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Intersecting knowledge worlds: describing the cultural interfaces within a socioscientific issue

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Abstract
Increasing numbers of science teachers in Aotearoa New Zealand are exploring ways to incorporate indigenous mātauranga Māori (Māori knowledge and ways of knowing) into their science programmes. This article presents findings from a study that examined how senior biology students in two English-medium secondary schools incorporated mātauranga Māori alongside biological science knowledge in their discussions about the use of 1080 poison to control mammalian predators. From a social constructivist ontology and interpretivist mode of inquiry using qualitative methodology, a triadic epistemic agency conceptual framework was developed inductively and used to analyse students' written scripts for their national school leaving qualification (NCEA), and transcriptions of individual interviews. The study took place prior to the introduction of equal status to mātauranga Māori within the New Zealand Curriculum. Deductive analysis using the Triadic identified a group of ten students who drew from both knowledge systems, with varying degrees of knowledge integration. In addition to detailed representations of the theoretical space of the locale of the learner, the findings also identified three distinctive cultural interfaces occupied by the students: conflicted, parallel, and, connected. The findings underscore the importance of enabling diverse knowledge systems in biology classes to converge. Specifically, the incorporation of mātauranga Māori alongside biological science knowledge encourages a critical stance towards knowledge claims, supports pluralist knowledge use among culturally and linguistically diverse learners and promotes critical engagement with socioscientific issues (SSI) in senior secondary school biology.

Keywords Cultural interface · Mātauranga Māori · Biological science knowledge · Socioscientific issues · Epistemic agency

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Urban English-medium secondary biology classes in Aotearoa New Zealand include students from diverse ethnic, cultural, linguistic, and socioeconomic backgrounds. In the face of dominant Western science discourse and practices, many linguistically and culturally diverse students find traditional science instruction culturally incongruent (Meyer and Crawford 2011), often met with disengagement and disinterest. Russell Bishop asserts that "classrooms… need to be places of interaction and dialogue where students of diverse cultures can bring who they are, what they know and above all, how they understand and make sense of the world to the conversations that generate learning" (2019, p. 2).

The current curriculum framework refresh and review of the national school leaving qualification (NCEA) have created an environment where increasing numbers of science teachers are exploring ways to incorporate the knowledge and worldviews students bring to their [science] learning. This presents opportunities and challenges for both. Specifically, this concerns the area of equal status for mātauranga Māori (Māori knowledge and ways of knowing), through 'He mana ōrite mo te mātauranga Māori,' and how a combination of curriculum localisation and teacher pedagogy can create spaces where multiple knowledge worlds come together—in this case, biology science knowledge and mātauranga Māori.

From within this context, Sara Tolbert, Rosemary Hipkins, Bronwen Cowie and Pauline Waiti state that "teachers and schools need a certain level of freedom, and epistemic agency, to build a local curriculum that is responsive to these multiple and local-level knowledges" (2024, p. 13). For issues of scientific and cultural importance, the use of mātauranga Māori alongside Western science knowledge is especially important for students in search of meaning and success through the validation of their worldviews and knowledge reserves. This knowledge interface deserves to reveal its splendour.

This paper reports on a group of senior secondary school biology students in Aotearoa New Zealand who use knowledge from Western science and mātauranga Māori as they develop and present an informed, justified response to the socioscientific issue of using sodium fluoroacetate (1080) poison use to control mammalian predators.

This study investigates how senior secondary school biology students draw on mātauranga Māori and biological science in formulating responses to the socioscientific issue of 1080 poison use. Specifically, it explores students' epistemic agency within the cultural interface and the 'locale of the learner'.

Knowledge use within a socioscientific issue

A central question concerns the use of knowledge—specifically scientific and cultural knowledge. A more culturally congruent science programme would require the pairing of these bodies of knowledge so that they can be appreciated within their respective paradigms (Mason Durie 2011). Accepting that there is more than one way of looking at the world and that both ways of viewing a phenomenon have equal validity and provide alternate perspectives towards it, the space between knowledge worlds in the context of a socioscientific issue presents this opportunity.

The control or eradication of introduced mammalian predators remains a major conservation priority (O'Donnell and Hoare 2012), and the use of 1080 is a biodiversity-related, environmentally critical issue of our present and future. It is of major importance to Māori, the scientific community in general and the wider public of Aotearoa

New Zealand. The 1080 controversy is prominent and has implications socially, economically, scientifically and culturally. The 1080 debate brings authenticity to the science classroom as students deal with real-world problems and controversial issues (Åkerblom Lindahl 2017). The debate serves as a useful context for learning more about the potential for cultural congruence within this zone.

The science contextual strand in the New Zealand Curriculum (NZC) represents a realist, objectivist, positivist view of science, whereas a Māori view of the origins of the universe and the personification of natural phenomena through whakapapa (genealogy) see the supernatural and the natural as holistic, dynamic and part of the unified whole (Beverley Bell 2005, p. 167). As Garrick Cooper points out, Māori students in science classrooms encounter an epistemic wilderness, barren of Indigenous knowledge where wisdom in the form of mātauranga Māori (Māori knowledge) is invisible. He contends that classrooms are the places where mātauranga Māori and epistemology should exist and thrive. The challenge laid down by Cooper invites science educators to explore this epistemic wilderness to discover an unexplored world free from "the epistemic normativity of Western modern science, which has, for so long, questioned the validity of mātauranga Māori" (2012, p. 67).

Ocean Mercier, Nathan Stevens and Anaru Toia (2012) remark that worldviews have validity within their own cultural setting and where diverse cultures hold different forms of 'situated' knowledge (Wally Penetito 2015, p. 42). Durie (2011) and others note that while mātauranga Māori is distinct from other knowledge bases such as science, both are equally valid as ways of viewing, describing and understanding the world.

Māori scholar Te Ahukaramū Charles Royal (2004) highlights the contrast between the two knowledge worlds by pointing out that the single-most important aspect of an Indigenous worldview is the universal notion that the natural world is alive, conscious and flowing with perennial energy—not so much the repository of wisdom but rather is wisdom itself, flowing with purpose and design (Royal 2004, p.218). This view closely aligns with Durie's assertion that indigeneity represents a fusion of Indigenous peoples with their customary environment in a reciprocal and mutually sustaining relationship (2005, p. 151).

A concern expressed amongst researchers internationally is that even though there are multiple worldviews, cultures and sciences, school science has become standardised through its presentation of canonical knowledge, techniques and Eurocentric worldviews (Mijung Kim 2017, p. 606). Overseas, research has explored the potential for Western science knowledge and Indigenous knowledge to coexist within a Western science/biology programme (Gondwe and Longnecker 2015). Despite differing worldview perspectives and epistemologies, and the ongoing contestability in this space, the possibility exists that under certain conditions and circumstances one knowledge world could show something that is beyond the reach of the other in a cross-cultural hybrid form (Fulvio Mazzocchi, Dragos Simandan, Mohsen Taheri Demneh, Dennis Ray Morgan, Sepehr Ghazinoory, Fatemeh Saghafi, and Maryam Mirzaei 2018, p. 29).

There is increasing evidence in recent studies of a sustained movement taking place in science education worldwide towards making science knowledge more accessible and increasingly relevant to students (Kim 2017, p. 607). By its very nature the socio-scientific issue of pest control using 1080 sits within the 'third' space (Homi Bhabha 1994), between the boundaries of the two knowledge worlds (Aikenhead and Ogawa

2007). SSIs offer authentic tasks to bridge across to the third space between the first space of the child's everyday knowledge and the second space of the school/disciplinary knowledge, where discourses may be interlaced (Åkerblom and Lindahl 2017, p. 206).

The cultural interface and the 'locale of the learner'

Indigenous research scholar Martin Nakata (2002, 2007) theorised the formal learning space of the cultural interface. Nakata describes this interface as "the place where we live and learn, and relationships develop, the place that conditions our lives and shapes our futures, where we are active agents in our own lives and where we make decisions—our life world" (2002, p. 285). The cultural interface connects Indigenous knowledge worlds and non-Indigenous knowledge worlds and knowledge economies (Deanne Minniecon, Naomi Franks and Maree Heffernan 2007, p. 24). The cultural interface also recognises the importance of personal agency where people are active agents as decision-makers in their own lives—where students negotiate 'the expanse in between' (Nakata 2002).

The multi-dimensional space of the cultural interface brings into analytical focus the presence of actively resourceful students who draw information from both knowledge worlds (Tang and Yang 2017). At the confluence of mātauranga Māori and biological science knowledge, there exists an experiential, interstitial third space that Mercier (2007) describes as "a neutral space of free-flowing interaction between science and indigenous knowledge worlds." (p.22). The cultural interface affords the opportunity, according to Durie (2005), for individuals to combine both worlds with the likelihood that the insights of one could enhance the other and where the energy of the two systems could combine to create new and innovative outcomes.

Described as a positive metaphor by Ella Kahu and Karen Nelson (2018), the cultural interface is a multi-layered, multi-dimensional space of dynamic relations, where different systems of thought and knowledge converge. Here, activity is focussed on actively drawing on a range of diverse understandings and lived experiences which become an opening for active inquiry (Emma Kearney, Leone McIntosh, Bob Perry, Sue Dockett and Kathleen Clayton 2014, p. 340).

Cultural interface theory provides a useful theoretical framework for thinking about how we might engage and relate these potentially conflicting, combining or co-existing knowledge worlds. Nakata proposes that the interface is where these understandings, experiences and knowledge domains intersect. There is also a second theoretical concept of a space within the cultural interface Nakata (2007) calls the 'locale of the learner', described as where and how individuals position themselves and are positioned by others. It is also how learners experience and navigate different knowledge systems (p. 10).

Critically, Nakata's (2002) premise is that the 'locale of the learner' is comprised of three elements: position, experience and navigation. Furthermore, Nakata's reference to people as "active agents" (p. 285) at the cultural interface opens the possibility to foreground the concept of student agency to deepen our understanding of the locale of the learner.

Closely related to self-efficacy, agency is rooted in the desire to fulfil basic human needs and refers to the ways people act and interact within socio-cultural settings (Deborah Blair

2009). Learner agency implies learners "moving from powerlessness to a sense of control and hope for the future." (p. 180), as they exercise their decision-making to make choices followed by purposeful actions. Susan Kirch and Jasmine Ma (2016) note that agency "is a combination of both the capacity to act as well as the intentional engagement with the world [and its resources—which includes its knowledge worlds]" (p. 1107). The capacity to act and engage with an issue is the central tenets for a discussion of SSIs which ties together the close relationship between agency and the opportunity it provides to debate and argue a position on a controversial issue.

As an agentic space, the cultural interface is characterised to encompass students' knowledge use. Therefore, students are decision-makers who, by the exercise of their agency, can view knowledge worlds as a resource from which they decide to draw information from. Maria Varelas, John Settlage and Felicia Mensah (2015) describe this agency as "a person's capacity to engage with cultural schemas and mobilise resources in ways that did not exist before, creating new contexts and practices." (p. 439).

The concept of agency described by Heather Zimmerman and Jennifer Weible (2018) and operationalised for this research is 'epistemic agency' and relates explicitly to decisions surrounding knowledge use, knowledge claims and making sense of new information—specifically, decisions made by students to include biological science knowledge and cultural knowledge. Epistemic agency can therefore be used to demonstrate how students venture beyond simply meaning-making from scientific information and viewing themselves as capable of engaging with, critiquing and interpreting knowledge to share with others (Zimmerman and Weible 2018).

Within the 'locale of the learner', in the space between these two knowledge worlds, active, agentic processes of discovering, negotiating, decision-making and experiencing occur (Kahu and Nelson 2018). Inside these relational spaces that learners occupy at the cultural interface, students can act and respond to situations with agency by drawing on several modes of understanding and experience (Emma Kearney, Leone McIntosh, Bob Perry, Sue Dockett and Kathleen Clayton 2014, p. 341).

Thus, it follows that the cultural interface describes how and where students can demonstrate their agency as they actively draw on 'both ways of being' and make decisions as they engage with and negotiate the information across the space in between the knowledge worlds of biological science and mātauranga Māori.

Method

Participants

This study centres on two classes of Year 13 biology students in their final year of secondary education at two urban Auckland English medium secondary schools in 2015 as they completed a 3-credit Level 3 internal assessment (achievement standard AS91602) for their NCEA Level 3 school leaving qualification (Madjar and McKinley 2013). The achievement standard focused on the contemporary socioscientific issue of the use of 1080 poison to control mammalian pest animals in Aotearoa New Zealand. This provided the context for this study.

Socioscientific issues (SSI) are defined in the science education literature as "open-ended, ill-structured, debatable problems, which are susceptible to multiple perspectives and solutions" (Lindahl and Linder 2013, p. 2302), and who also found that an SSI was deemed an appropriate context for the study of the development of agency and reasoning by students (Lindahl and Linder 2013, p. 2300) as they try to negotiate possible solutions to the problems encountered. Deeper still, Amanda Woods-McConney, Mary Oliver, Andrew McConney, Dorit Maor and Renato Schibeci (2013, p. 250) found that SSIs allow a high degree of student control (through autonomy and agency) and provide relevancy (authenticity) of science content which together are important factors to building science engagement.

The standard required that students *'integrate biological knowledge'* as they developed an *'informed response'* to the socioscientific issue in this case the control of possums using 1080 poison by presenting a justified personal position and proposed action(s) by analysing and evaluating the biological knowledge relating to the issue. The assessment task at one school was specifically contextualised and focused on a proposal by local authorities to drop 1080 near water catchments in the Hunua Ranges, south-east of Auckland, while at the other, the task required students to research and write a speech of a generalised nature about the use of 1080 to control possums in Aotearoa New Zealand. The researcher is an experienced non-indigenous science and biology teacher who, as an external observer, was not connected to either school other than through this research. This involved several visits to the schools to outline the project, invite participation, collect unmarked assessment scripts and carry out individual interviews with consenting students at the completion of the internal assessment period. The researcher took part in some pre-teaching activities and attended an external field trip with the classes so that the students became comfortable with their presence.

Data sources

The data generation and collection period of this project aligned with the four school terms from February–December 2015. Using a purposive sampling method (Uwe Flick 2014), two English medium secondary schools in the Auckland urban area were selected. They matched two criteria set at the outset of this investigation. The first was that the composition of the school's population consisted of sufficiently large numbers of students who were predominantly, though not exclusively, of Māori and Pacific ethnicity. Table 1 details the numbers of students from each biology class who consented to participate in the data collection phases.

Table 1 Participants consenting

Participating school	Level 3 biology class roll	NCEA summative assessment scripts	Interviews completed
High School	25	21	19
Secondary School	26	18	15
Total	51	39	34

As Level 3 biology is an optional subject, the second criterion required that in addition to offering biology at Year 13, students study the topic of animal pest control as part of their biology programme.

The documentary data originated from three primary sources. Firstly, the participants' written summative assessment scripts were collected, copied and returned to them prior to being marked and returned by the teacher. Second, the transcripts of the recorded interviews with individual participants and third, a reflective journal kept throughout the time the participants were engaged in the research project that provided an "on-going narrative account of the process of the study" (Penelope Hacker 2008, p. 90), that enabled decisions and new insights to be tracked.

Interviews

The face-to-face semi-structured interviews with individual participants took place after the completion of the assessment period and the handing in of their completed summative assessment script to their teacher for marking. A set of pre-prepared, mostly open-ended questions guided the interviews (Garner and Scott 2013) and enabled the study to "to explore the participants' interpretations and meanings of events and situations, and their symbolic and cultural significance" (Keith Punch 2014, p. 147). Interviews used a conversational tone in the spirit of 'talanoa' (a shared conversation) whilst preserving the uniqueness of the participants' worldviews and perspectives (Sharan Merriam 1998).

Participants were able to elaborate on their decisions to include elements of biological and cultural knowledge and to elucidate and expand on the relevance of these statements to their justified position. The audio recordings were transcribed and over a two-week period, each student's transcript was given back to them for validating and editing before being returned for analysis. Therefore, the concepts of the cultural interface and the 'locale of the learner' (Nakata 2007) provide the opportunity to, 1) inductively create a functional theoretical framework when describing students' agentic processes that, 2) can be used to deductively analyse student-participant data to create representations of their cultural interfaces.

Ethical procedures and positionality

Having taught and observed students in multiethnic urban high schools for an entire career, the researcher had become increasingly concerned for those students who seemed to disengage with science regardless of the topic or teaching approach. As a non-indigenous science teacher with a reasonable fluency in spoken Māori and Samoan language, the researcher has a working understanding of Māori and Pacific knowledge worlds. It was important to build and maintain trusting relationships with participants by adhering to the cultural norms of the researcher-participant relationship throughout the research data generating and gathering phase and in accordance with the institutional ethics requirements as part of the approval for this project.

Māori and Pacific cultural practices were given prominence to acknowledge the status and sensitivity of the participants' knowledge, which they shared willingly as a taonga (treasure), gifted to this research in both written and verbal form. Ethical practices used throughout included an acknowledgement of the partnership with indigenous Māori through Te Tiriti o Waitangi (Treaty of Waitangi) and its inherent obligations of respect, reciprocity and power sharing (Mere Berryman, Suzanne SooHoo and Ann Nevin 2013). This extended to appropriate and equal sensitivity towards Pacific participants using culturally appropriate language and protocols during engagement with participants. In-person engagements were conducted respectfully in accordance with customary practices to provide a culturally familiar and protective safe space for participants to engage with the researcher in conversation (Ministry of Education, 2001). The gifting of food and refreshments was available to acknowledge and thank participants for their time, knowledge and expertise.

Data analysis

An inductive thematic data analysis revealed the knowledge concepts used by the students (Table 2). The data were interpreted in accordance with Virginia Braun and Victoria Clarke's six phases of thematic analysis (2006, p. 87). Table 3 displays the biological concepts and Table 4 the mātauranga Māori concepts revealed. From the initial analysis, an epistemic agency conceptual coding framework was developed. Figure 1 displays this Triadic framework, which was used for the deductive systematic analysis of the data (Hennie Boeije 2010). This enabled the identification and representation of the different knowledge world interfaces. Throughout the abductive analysis process, coding and theme development by the principal researcher was checked by the co-researchers to ensure reliabilit

Table 2 Participants who used knowledge from both knowledge systems

Name (Pseudonyms)	Ethnicity (Self identified)	Biological Science Concepts		Total	Mātauranga Māori Concepts		Total
Manu	Māori	6	3	9	12	-	12
Spec	Sāmoan	6	-	6	2	-	2
Rose	Khmer	10	-	10	0	12	12
Dee	Māori	-	3	3	3	20	20
Sam	Māori	10	-	10	4	-	4
Nadia	Sāmoan	20	-	20	15	-	15
Anders	Māori	8	-	8	2	-	2
Sina	Māori/Sāmoan	4	-	4	1	-	1
Lavinia	Tongan	2	-	2	18	-	18
Chloe	Māori	16	-	16	20	-	20

KEY: Green numerals are statements in support of 1080
Red numerals are statements opposed to 1080

The triadic epistemic agency framework

Epistemic agency describes how students locate themselves by using a combination of one or more of the following three processes: positioning, navigating and experiencing these knowledge worlds. From an interpretation of Nakata's (2007) concept of the 'locale of the learner', incorporating these three processes, a framework was created to represent how students respond to and deal with the knowledge available to them.

These expanded descriptions, presented in Fig. 1, have been interpreted and defined as agentic processes with respect to knowledge use in the following ways. For example:

- **Positioning.** Whenever students decide to either include or discard information.
- **Navigating.** Whenever students negotiate and critique the relevance, suitability and compatibility of the information.
- **Experiencing.** Whenever students recount their experiences or describe the experiences of others.

Coding using the Triadic enabled statements to reveal their agentic processes shown thus:

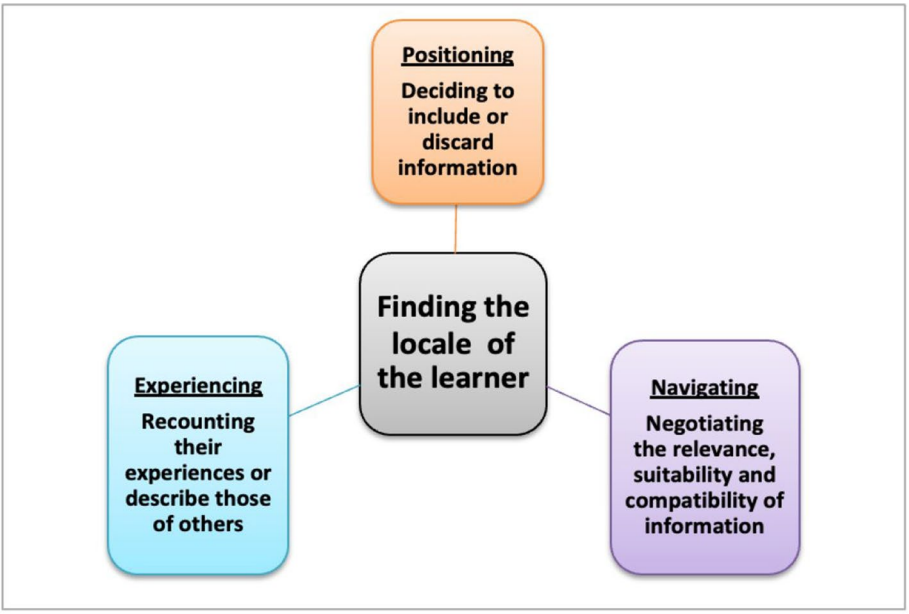


Fig. 1 The triadic epistemic agency framework. (Color figure online)

…and because I'm Māori myself, I know that, well I'm not really in touch with the whole culture and land and I don't really understand the whole beliefs behind it, but my Nana is really like a really strong Māori like she grew up in that community…. She is old school, old fashioned.

This shows the presence of all three agentic processes in one statement, with each colour representing an agentic process. The Triadic, applied deductively, enabled a deeper systematic exploration of student data to reveal more about how students at the cultural interface used scientific and cultural knowledge as they justify their view towards the use of 1080. Consequently, it represents the mechanism in which the students can locate their locale at the cultural interface (Fig. 2).

Representing the three knowledge world interfaces

The three distinctive knowledge world interfaces are presented in Fig. 3. The features common to all three illustrations are:

- The **biological knowledge domain** and the **six named biological concepts** appear in **blue**.
- The **mātauranga Māori knowledge domain** and the **seven named cultural concepts** appear in **green.**

The arrows representing the knowledge drawn from each of the domains are orientated in such a way as to illustrate the outcome of the distinctive epistemic agency demonstrated by the participants at each of the three knowledge world interfaces. Unique to each

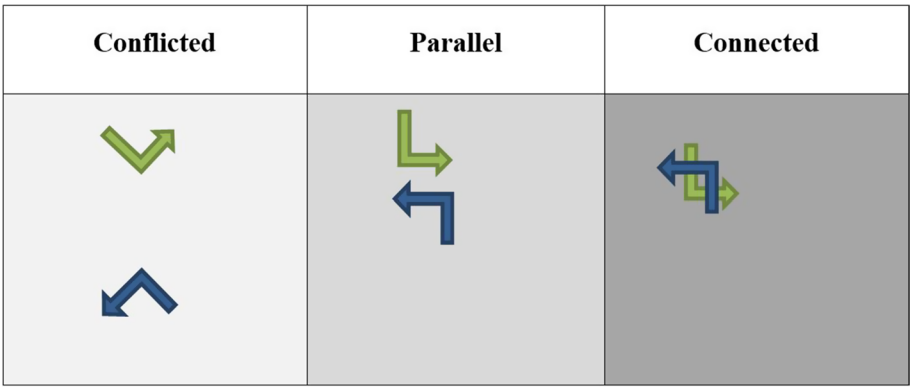
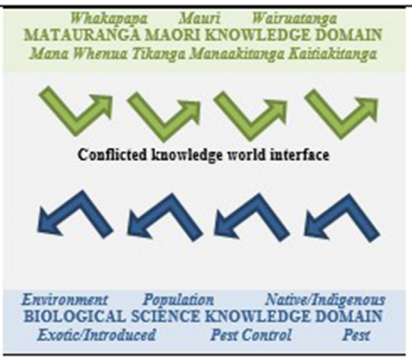
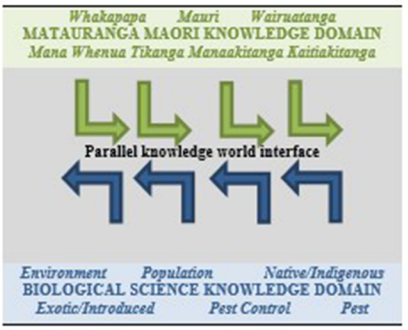


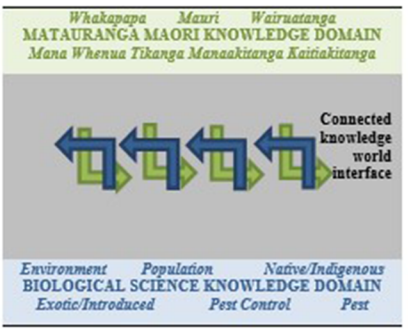
Fig. 2 Arrows representing the three distinct types of epistemic agency at each knowledge world interface. (Color figure online)



(a) Conflicted knowledge world interface. Conceptual knowledge drawn from both knowledge systems is orientated **back towards their origins**.



(b) Parallel knowledge world interface. Conceptual knowledge drawn from both knowledge systems is orientated in **parallel.**



(c) Connected knowledge world interface. Conceptual knowledge drawn from both knowledge systems is orientated to **connect** and **interweave.**

Fig. 3 Three knowledge world interfaces. (Color figure online)

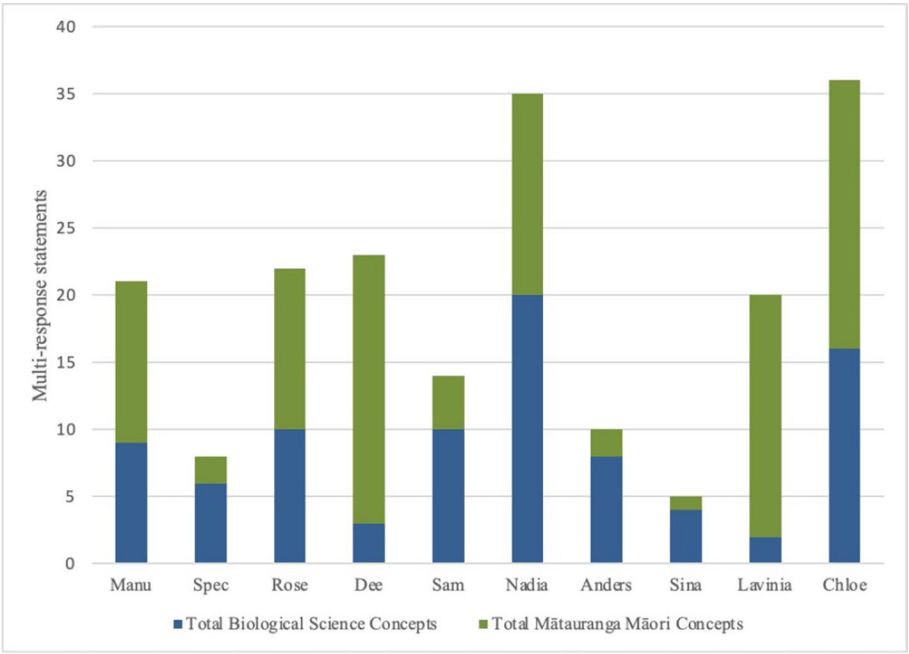


Fig. 4 Number of biological and mātauranga Māori concepts used by each participant. (Color figure online)

interface is the orientation, shape and proximity to each other of the blue and green arrows in the 'space in between' the two knowledge domains and shaded grey appear in Fig. 2.

Results

Drawing from both knowledge worlds

Table 2 shows the total number of concepts from both knowledge systems each participant used to support or oppose 1080 use. Figure 4 displays the total number of biological and mātauranga Māori concepts used by each of the ten participants. This establishes that for these participants, a shared knowledge space exists.

Table 3 Biological science concepts used by participants

	BIOLOGICAL SCIENCE CONCEPTS	HS 04	HS 12	HS 19	HS 20	SS 27	SS 28	SS 32	SS 34	SS 37	SS 39
	Pseudonym	Manu	Spec	Rose	Dee	Sam	Nadia	Anders	Sina	Lavinia	Chloe
1	**ENVIRONMENT**										
a	The environment as a non-specific entity		1			1	2				2
b	The environment is separate from living organisms			1						1	1
c	The environment is comprised of living, named organisms			1			1				1
d	The environment comprises living (biotic) and non-living (abiotic) factors										
2	**POPULATION**										
a	A group of named organisms living in an area	1		1		1	1	1			
b	Population numbers can change	2	3			2	2	2			
c	A change in the numbers of pests influences the numbers of the native population	1		1		1	1	1			
3	**NATIVE/INDIGENOUS**										
a	Native species are named	1 + 1		1			2				
b	Native species belong to New Zealand	1		1		1	3	1			3
c	Native species are targeted by introduced species			1		1	3	1			1
4	**EXOTIC/INTRODUCED**										
a	Introduced rats are mammalian pests										1
b	Introduced rats negatively affect native populations										
c	Humans brought the pest into the habitat	1									
d	Introduced pests can be predators										
5	**PEST**										
a	The pest is named as an animal				1		3		1		1
b	The pest animal is identified as a mammal					1					1
c	The pest is an animal introduced from elsewhere; by humans										1
d	Pests are harmful to a named species				1		1				
e	Humans are also pests	1									
6	**PEST CONTROL**										
a	A target species can be targeted					1	1	1	1	1	1
b	1080 is a poison that can kill			2	1			1			1
c	1080 can control pest population numbers		1						1		
d	Alternative methods of pest control		1	1		1			1		
	TOTAL	9	6	10	3	10	20	8	4	2	16
	KEY										
1	Represents a single statement supporting 1080 use										
1	Represents a single statement opposing 1080 use										
2	Represents two statements supporting 1080 use										
2	Represents two statements opposing 1080 use										
1 + 1	Represents two statements: 1 in support and 1 opposed to 1080 use										

Mapping the cultural interfaces

To support the existence of a specific knowledge world interface, three students' evidence is presented to illustrate how they demonstrated their agency, which characterised their individual cultural interfaces. Using the Triadic (Fig. 1) as a guide, quotes from participants appear highlighted in a colour to indicate which agentic processes they used as they actively engaged with the information as follows.

Table 4 Mātauranga Māori concepts used by participants

	MĀTAURANGA MĀORI CONCEPTS	HS04	HS12	HS19	HS20	SS27	SS28	SS32	SS34	SS37	SS39
	Pseudonym	Manu	Spec	Rose	Dee	Sam	Nadia	Anders	Sina	Lavinia	Chloe
1	**WHAKAPAPA**										
a	Kinship of all living things descended from the gods	2		5	5		5			4	2
b	Unity among humans, living and non-living elements of the natural world (e.g. land)			1	3		1			2	
c	The source of knowledge inherited from ancestors			1			1			1	
2	**MAURI**										
a	Force that links the physical to the spiritual world			1	1					1	
b	Source of respect towards all things				1						2
c	Vitality/fruitfulness of the natural environment				2					1	1
d	Enabler for everything to live in accordance with the conditions and limits of its existence				1						2
3	**WAIRUATANGA**										
a	Material world is subordinate to spiritual world			1							
b	A spiritual connection to land								1	1	
c	Karakia/incantations to ensure spiritual safety										1
4	**MANA WHENUA**										
a	Mana – the power of the gods, ancestors, land and the individual			1						1	
b	Mana whenua - authority/control over the management of natural resources					1		2		2	1
5	**TIKANGA**										
a	An expression of values	1			1		4		1	2	1
b	Customary practices, beliefs, rituals and protocols	2		1	1	3	2			1	6
6	**MANAAKITANGA**										
a	Acts of caring by showing respect and kindness	1			2					1	
b	Holistic nurturing of relationships through reciprocation, by acknowledging worth and ensuring safety	1			1		1			1	
c	Demonstrating mana-enhancing behaviours				1 + 1						
7	**KAITIAKITANGA**										
a	Active guardianship of the environment in accordance with tikanga	2	1	1	2		1		1		1
b	Protection of the natural environment and its taonga	2	1								2
c	There are human, non-human or spiritual kaitiaki	1		1	1						1
	TOTAL	12	2	12	23	4	15	2	3	18	20
	KEY										
1	Represents a single statement supporting 1080 use										
1	Represents a single statement opposing 1080 use										
2	Represents two statements supporting 1080 use										
2	Represents two statements opposing 1080 use										
1 + 1	Represents two statements: 1 in support and 1 opposed to 1080 use										

- **Positioning.** This took place when students made **decisions** as they **chose** to **include** or **discard** the information. Quotes are ***dark orange*** with significant words or phrases ***underlined***.
- **Navigating.** This took place when students **negotiated** and **critiqued** the **relevance, suitability** and **compatibility** of the information. Quotes are ***dark purple*** with significant words or phrases ***underlined***.
- **Experiencing.** This took place when students **recounted their experiences** or **described those of others.** Quotes are ***teal blue*** with significant words or phrases ***underlined***.

From this, the interfaces of three participants will be discussed to provide a detailed examination of a strong example of each interface type: Manu's conflicted interface, Rose's parallel interface and Chloe's connected interface. The evidence presented will be interpreted to show how they experienced the different knowledge worlds that characterise their knowledge interfaces, which are presented for each student.

Manu's conflicted knowledge world interface

Epistemic agency is displayed by the information Manu gathered and responded to. As the sole occupant of a conflicted knowledge world interface, Manu supported the use of 1080. They did not connect, combine, overlap or interweave the knowledges. Instead, Manu maintained a distance between the two knowledge systems and discussed their decision to openly favour the use of concepts from one knowledge world in preference to the other.

Manu's interface world is a conflicted one, where the approach to possum control is viewed simultaneously from two opposing, potentially conflicting perspectives. On the one hand, the possum is viewed as a highly respected taonga, treasured through a duty of care by the exercise of respectful behaviours towards the animal under Māori customary practice as manaakitanga. On the other, the animal is viewed as a pest to be eradicated. Manu also saw the information from each system as distinct and potentially conflicting. The agentic processes of navigating and positioning were revealed through Manu's explanation as to how they dealt with information which appeared to be at odds with their knowledge world.

Manu's agentic positioning developed from an increasing awareness of a growing disparity between the two knowledge worlds. Manu distinguished between clinical, academic, factual evidence on one side and cultural evidence on the other. The two domains seen as increasingly incompatible and conflicted.

*When I was writing **I sort of took it from an academic point** where it is sort of **clinical and just stating facts.***

Manu contrasted these factual, 'clinical' references with those termed 'cultural.'

*Because even here where it is under cultural **even though I am Māori,** I put culture in **New Zealand forests were protected by tangata whenua**.*

After acknowledging their Māori identity, then critiquing the relevance of the information, Manu decided to discard information that was increasingly at odds with their culturally held beliefs. Through the agentic process of positioning, Manu stepped back and detailed how they dealt with these two competing, contradictory knowledge domains.

*I didn't mention that I was part of the [Māori] people. **I sort of distanced myself** to put it onto the paper. **I sort of put a distance between my own [cultural] beliefs and the [scientific] facts.***

As Manu distanced himself from their Māori whakapapa, they regarded their Māori cultural beliefs as non-factual and incompatible with scientific information. Manu dealt with this incompatibility by putting a distance between 'the facts' and their 'cultural beliefs'. Manu saw a clear distinction between 'beliefs'—based on cultural thinking—and academic 'facts' sourced from scientific literature. This was reinforced when Manu made a direct reference to their ethnicity as they described how they separated a Māori worldview when discussing the issue from a 'factual-clinical' perspective.

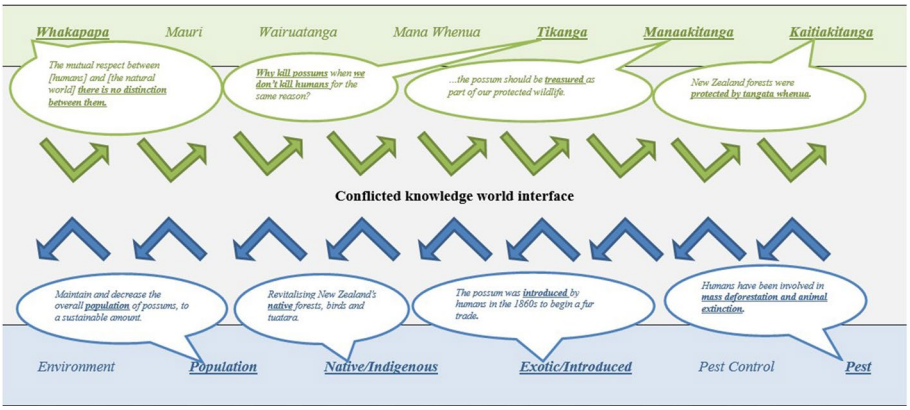


Fig. 5 Manu's conflicted knowledge world interface. (Color figure online)

I am no longer a part of being Māori when I was doing this, I sort of separated myself and stated what it was.

Manu's overt strategy to distance themself from their Māori cultural heritage prior to putting their justifications on paper reinforces that a process of navigating was also occurring.

As an active agent at the cultural interface, Manu's decision to draw support from one knowledge world, while at the same time distancing themself from the other, illustrated the degree to which they saw the two knowledge worlds as incompatible and potentially conflicting as they made the conscious decision to leave aside their cultural domain in favour of the scientific one. This is reinforced by the reason Manu gave for the dominance of one worldview 'Western culture' over the other 'Māori culture' revealed how Manu viewed the influence of the two knowledge worlds as they navigated them.

Again, there was just the assessment standard, but I feel like I guess in a way it sort of reflects New Zealand I guess, you know, we are watched over by western culture I guess, and just a dab of Māori culture.

Manu saw a dominance of Western thinking and culture over their Māori cultural view which characterised their agentic approach as they grappled with two knowledge worlds increasingly at odds and conflicted. Manu's conflicted knowledge world interface is displayed in Fig. 5.

Rose's parallel knowledge world interface

Rose maintained both knowledge systems in an unconnected but parallel fashion as they actively used information from both systems to support their views about the use of 1080. They occupied a parallel knowledge world interface.

Rose justified their support for 1080 by using biological knowledge while at the same time drawing upon mātauranga Māori knowledge to justify their opposition to 1080 use. On the one hand, Rose favoured the use of 1080 as an efficient, effective method of pest control in contrast to the more traditional methods of controlling possums, such as trapping. On the other hand, Rose made use of the concepts of whakapapa, mauri, wairuatanga and elements of the concept of kaitiakitanga in their developing opposition to 1080. Thus, Rose's paralleling of concepts from the two knowledge domains became increasingly evident.

With the concept of whakapapa, for example, the view that there is kinship and unity between all living things resonated with Rose who described the relationship the natural world has with the non-living (spiritual) world through whakapapa. In referring to a specific advantage to humans of this close relationship, they referred to the natural world as a form of navigational aid by giving knowledge and understanding to humans.

…as the natural world 'speaks' and gives knowledge and understanding to humans.

Rose understood that through a whakapapa connection, humans derive and receive their knowledge about, and understanding of, the natural world through a channel of communication where whakapapa is the conduit. Rose also referred to the force that binds humans and the natural world through mauri as a source of human power, referred to as 'nature'.

You would think there was no relationship but really it means so much because it was a source of power to humans and humans were our source of power to nature itself.

Rose used the agentic process of positioning by including information from other viewpoints and showing an awareness of mātauranga Māori when discussing some of the cultural information which had both relevance and compatibility with their views.

Thinking of the people of the land obviously and how they connect this topic to their cultural beliefs but also spiritual beliefs…kaitiakitanga.

As Rose continued to gather more information, they began to realise the negative effects the 1080 poison had on the animal. This tempered their initial support for 1080 use.

Along the way ***when I was able to do more research, I just thought it is really unfair.***

This new information challenged their initial belief that the poison was safe and worked quickly on the animal. Continuing to navigate, Rose continued to demonstrate learner agency, showing how negotiation helped towards a final view referred to as a new perspective.

So, [looking into another culture] that and learning tangata whenua just people of the land. It made me think that was my new perspective, learning other people's view. That is how it helped me come up with this perspective.

Through a growing awareness of other points of view, Rose saw how this related to a difference in the priorities inherent within these two different worldviews. Rose's agentic approach towards these different worldviews was not to discard or deny one in favour of the other, but to accept and embrace the difference as if each had its own legitimacy based on the cultural domain from which it originated. Rose continued to demonstrate the process of navigation and how these two co-existent and parallel worldviews assisted the development of their final view on the issue.

…and that is what I found out about those two groups, and it helped me come down. Those two perspectives actually helped me conclude my overall thinking.

The twin agentic processes of navigating and positioning, exemplified in this quote, characterised how Rose approached the two parallel knowledge worlds, summed up best by their changing views about 1080 use.

Because thinking about it, if I was to do it in the beginning it would have been for 1080. Looking at it back now it is actually against because in the beginning I actually agreed on [the use of] 1080.

This typified the parallel interface. Rose's parallel knowledge world interface is displayed in Fig. 6.

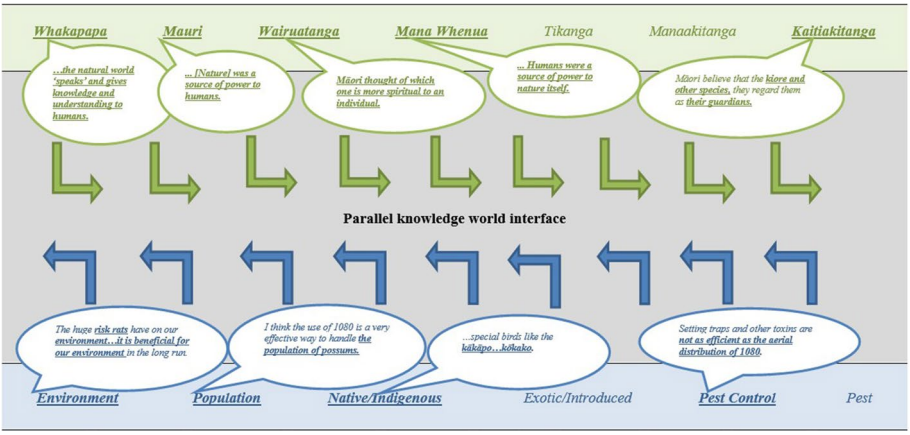


Fig. 6 Rose's parallel knowledge world interface. (Color figure online)

Chloe's connected knowledge world interface

Chloe connected both knowledge systems by actively bringing together and uniting information to support the use of 1080. Chloe occupied a connected knowledge world interface.

Personally, I support the use of 1080. Whilst researching about the poison, I gained a clear perspective and was able to come to a conclusion about where I stood. Having known nothing about 1080 or its purpose prior to this assessment, I feel as if I am able to make a rationalised judgement.

Chloe's 'rationalised judgement' on this issue relied on a combination of navigational and positioning ability which confirmed an active, agentic approach towards gathering relevant information.

Because there have been a mass amount of [scientific] research carried out by multiple organisations, I am allured to condoning the use of 1080.

Chloe's justification for the use of 1080 also revealed an integrative approach, acknowledging the pest animal problem and the likelihood of it worsening if left uncontrolled.

The problem of these pests is only going to grow and grow and is only getting worse.

Drawing further from the scientific domain, Chloe mentioned a preferred method of pest control related to a rationale based upon support for saving Aotearoa–New Zealand's native populations of birds and plants.

So, methods like aerially dropping 1080 have to be put into action in order to save our native birds and plants. New Zealand lacks native mammals with the exception of the bat, so protecting our unique species needs to become our responsibility, and I believe 1080 is the most effective way to maintain and prioritise the survival of our native birds and plants.

Chloe supported 1080 by navigating through several biological concepts. This showed a high level of understanding of the environmental effects of the pest animal, and the benefits to the environment and its inhabitants following the removal of the pest population using the poison.

I was like poison rats died like sort of how I felt about it but when I sort of understood the huge risk rats have on our environment, I sort of understood why 1080 was being used…

The rational approach Chloe took towards considering the use of 1080 was summed up in their acceptance of the need to exterminate the rat and connected to the benefits to our native bird populations (such as the kākāpo and kōkako) of their demise, which outweighed any slight concerns held for the eradication of the threatening rat population.

…and even though it is sad that lots of rats have died, ***it is beneficial for our environment in the long run*** *because, you know,* ***special birds like the kākāpo…kōkako.*** *They are able to sort of live easier without the rats because the* ***rats pose a huge threat to their population.***

In favour of eradication of the rat pest, Chloe elaborated on the special nature of birds and called for their protection using kaitiakitanga.

I would say a special bird, not a special bird that's not really the right word, but I feel like we are ***getting so scarce with the native birds*** *in our country and* ***what [small populations of] birds we do have left we would want to protect them in any way that we can.*** *So,* ***getting rid of the rats would be the best way to do that.***

Chloe also mentioned some first-hand experiences of 'the impeccable greenery' of Aotearoa–New Zealand's forests and the negative impact of mammalian pests on our forests.

Growing up in New Zealand my whole life, ***I have witnessed the impeccable greenery from the abundance of forest and local rivers. I have also witnessed*** ***the fast-growing problem of introduced mammalian pests such as rats pose on our environment.***

Chloe illustrates the agentic process of experiencing, vividly recounting regular visits to an area of regenerating native forest to collect plant material from selected native flora for use in Rongoā Māori (traditional Māori medicinal knowledge and practices).

[My grandmother] makes this sort of medicine and when I used to go out and get the, I forget what it's called that she uses, but every time that she would take it, she would always say a karakia *just to* ***ask basically the land god for permission.***

The recitation of karakia (incantations) prior to the removal of plant material from the forest was a respectful customary practice that acknowledged the wairua of the forest in accordance with tikanga Māori. It is an active process to seek permission from the kaitiaki, spiritual guardians who inhabit the forest, to allow the mortal humans to safely remove the plant material. Chloe explained.

It's all natural and she cooks it up in a pot and my sister wants to go and get that plant that she uses, but my Nana said there's so much more than just go picking up the plant, because she believes you need to ask for permission for all the stuff.

To illustrate the depth of Chloe's understanding and experiences and how these provided a link between the two knowledge worlds at the cultural interface, Chloe shared the strategy used to organise new research material, sorted into knowledge baskets.

There was a lot of information in this little....in my basket. I have my social basket, I have my 1080 basket, I have my biological basket, that is what I do a lot actually…. And incorporate it somehow into my report.

Chloe acknowledged the specific reference to knowledge baskets, which are synonymous with the concept from Te Ao Māori of the three baskets of knowledge obtained by the forest god Tāne Mahuta in pre-human times. Chloe then illustrated the agentic process of positioning by describing the contents of each knowledge basket. For example, Māori cultural knowledge was placed into the 'social basket'. This was followed by a rationale for this decision based on the agentic process of experiencing related to Māori worldviews.

Well, say I found something to do with Māori like how they see the land. I would put that in my social basket, because it sort of relates to community and how people react to 1080 and how they sort of view it.

Chloe used whenua (land) as an example and continued.

…and because I'm Māori myself, I know that, well I'm not really in touch with the whole culture and land and I don't really understand the whole beliefs behind it, but my Nana is really like a really strong Māori like she grew up in that community…. She is old school, old fashioned.

Chloe seamlessly wove together two knowledge worlds at the connected knowledge world interface and demonstrated the importance of experience to connect biology and mātauranga Māori. Chloe's connected knowledge world interface is displayed in Fig. 7.

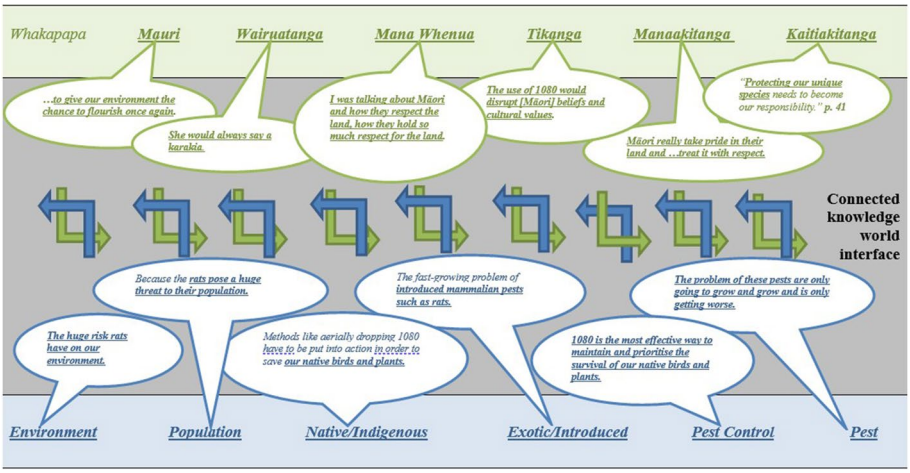


Fig. 7 Chloe's connected knowledge world interface. (Color figure online)

Discussion

This study asked how students use knowledge from two systems when constructing arguments about a socioscientific issue. By using the Triadic as an empirical-analytical tool, this study demonstrated the multi-conceptual space of the cultural interface whose inherent validity resides in the coexistence of Western scientific and non-Western mātauranga Māori knowledge worlds.

The Triadic enabled the application of the concept of epistemic agency to reveal *how* the participants *wove together* aspects from both knowledge systems and populated the cultural interface by drawing upon biological concepts *and* mātauranga Māori concepts to justify their support or opposition to the use of 1080. A shared discussion space occurs where more than a single discourse can coexist within the controversy as shown by the voices of these ten participants as they participated in the 1080 debate. Amongst the ten, there exist three distinctive cultural interfaces: conflicted, parallel and connected. Together, these three interfaces—conflicted parallel and connected—illustrate the spectrum of student epistemic engagement, from compartmentalisation to full synthesis. These variations reflect both individual dispositions and institutional structures. The cases of Manu, Rose, Chloe exemplify the spectrum of epistemic agency enacted at the cultural interface.

The evidence presented in this report extends our understanding of the cultural interface and the role of learner agency when students use knowledge to support their positions on a socioscientific issue. Furthermore, the evidence confirms Nakata's (2002) view of the interface as a place where learners are active agents as decision-makers within an agentic space where the importance to learners of their personal agency is recognised and revealed by the participants as they negotiated 'the expanse in between' (Paul Meredith 1999). It has been shown that when students enact their epistemic agency (Zimmerman and Weible 2018) by engaging with and mobilising their knowledge resources within an authentic socioscientific issue in ways that are new for them, their cultural interfaces and learner locales are revealed.

Conclusion

Two major findings enrich our understanding of the importance of recognising the theoretical space of the cultural interface for diverse learners in our science classrooms. The focus of this research was to seek answers to the question of how biology students use knowledge concepts when discussing a controversial socioscientific issue.

The first finding is to confirm that for some, diverse learners' knowledge world interfaces do exist within the dialogic spaces of a socioscientific issue. The second is that within these knowledge spaces, learners exhibit a set of behaviours characteristic of their epistemic agency when they drew upon and utilised information from two knowledge systems—biological science *and* mātauranga Māori. This, in turn characterised their cultural interfaces, learner locales and knowledge worlds. Significantly, this research combined the theoretical concepts of the cultural interface and locale of the learner with the notion of active epistemic agency.

The Royal Society of New Zealand Report (2012) titled *The Future of Science Education in New Zealand,* asked what is meant by the term "The knowledge society." Central to their thesis is an acknowledgement that how knowledge is thought about and used will change. Knowledge will change from being "something to accumulate" to "something that does things". It will require a reorientation to view knowledge as a verb (as something we do) as suggested by Jane Gilbert (2005), rather than as a noun (as something we have). The findings from this study illustrated how the Triadic could be an effective teaching and learning tool that enables an active engagement with diverse knowledge systems.

How this knowledge reconceptualisation might look in practice has been illustrated in this study and offers ways to address equity in assessment by taking a broad, inclusive focus on knowledge world contributions. From this emerge two useful pedagogical practices that could be adopted by science teachers.

Firstly, the Triadic could be the starting point to develop learning activities that encourage students to apply agentic processes to the use of knowledge concepts from Western science and non-Western epistemologies. For example, learners who already apply agentic processes to the use of knowledge would extend their repertoire of skills. This would validate their knowledge use and reward their approach to learning.

Secondly, this would require teachers to be upskilled in pedagogies to enable the epistemic agency of their students to flourish. They could teach students the processes and skills of agentic learning. Specifically, the Triadic would target the students' application of the three agentic processes when they are faced with knowledge concepts from Western science and non-Western epistemologies. These teacher development practices will foster agentic knowledge use and critical engagement with science.

Two fruitful areas for further research would see the Triadic tested and refined. Firstly, the model could be trialled with pre-service teachers to pilot its use with junior secondary school science students who are discussing a socioscientific issue. This could be expanded to include schools. Secondly, the framework could be used in different SSI contexts. For example, Pacific epistemologies would enable a specific focus on the cultural interface for Pacific learners using Western science within Pacific socioscientific issues such as immunisation or climate change and the effects of sea-level rise on low-lying atolls and islands. Of most importance, the outcomes would contribute to enriching our understanding of scientific literacy and knowledge use by Māori and Pacific learners in English medium secondary school science and biology classrooms.

This study illustrated the value of epistemic agency at the cultural interface within the biology curriculum. Pluralist knowledge use among culturally and linguistically diverse learners promotes critical engagement with socioscientific issues (SSI) in senior secondary school biology. Teachers can use the Triadic with students to connect their lifeworlds to the epistemically creative space of the cultural interface—alive with richness and unlimited, ongoing potential.

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Data availability The datasets generated during and analysed during the current study are not publicly available as permission was not sought from the participants to release their data as part of the ethics application.

Declarations

Competing interests The authors declare no competing interests.

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