexity of views within post-normal science issues where risk is prominent. Stevenson et al. (2014) believe that potentially, if these situations were arranged, the knowledge of people with relevant scientific expertise could be presented along with knowledge from lay people within the community who have a wealth of pertinent, local information. These strategies could provide opportunities for students to expand their understanding of the risk issue, assisting them to develop an in-depth appreciation of the complexity of an issue, perhaps even to modify their views (Hodson 2008), as well as understand that other members of their class may have varying opinions about the risks involved, so developing both their discussion and critical thinking skills.

Limitations of this research

Despite the advantages of using this framework and the empirical data analysis it facilitated, the authors acknowledge that there are several limitations to this research. Firstly, our analysis of the student responses followed Douglas's "polythetic method" (1997, p.15) to identify individual Cultural Types. Use of this method meant that while most of the student responses provided multiple attributes for each of the common characteristics, only some characteristics were necessary to define any person's Cultural Type. While these attributes were revealed using an iterative and peer-checking process to establish a bank of unique identifying phrases and words for each Cultural Type, because this is a small-scale study, the number of these phrases and words were limited. Therefore, we recognize that the tentative placement of some students' responses could be seen as a weakness. Secondly, there were only a limited number of student responses identified within the Cultural Type *Nature Capricious* (Table 1), possibly due to there only being 40 participants. However, this small number could also reflect Douglas's assertion that there are only small number of people in a society who hold this Cultural Type (2003b). Moreover, we recognize that the *Nature Capricious* responses were difficult to analyse because these students typically wrote very little or did not respond at all, as Douglas (2003b) predicted. Finally, while Douglas asserted that any analysis framework needed to "transcend the culture in which the risks are being debated" (2003c, p. 31), we recognise that this new framework has only been tested within a New Zealand context, and only with 16–17-year-old school students. Consequently, we believe that it will prove fruitful to utilize this framework with other, perhaps larger groups of people, potentially also with younger, but adolescent-aged students (Stevenson, Peterson, Bondell, Moore and Carrier 2014), or to explore other controversial issues that involve risk.

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Declarations

Competing interests The authors declare no competing interests.

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