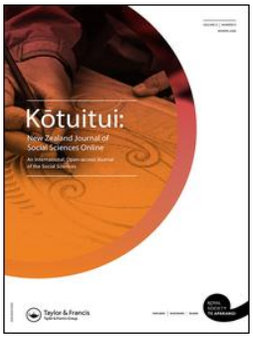

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RESEARCH ARTICLE

Engaging young people in science education through socioscientific issues of biosecurity

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ABSTRACT
The biosecurity system is extremely important to New Zealand because the economy is based largely on exporting products derived from primary industry practices. Recent developments in trade practices such as online trade have put the biosecurity system in New Zealand under further strain. In light of this, engaging young people to support biosecurity initiatives is crucial. A qualitative approach using the interpretive mode of inquiry was used to investigate the message young people got out of biosecurity educational material in the public. One hundred and seventy-one young people completed a questionnaire that consisted of Likert-scale type questions and open-ended questions that focused on getting young people's understanding of biosecurity related educational material. The findings show that young people emotionally connected with the biosecurity educational material, but were unable to get the biosecurity message. Building prior knowledge about biosecurity through teaching and learning is recommended.

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Introduction

Globally biosecurity as a term is related to a range of concerns in different practices (Hinchliffe and Bingham 2008). For example, biosecurity is used in relation to the spread of harmful biological agents that can fatally affect humans such as anthrax (*Bacillus anthracis*) (Zhou et al. 2019). Biosecurity also includes efforts to limit the spread of highly pathogenic zoonotic diseases such as the 2009 pandemic caused by the H1N1 strain of the swine flu in Hong Kong (Lycett et al. 2019). Another area where the term biosecurity is extensively used is in attempts to manage agricultural pests and diseases and attempts to reduce the effects of invasive species on native flora and fauna (Hinchliffe and Bingham 2008). This paper deals with the form of biosecurity that attempts to limit the spread of agricultural pests and invasive species.

Biosecurity is an important concept in New Zealand, this inference can be made because the New Zealand government has not only allocated the responsibilities of maintaining biosecurity to a government ministry, the Ministry for Primary Industries (MPI)

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but has also legislated biosecurity through the Biosecurity Act 1993 (MPI 2017). The purpose of the biosecurity system in New Zealand is to protect the economy, environment, human health, and a range of social and cultural values (MPI 2018a). In this way, first and foremost, biosecurity in New Zealand is about protecting key industries that support the economy through preventing agricultural pests and invasive species from establishing. It can be said that biosecurity is connected to all walks of life in New Zealand. An example of this can be seen in the '100% Pure New Zealand' brand. This brand has become world famous and is not only used to advertise the country's economic prowess but also differentiate it from the rest of the world.

The current system of creating awareness in New Zealand about biosecurity can be said to be through a top-down approach. In this system, the authorities, including the New Zealand Government and the Ministry for Primary Industries, have taken on the sole responsibility to maintain biosecurity through an advanced system of rules, regulations, Acts, and laws which are imposed on all citizens. However, a bottom-up approach whereby familiarity with biosecurity through education in schools might lead to a greater awareness of biosecurity in the community.

A bottom-up approach can develop knowledge, skills and attitudes in young people to address issues associated with biosecurity. Bottom-up approaches are democratically accountable, increase participatory input and are inclusive. Bottom-up initiatives drive citizens to think independently opening channels through which citizens can tell policy makes what they think (Fraser et al. 2006). Further, bottom-up participatory approaches allow communities to benefit from education by increasing their knowledge of key societal issues (Avery and Hoxhallari 2017). Such an approach can allow for a better informed community that can contribute to the biosecurity debate (Mitlin and Thompson 1995; Fraser et al. 2006; Avery and Hoxhallari 2017).

The call to get biosecurity into teaching and learning has been steadily gaining momentum. For example, the Minister for Primary Industries suggested that biosecurity should be taught in schools (Guy 2016). As the New Zealand government moves to strengthen New Zealand's biosecurity system through a future focussed agenda, one that looks ahead to 2025 and hopes 'all New Zealanders to [will] participate' in strengthening the biosecurity system (MPI 2016). A bottom-up approach via education through schools may lead to more participation of young people in biosecurity related discussions (Ram et al. 2016). Another initiative that may benefit from a bottom-up educational approach is the drive to become predator-free by 2050. New Zealand has set a goal to eradicate the most destructive introduced animals including possums that threaten New Zealand's natural taonga [treasure], economy and primary sector by 2050 (Predator Free New Zealand, 2018). Education about the biosecurity related predator-free stance could engage more young people to support the drive.

Biosecurity is important to New Zealand and so are finding ways to educate young people (Ram et al. 2016). However, there is the issue of young people's disengagement with a science-related curriculum to address. Internationally there have been concerns about the lack of interest in science and scientific learning in schools according to the Programme for International Student Assessment (PISA). For example, Dawson (2015) used the 2006, Programme for International Student Assessment (PISA) scientific literacy results as a basis to conduct a study to show that Australian (10- to 15-year old) students may benefit from curricular designed to enhance understanding and decision-making

skills about climate change. In terms of New Zealand, PISA tests show 17% of 15-year olds performed below level 2 (baseline level) in science (May et al. 2013). Further, results for science proficiency levels for New Zealand students have not changed since PISA 2012, showing a 3% increase in the number of 15-year-old poor performers from 2006 to 2015 and a decline of 5% in science proficiency in top performers over the same period (Education counts 2019). It is claimed that schooling practices may play a part in the discourse around student engagement.

Schooling practices are said to have not only disenfranchised young people but also contributed to their disengagement from subjects such as science. For example, Fredricks et al. (2019) identified boring and irrelevant curricula as key factors that contributed to the disengagement of urban youth in urban schools. Smyth et al. (2013) state that young people complained of being ushered around and made to learn concepts that was in direct contrast to how they lived their lives. In light of these revelations, they postulate that the concept of traditional formal learning becomes a key issue in whether young people are ready to engage with learning; so for learning to occur, an alternative education programme that focuses on re-engaging young people by 'learning through interest' could be one way of getting young people re-engaged in science-related learning in schools (Talbot and Hayes 2016).

Learning through interest or in other words making the school science curriculum relevant and mirror real-world issues have been previously argued. Dewey (1916/1997) postulated that young people were divorced from the concept of education because it lacked relevance to their lives. He suggested exposing young people to meaningful, authentic and relevant problems to foster engagement. Hodson (2011) said that the current school science curriculum does not serve the interests, aspirations and needs of the modern citizen and called for the science curriculum to be more relevant to give young people an opportunity to tackle real-world issues that have a scientific or environmental component. One way to achieve relevance in the science curriculum could be through including issues that are important to a nation like biosecurity which could create a base for young people to construct an understanding that is personally relevant, meaningful and important.

Presenting science as a socio-scientific issue in the classroom has been purported to solve the relevancy problem in teaching and learning (Driver et al. 2000; Sadler and Zeidler 2009). Socio-scientific issues are polemic social issues with conceptual and technical links to science (Sadler et al. 2004). Socio-scientific issues tend to present themselves as issues without a specific solution but with many potential solutions. The solutions are based on scientific principles, but scientific principles cannot fully provide solutions as the issues are linked to social, political, economic and ethical disciplines (Sadler 2011).

Socio-scientific issues of biosecurity

A plethora of organisms cause a vast array of biosecurity problems in New Zealand. From didymo (*Didymosphenia geminata*) a diatom that forms dense mats in freshwater rivers, choking out all other life to a fungus-like organism (*Phytophthora agathidicida*) that attacks the vascular tissues of kauri (*Agathis australis*) trees killing them overtime. To control the spread of didymo, the South island of New Zealand where the didymo exists has been declared a controlled area.

Similarly, to control the spread of the Oomycete that causes kauri dieback disease, the public have been barred from entering forest parks where kauri trees are found. In light of these threats, the government's response can be described as unprecedented; 'a do whatever it takes' stance to eliminate or restrict the movement of these organisms. The issues that arise as a result of biosecurity restrictions can be described as socio-scientific because they are polemic and pervade across the social and scientific domains.

Other socio-scientific issues related to biosecurity stem from international trade. The use of biosecurity policies to restrict trade appears to be common practice. Increasingly governments around the world are using biosecurity as a means to restrict trade by internationalising and standardising biosecurity protocol without taking into account the impact on production systems and human populations (Potter 2013).

For example, unsubstantiated claims by Australia that Giant African snails could arrive in containers from Fiji, when Giant African Snails are not found in Fiji, has affected farmers livelihoods who rely on export for their income in Fiji (Perrottet 2016). Similarly, unsubstantiated, claims that fruit flies could establish in New Zealand from fresh produce coming from Fiji, caused great economic and social distress to farmers in Fiji (RNZ 2015). It can be said that biosecurity protocol in this way is controversial because it appears to be contributing to poverty in developing nations.

Further, a European Union funded project on Facilitating Agricultural Commodity Trade in the Pacific, found that quarantine import protocols implemented by New Zealand, Australia, United States and Japan were the major barrier for Pacific Island countries such as Fiji, Samoa and Tonga in increasing their exports of taro (*Colocasia esculenta*) a root crop. The study also reported that increased taro exports would increase the quality of life for large numbers of poor rural people in the Pacific (Secretariat Pacific Community 2011).

Yet another controversial issue to do with biosecurity is the blanket hatred towards the Australian brushtail possum (*Trichosurus vulpecula*) and the support of the authorities to eradicate them by poisoning, trapping and shooting. Because possums are framed as alien/ unwanted species in New Zealand, and officially people have the right to eradicate them. It is claimed that it has become part of popular culture in New Zealand to show animosity towards the Australian brushtail possum (Ram 2019). Inspite of animal welfare agencies publically denouncing the use of 1080 (sodium fluoroacetate) poison to kill possums because of the painful and torturous nature of the death caused by 1080 poison (Safe for Animals 2019) the authorities move ahead undeterred.

Nonetheless, what appears to be controversial is the use of terms such as alien, exotic and/ or unwanted used to frame invasive species and then moved across and used to describe human immigrants (Warren 2007; Ram 2019). Subramaniam (2001) states that a fear of immigrants engulfing the country is why terms such as alien, exotic, illegal and unwanted are extended to describing humans. Comaroff and Comaroff (2001) give examples of dire consequences when hostility moves from demonising invasive flora and fauna to people who look different in South Africa. Clark's (2015) findings showed that the framing of animals as invasive has a desensitising effect, prompting people to disregard animal welfare when dealing with invasive species. Blair (2017) showed how early British settlers framed non-human and humans of South American and Atlantic decent as native pests in the Falkland Islands. Ram (2019) presents data to show how narratives on popular media about invasive flora and fauna cause young people to develop nativist views.

Biosecurity related practices such as the poisoning of possums, restrictions into public parks, xenophobia and indiscriminate trade decisions that contribute to global poverty present a moral dilemma. How can young people comprehend? When the survival of one species is directly dependent on the death of another or the livelihood of one nation is directly correlated with preventing prosperity in another. Such questions are referred to by Simonneaux (2014) as socio-scientific because they are not only controversial but include aspects of uncertainty and risk. Moreover, she postulates that engendering solutions to these types of questions are crux of the problem educators and learners face in the global society which is influenced by pandemics, environmental degradation and trade wars. Hence presenting science as an SSI in schools contributes to the development of critical thinking, promoting an engaged citizenship.

Socio-scientific issues are widely regarded as contributing to scientific literacy through providing young people with contexts to engage with personal, scientific and social issues to make informed decisions (Zeidler and Keefer 2003). Authentic, societal problems form the crux of any teaching and learning using SSI (Sadler 2004). Authentic societal issues provide young people an avenue through which they can begin to contribute to democracy by taking part in relevant and current social debates (Hodson 2008; Levinson 2010).

The key element in engaging young people with authentic socio-scientific issues is to link school or abstract knowledge with experiential or everyday knowledge (Sharma and Anderson 2007; Young 2008). Once the connection between experiential and abstract knowledge has been made, young people enter a 'third space', where socio-scientific issues become meaningful. In this space, young people are not only able to make sense of abstract/conceptual knowledge but also communicate using abstract ideas (Moje et al. 2004; Wallace 2004).

Simonneaux (2014) posits that a good way to introduce controversial issues in the classroom is through allowing young people to see science-related topics on a continuum. Controversial biosecurity related topics such as the killing of possums in New Zealand society can be introduced to engender interest first – experiential learning. The issue of mass eradication would be brought in after young people have had a chance to develop a better understanding of concepts such as risk evaluation and stakeholder interest – abstract/conceptual knowledge. Emotional connection with the issue is critical, Simonneaux states, as this allows young people to recognise SSI's as controversial in society and be able to contribute to the issue through informed opinion generated through debate and research.

Klosterman and Sadler (2010) used SSI based curriculum to see whether it could make a difference in enhancing young people's science content knowledge. A three-week intervention programme was used to determine students' knowledge of socio-scientific issues of global warming. Analysis of the data not only showed statistical significance but also showed that students who had undergone a three-week intervention programme using socio-scientific curricular had on average a more complex understandings of global warming, the greenhouse effect and a stronger emotional connection with the issue.

The important role emotions play in engaging young people with socio-scientific issues cannot be disregarded. Sadler and Zeidler (2005) report that empathy assists student's engagement with controversial socio-scientific issues such as reproductive cloning. They claim that young people benefit when given multiple ways to reason when dealing with socio-scientific issues. Similarly, Tomas and Ritchie (2012) state that Australian Year 12 students reported that strength, pride, determination and interest were most evident

when writing narrative storylines about socio-scientific issues of biosecurity. Turner (2007) states, that using primary emotions such as anger, fear, sadness, happiness, disgust and surprise further enhances an individual's understanding of learning concepts. It appears that engendering emotions may play a critical part in understanding socio-scientific issues.

Research design

The researcher approached schools in the Auckland region via letters to the principal and the board of trustees. Teachers interested in participating in the research approached their head of department who then approached the researcher. Data was gathered via a questionnaire which was administered by respective classroom teachers during science class periods. The questionnaire was adapted from Sheley et al. (1996) study which investigated knowledge of noxious weed through a telephone survey. The questionnaire was adapted by rewording the questions. For example, Sheley et al. asked, 'In your opinion, how serious a problem are noxious weeds in Montana?' (Sheley et al. 1996, p. 593) was reworded to 'In your opinion how serious a problem are unwanted organisms in New Zealand?' Results from only select questions are presented because they show interpretations and understandings of biosecurity of young people.

A descriptive interpretive mode of inquiry was adopted for this research because it allowed the researcher to gather personal points of views and then interpret their meaning by finding relationships within data and linking them to young people's understandings (Neuman 2003). The categories used in this paper were derived as a result of an interactive process; repeated review of transcripts, coding and recoding (Braun and Clarke 2006) – an interpretive process.

Social research can be descriptive and interpretive, a descriptive approach allows for detail to be emphasised whereas the creation of categories is an 'interpretive process on the part of the researcher' (Elliott and Timulak 2005, p. 154), with 'ideas for categories originating from the researcher's knowledge of previous theorising and findings in other studies' (p. 154).

Purposive sampling was used to identify two urban multicultural schools from Auckland because the school rolls represented the multicultural nature of Auckland City, the largest city in New Zealand. Thirteen to fourteen year old, Year 9 students were chosen for this research because it was the researcher's view that these young people may reflect the next generation of New Zealanders' views of biosecurity and their opinions about its importance to the economy, environment and society.

Ethics approval to conduct research was granted by the University of Auckland Human Participants Ethics Committee (Ref: 9198). One hundred and seventy-one students from two schools (School A and B) took part in the study. Data was gathered from students in Year 9 science classes. A total of five classes participated from School A and two from School B. Students answered the questionnaire during scheduled science lessons, this was seen as normal teaching and learning so ethical consent from parents was not sought. However, parental consent was sought and granted for the nine students who were interviewed.

A total of nine young people were interviewed, (five males and four females) and included those who had provided rich and descriptive accounts of their biosecurity

experience. The interviews were face-to-face with a set of questions that allowed young people to expand on their questionnaire responses. Data for this research was derived from two multicultural schools located in the largest city in New Zealand, Auckland. In light of this, the results may vary between urban and rural locations.

Data analysis

The analysis of the open-ended questions was conducted by thematic coding into categories. For example, preventative measures like monitoring through X-rays and physical checking are routinely undertaken by the MPI to mitigate against risk from unwanted organisms. Hence all responses related to ideas such as 'train detector dogs to sniff out unwanted plant' and 'we need more people to check people's luggage' were allocated the 'Bio act' code. The 'Bio act' abbreviation stood for 'Biosecurity activity' category.

Categorised data and related Likert-scale data were entered into the SPSS qualitative analysis software programme, through which frequency tables for each question was, generated (SPSS Software 2017). This allowed data related to each response to be viewed as a frequency and percentage and enabled the researcher to determine patterns and trends in the young people's responses.

Interview data were transcribed and young people's responses to each question were placed together. For example, each student's response to Question 1 was grouped together. Similarities and differences in each response were analysed and grouped data allocated into the categories developed for the questionnaire responses. Interview data was then matched and compared to the questionnaire data to look for similarities or new concepts not mentioned in the questionnaire.

Findings

Young people's interpretations of the biosecurity poster

Posters are widely used by the MPI to inform the public about biosecurity. For example, 'Save our Kauri' poster (Kauri dieback 2018) is currently used to inform the New Zealand public about the devastating effects of the kauri dieback disease caused by the water mould (*Phytophthora agathidicida)*.

To see what message young people got out of biosecurity related posters, included in the questionnaire was a poster (a young girl covered with didymo, see Figure 1) used by the MPI to raise awareness about the spread of the freshwater pest didymo (*D. geminata*). Young people were given an opportunity to indicate the message they got out of the poster (see Table 1).

The *Child is the focus of the worry* category emerged from the data and was used to include responses such as 'worried for the child' and 'because the moss is all over the little girl'. The *Environmental fear* category emerged from the data and had responses such as 'damaging environment' and 'worried for the environment/water'. The *Anger against others* category included responses such as; 'people are dumping things in the water' and 'angry at people who are damaging the environment'. The *Worried about self*-category had responses such as 'It makes me feel unclean and not fully protected or

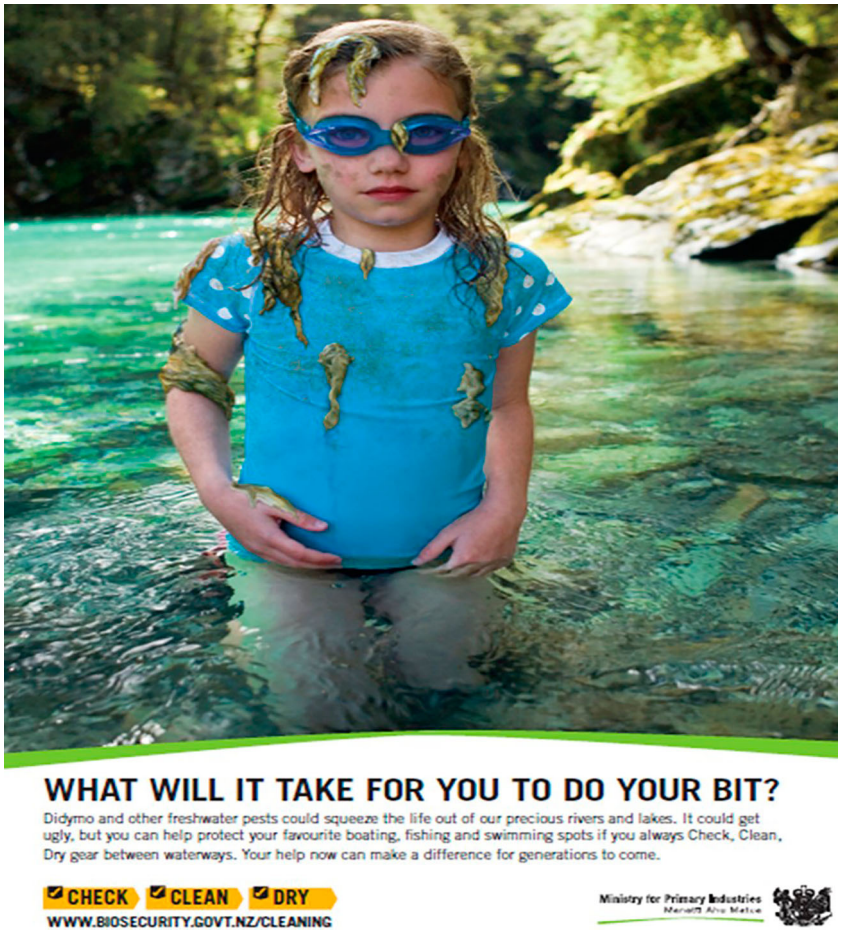

Figure 1. Poster showing a girl covered in didymo/rock snot (MPI 2018b).

Table 1. Message in the biosecurity educational poster.

Interpretations of the biosecurity poster	Frequency of student responses	Percentage (%)
Child is the focus of the worry	41	24.0
Environmental fear	24	14.0
Anger against others	16	9.4
Worried about own-self	7	4.1
Fatalistic	5	2.9
Affects future generations	4	2.3
No response / Don't understand	74	43.3
Total	171	100

sure that I can go for a swim and not get viruses crawling on me' and 'I don't want it to happen to me'. The *Fatalistic* category had responses with ideas such as, 'I don't care' and 'I can't do anything about it'. The *Affects future generation* category had responses such as 'It's important to New Zealand for the future generation' and 'It will be a much nicer place for our next generation'. The 'No response / Don't understand' category recorded almost half of the responses.

Interview data

The nine students that were interviewed were asked for their interpretation of the poster. They were also asked to identify the green stuff caught on the girl. Eight of the nine students interviewed were concerned for the well-being of the child in the poster so their responses were placed in the 'Child is the focus of the worry' category. The response for student six was placed in the 'Environmental fear 'category because of concern for the health of New Zealand's lakes and rivers.

Young people's attempts to name the organism found on the girl in the poster were placed in three categories. Students one, two, three and student sevens response were placed in the 'Microorganism category because they referred to the organism as bacteria. Students, four and nines response was placed in the 'Floating debris 'category because these students thought that the green blobs were rubbish floating in the water which got caught on the girl. Student's five and students eights response was allocated into the 'Diatom' category because they stated that the organism was some sort of algae. Student fours response was placed in the 'Aquatic plant' category because they indicated that it was some sort of seaweed. Young people's interpretations of biosecurity poster can be visualised in Table 2.

Young people's understandings of the biosecurity poster were further gauged by asking them to indicate whether they would be prepared to follow the instructions found at the bottom of the poster which reminded people to, 'Check, clean and dry gear between waterways'. To answer this question young people were required to choose one from the following terms: always, sometimes, maybe, and never to indicate their intent. The different categories, frequency of responses and the percentages are shown in Table 3.

Table 3 shows that 56.2% of students indicated that they would *Sometimes* or *Maybe* follow the instructions. The results show that 4.1% of students indicated they will *Never*

Table 2. Student interpretations of biosecurity poster: interview data.

Student	Category	Student interpretations of poster	Name of organism	Category
Student 1	Child is the focus of the worry	'Yes I feel sorrow'	Some rubbish looks like some bacteria'	Microorganism
Student 2	Child is the focus of the worry	'The girl she's covered in dirty seaweed I felt sorry for her'	'Is it fungi'	Microorganism
Student 3	Child is the focus of the worry	'She's fairly dirty'	'I think that's germs or some other things that is not good'	Microorganism
Student 4	Child is the focus of the worry	'I see a little child who wants to like go for a swim but there's like all these plants and everything, there's dirty stuff on her'	'I think it's seaweed'	Aquatic plant
Student 5	Child is the focus of the worry	'I see this little girl she just wants to have fun but she's all covered in algae and it could be poisonous and it could not be but it's all dreadful and yucky'	'I think that's algae	Diatom
Student 6	Environmental fear	'all the rivers and the lakes and like how we need to protect them'	'Is it like rubbish'	Floating debris
Student 7	Child is the focus of the worry	'The filth on her it's just it's kind of scary'	'Bacteria'	Microorganism
Student 8	Child is the focus of the worry	'The girl's all covered in all these dirt or seaweed'	' alga or some plants from the water'	Diatom
Student 9	Child is the focus of the worry	'The waste covering the little girl swimming'	'Sewage maybe remnants of people fishing like fish guts'	Floating debris

Table 3. Intent to follow instructions on the biosecurity poster.

Intent to follow instructions on the biosecurity poster	Frequency of student response	Percentage (%)
Always	39	22.7
Sometimes	41	24.0
Maybe	55	32.2
Never	7	4.1
No response	29	17.0
Total	171	100.0

Table 4. Why is biosecurity important in New Zealand?

Why biosecurity is important in New Zealand	Frequency of student responses	Percentages (%)
Keep New Zealand safe	78	45.6
It is the law	1	0.6
No response	92	53.8
Total	171	100.0

follow the instructions on the poster and a further 17% of students failed to give a response to the question.

The process of biosecurity is very important to New Zealand for economic, ecological and social reasons. For example, to continue exporting milk powder, butter and cheese which was the most exported commodity (New Zealand Trade & Enterprise 2018), New Zealand needs to maintain its disease-free status. In an open question, students were asked to explain why biosecurity was important to New Zealand. Student responses were thematically categorised and the different categories, the frequency of responses and the percentages are displayed in Table 4.

The *Keep New Zealand safe* category had responses such as, 'keeping New Zealand safe'. One response was received for the *It is the law* category. The *No response* category recorded just over half of all responses.

Discussion

It can be inferred from the results of this study that the biosecurity educational material such as the poster (Figure 1) released in the public domain to make people aware of biosecurity issues in New Zealand relies on engagement through emotion. For example, Holtz-Bacha and Lessinger (2017) state that posters are designed to appeal emotionally to the public. Gardener (2007) states that the most critical component of a poster is the image because images on posters are not only supposed to speak to audiences but make them think of the wider implications. The data from this research shows that the biosecurity poster (see Figure 1) showing a young girl rather distressed with green blobs covering her clothing and skin engaged its audience by drawing a strong emotional response from the research cohort.

However, although, the biosecurity poster – one of the key instruments through which scientific ideas are concisely communicated (Hay and Thomas 1999), emotionally engaged young people, data shows that their concerns were largely focussed on the well-being of the girl in the poster (see Table 1, 'Child is the focus of the worry' category) and as a

result young people failed to get the biosecurity message in the poster. This concern for the girl was also seen in the responses to face-to-face interviews where all young people but one (student 6) alluded towards concern for the girl in the poster (see Table 2, interview data).

A possible explanation for this concern could be that the majority of the young people who took part in the research were 13-year old, Year 9 students. Hence it can be said that these students were young and impressionable, so lacked the maturity to engage with the poster at the intended level. Although young people engaged with the poster (see Table 1 for categories), it appears that their emotions and understanding were still developing and coalescing. The cues for this claim is evident in the results because young people not only interpreted the poster literally but put themselves in the place of the girl in the poster to try to make some sense on how they could interpret the poster. For example, 'It makes me feel unclean' … . and/or 'I don't want it to happen to me' (see Table 1). Another reason why young people were unable to engage with the poster at the intended level could be because they lacked prior knowledge of biosecurity. For example, Liu et al. (2017) state that learning about any concept is enhanced when new information is associated with information that we already have about it.

Engagement with emotion provides opportunities to involve young people in biosecurity learning concepts. For example, emotions such as fear and anger (see Table 1, 'Environmental fear; 'Child is the focus of the worry'; 'Anger against others' and 'Worried for self' categories) were expressed by students to interpret the biosecurity poster. Anger and fear are innate primary emotions in humans (Turner 2007) which provide evidence of attentiveness, hence engagement through emotion with the biosecurity educational material. Further, emotions such as empathy expressed by young people when they encountered the biosecurity poster are said to be variants of primary emotions (Turner 2007) which point towards an elicitation of self-conscious emotions. Sadler and Zeidler (2005) reported that empathy assisted young people's engagement with controversial socio-scientific issues. In this way, core self-emotions learnt and built up overtime from conscious and unconscious feelings that matures during late adolescence (Turner 2007) can be used to help young people connect emotionally with biosecurity concepts.

Elicitation of emotions such as fear and empathy expressed by young people to interpret the poster shows that biosecurity could be introduced as a socio-scientific issue in the classroom. Simonneaux (2014) describes elicitation of such emotions a result of engagement with the 'hot end' of the socio-scientific issue because young people have emotionally connected so are able to recognise it as important and are able to contribute to a solution through informed opinion. Presenting science, especially biosecurity related science, as a socio-scientific issue may engage young people further and contribute towards helping them build an understanding of biosecurity.

Learning using socio-scientific issues of biosecurity are most effective because they are authentic, relevant, and meaningful and the gap between experiential and disciplinary or abstract knowledge is breached (Sharma and Anderson 2007; Young 2008). Both experiential and abstract knowledge are perceived as critical components for self-development (Epstein 1993). Abstract knowledge is crucial as it allows individuals to imagine alternative futures by thinking the 'not-yet-thought and 'unthinkable' (Bernstein 2000). Abstract knowledge allows individuals to learn disciplinary styles of reasoning enabling people to understand how knowledge is used and subsequently apply it to evaluate the validity of

arguments in society such as mass eradication of animals deemed pestilent or trade restrictions based on the threat to biosecurity (Wheelahan 2010). In this way, not only young people's interest in learning with a scientific context can be enhanced but their self-development can be positively influenced, through learning using authentic, relevant biosecurity related socio-scientific issues.

Although young people gave varying levels of indication that they would follow instructions found at the bottom half of the poster (see Table 2), it was unclear whether they read the instructions on the poster because only two of them were able to identify the organism – interview data shows that Students five and eight referred to the organism as an alga. Didymo or *D. geminata* are single-celled algae (NIWA 2018). Perhaps more young people would have been able to identify the organism as didymo if they had learnt about such invasive species as part of teaching and learning. Another explanation for why young people failed to find the biosecurity message and subsequently discover the name of the organism could be because the message was in fine print – found at the bottom half of the poster.

The purpose of the biosecurity system in New Zealand is to protect the economy, environment, human health, and a range of social and cultural values (MPI 2018a). However, young people appear to be unaware of this expansive role of the biosecurity system (see Table 3). A possible reason why young people were unaware of the expansive role of the biosecurity system was because of the top-down approach currently taken by the authorities to manage biosecurity – information is only shared on a need to know basis. For example, educational biosecurity brochures were sent out to residents during the fruit fly outbreak in Grey Lynn (MPI 2015). The MPI states that 'we all need to participate in biosecurity' (MPI 2016). However, this can only be possible if the public including the next generation knows and understand about biosecurity.

Conclusion

Using current, societal and relevant issues such as socio-scientific issues of biosecurity can help better engage young people in the classroom by providing a platform to share and discuss personal views (Sadler and Zeidler 2005) about issues such as didymo, biosecurity related trade restrictions, and mass eradication of marsupial mammals such as possums which are labelled as invasive. Prior knowledge is important, as knowledge of an issue leads to high involvement (Bewsell et al. 2012). This study has shown that prior knowledge may help students understand and better engage with biosecurity related educational material. Even though young people emotionally connected with the biosecurity poster, they were mainly concerned for the well-being of the girl in the poster rather than the damage that didymo could do to New Zealand's waterways.

A better approach could involve allowing young people to come into contact with biosecurity related material in school during adolescence when experiences and encounters are being coalesced (Turner 2007) or better still, involve young people during the design of such educational material. Building prior knowledge about biosecurity through presenting biosecurity as a socio-scientific issue will not only enable young people to connect with biosecurity critically but also develop in them a willingness to contribute to democracy through making informed future decisions related to biosecurity.

The importance of biosecurity to New Zealand warrants that all young people develop strong positive emotions towards biosecurity which could be developed by introducing young people to both experiential and abstract biosecurity knowledge in schools. It may not be obvious but biosecurity decisions affect all of us all the time.

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