Research in Science Education
https://doi.org/10.1007/s11165-025-10239-z

Does Topic Matter? Investigating Students' Interest, Emotions and Learning when Writing Stories About Socioscientific Issues

Senka Henderson[1] · **Louisa Tomas**[2] · **Donna King**[3]

Accepted: 17 February 2025

Abstract
This case study of a Year 8 science class in South-East Queensland investigated the affective and cognitive experiences of engaging students in a science-writing project. Building on the work of Tomas, Rigano and Ritchie (2016), students wrote a series of short stories across two school terms about the socio-scientific issues (SSIs) of coal seam gas (CSG) mining and skin grafting. Data were collected using an emotion diary (in which students self-reported their interest and emotions at the end of each lesson), written thinking prompts (designed to elicit students' evolving understanding of each SSI) and semi-structured, end-of-project student interviews. Three main assertions emerged from analysis of these data. First, students' self-reported interest was statistically higher in relation to skin grafting compared to CSG. Second, interest and positive emotions reported by students in the skin grafting unit were associated mostly with the topic, while in the CSG mining unit, they were related mostly to pedagogical approaches. Thirdly, students could explain the scientific, social, moral and ethical dimensions of each SSI and an evidence-informed position at the end of both units. These assertions support our thesis that topic *does matter* when engaging students in writing stories about SSIs. At the same time, while the results of this study support the learning affordances of SSIs, they suggest that the teacher's pedagogical decisions *also matter* in keeping students cognitively and affectively engaged when learning about a less interesting or relatable topic.

Keywords Socio-scientific issues · Topic · Emotions · Interest · Stories · Science education

Introduction

Science education scholars have long called for engaging pedagogical approaches as a way of curbing students' waning interest in science, particularly in the middle years of schooling (Years 5–9) (e.g., Henderson & King, 2021, King & Henderson, 2018; Pusey & Pusey, 2015). Evidence suggests that negative experiences in these crucial years can serve to disen-

Extended author information available on the last page of the article

Published online: 05 March 2025

gage students and discourage them from electing to study science during the senior secondary years of schooling, or pursue science-related careers (Anderhag et al., 2016; Goodrum et al., 2012; Program for International Student Assessment [PISA], 2022; Potvin et al., 2020).

We have been involved in a program of research that has investigated the affordances of engaging students in an innovative writing-to-learn science approach known as *BioStories.* The BioStories project has engaged students in Years 5 to 12 in primary and secondary schools across Queensland, Australia, in writing short stories about contemporary socio-scientific issues (SSIs) such as biosecurity, coal seam gas (CSG) mining, organ and tissue donation, and assisted reproductive technology (see Ritchie & Tomas, 2013; Ritchie et al., 2011). SSIs are complex (and often controversial) problems that implicate science, technology and society, and require "a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues" (Zeidler & Nichols, 2009, p. 49). In doing so, they consider the ethical dimensions of science, as well as students' moral reasoning and emotional development (Zeidler et al., 2002).

BioStories may be described as a merging of genres; a 'hybridised' approach wherein students integrate scientific research and communicate their understandings through stories. While story writing is not commonly associated with teaching in science, this pedagogical approach is well-suited to engaging students with complex SSIs that do not lend themselves to other more traditional forms of experiential inquiry in science (e.g., practical science investigations and demonstrations). They also provide a vehicle through which students can explore and communicate the moral and ethical dimensions of SSIs.

Previous research has shown that writing BioStories develops both cognitive and affective learning outcomes in science by enhancing students' conceptual science understanding, as well as their interest and engagement (e.g., Ritchie et al., 2011, Tomas et al., 2011). Several studies have also examined students' emotional engagement when learning through BioStories (Tomas & Ritchie, 2012; King et al., 2015, Ritchie et al., 2011, King et al., 2017; Bellocchi & Ritchie, 2015). For example, Tomas and Ritchie (2016) found that Year 12 students who wrote stories about biosecurity found that the project elicited a range of emotions including pride, strength and determination, which were associated with their interest in learning about a new SSI, and their enhanced feelings of self-efficacy in successfully writing hybridised scientific narratives in science.

While there is a compelling body of empirical evidence that supports BioStories as an effective approach to enhancing students' cognitive and affective outcomes in science, and eliciting positive emotions, we were specifically interested in investigating whether *topic matters* when engaging students in writing stories about SSIs. This research is important given that no previous studies have investigated the value of different topics in this context, particularly given the diverse range of SSIs that students have written about through the BioStories project. In this study, we investigate the learning experiences of students in two Year 8 science classes who wrote stories about CSG and human skin grafting. We examine trends in students' self-reported interest and emotions, as well as their learning of science concepts, with a view to understand better the relationship between topic, emotions, interest and learning. Our overarching research question was, *Does the topic matter for students when writing stories about SSIs in science?* Specifically, our inquiry was guided by the following sub-questions:

1. Was there a difference in students' self-reported interest and emotions across the two SSIs?
2. In which lessons did students report heightened interest and positive emotions?
3. What occurred in these lessons to account for students' heightened interest and positive emotions?
4. What learning occurred for students across the two SSIs?

We begin by examining the theoretical perspectives that inform our understanding of emotions, before outlining our methodological approach to investigating these research questions.

Theoretical Perspectives

While definitions of emotions vary, depending on researchers' perspectives (biological, cultural, cognitive, or behavioural) (Turner, 2009), scholars generally agree that emotions are affective responses occurring in relation to a specific referent that are quick, automatic, often unconscious, and generally include a physiological response (e.g., increased heart rate) (Rosenberg, 1998).

This study was informed by Turner's (2007) sociological theory of human emotions, where emotions may be considered as "words and labels that humans give to particular physiological states of arousal" (Turner, 2009, p. 2). Turner's theory asserts that emotions are produced in "sociocultural conditions and once aroused (will) have effects on these conditions" (Turner, 2009, p. 342). This theory is founded on the premise that the dynamics of specific emotions and the social organisation that causes the arousal of discrete emotions are important in theorising about human emotions.

According to Turner (2007), there are four primary emotions: assertion-anger, aversion-fear, disappointment-sadness, and satisfaction-happiness. Emotions have been categorised into two valanced states by Stets (2010), as positive and negative (e.g., happiness/joy and enthusiasm would be valanced positive, while embarrassment would be negative) (Turner, 2007). In humans, emotions also can be aroused in varying levels of intensity from low through to medium and high-intensity states. For example, the medium intensity variant for satisfaction-happiness is enjoyment, while the high intensity variant is joy.

Research suggests that cognitive engagement is a mediator between emotions and academic achievement (Linnenbrink & Pintrich, 2004; Pekrun, 2006; Pekrun & Linnenbrink-Garcia, 2012) and that there are many ways to characterise cognitive engagement. Fredricks (2011) explains that cognitive engagement occurs when students willingly engage in effortful tasks with a purpose and use self-regulation to complete the task. Other researchers have described it as being related to the student's quality of thinking due to the cognitive strategies used such as elaboration, rehearsal or metacognitive strategies (Linnenbrink, 2007). These perspectives indicate that high engagement is associated with "students' deep, systematic and intentional processing of content which enhances opportunities for learning" (Sinatra et al., 2014, p. 415).

'Topic emotions' are a subtype of academic emotions that are expressed by students during learning in relation to a specific topic within a domain of study (Broughton et al., 2013; Pekrun & Stephens, 2012). Learning about certain scientific topics, especially controversial topics, has potential to trigger highly emotional responses amongst students. For example, global warming, genetically modified food, climate change, stem cell research, COVID-19, alternative fuels, and the reclassification of Pluto could be considered 'hot topics' in science (Broughton et al., 2013; Heddy et al., 2017; Hufnagel, 2015; Lombardi & Sinatra, 2013) that can elicit a myriad of emotions, either positive or negative. When students view a topic as controversial (such as climate change), or when a topic seems disconnected from previous experience or identity (such as Pluto's demotion to dwarf status), they can experience negative emotions (Sinatra et al., 2014). On the other hand, students can express positive emotions when a topic arouses interest (e.g., Tomas & Ritchie, 2012).

Research has revealed that different pedagogical approaches can impact students' interest and topic emotions, as well as their conceptual development (e.g., Heddy & Sinatra, 2013; Lombardy & Sinatra, 2013). For example, a study by Heddy and Sinatra (2013) examined the efficacy of the *Teaching for Transformative Experiences in Science* (TTES) model (Pugh, 2002) for developing college students' conceptual understanding and positive affect in learning about evolution. Students who experienced the TTES approach that modelled transformative experiences demonstrated a significant increase in enjoyment of the course content from pre-test to post-test, as well as higher levels of transformative experience than the comparison group. The authors argue that increased positive emotions such as enjoyment are important for supporting students' learning of a difficult topic like evolutionary biology, particularly given that the topic may conflict with students' worldviews. A more recent study by Toli and Kallery (2021) employed intervention strategies such as hands-on and simulated experiments for guided investigative tasks with second-year junior high school students learning about energy in Greece. The results demonstrated a notable increase in students' interest and academic achievement compared to a control group, where traditional teaching methods, such as textbook-based instruction, were used.

These studies have shown that how a topic is taught can elicit different affective responses in relation to students' interest and emotions. In the context of the current study, this research is significant, because it suggests that writing BioStories about controversial SSIs has the potential to elicit students' emotions in relation to the topic, while engaging in a novel pedagogical approach in science may further influence their emotional arousal.

Research Design & Methodology

In the following section, we begin by describing the context of our study, including our research participants and the design of the BioStories project, before detailing our approaches to data collection and analysis.

Research Context and Participants

This study was conducted at a large co-educational metropolitan school in south-east Queensland, with approximately 1750 students in years 7–12 from broad socioeconomic backgrounds. While the entire cohort of year 8 science students participated in the BioStories project (i.e., 12 classes of approximately 330 students), a single science class was selected to serve as the focus of a multi-method case study (Stake, 2005) based on a discussion with the class teacher, Mr. Sim (pseudonym). Mr. Sim had 30 years of experience teaching science. He was willing to implement innovative approaches to teaching science and improve his practice by participating in research studies.

The case study class consisted of 27 students (13 boys and 14 girls) typically aged between 12 and 13 years. This study was conducted over two 9-week period in Terms 3 and 4, which constituted a 'school semester'. In total, we attended 23 lessons in Term 3 and 26 lessons in Term 4. The science lessons were approximately 50 min in duration.

The BioStories Project

The research team had worked with the school to collaborate on curriculum design and had previously co-designed two units of work with the teachers on topics required by the *Australian Curriculum: Science V8.4* (Australian Curriculum, Assessment & Reporting Authority, n.d.) in Year 8, including energy (Term 3) and cells (Term 4). During both terms, students wrote BioStories about two different SSIs related to each content area. Selection of two topics and characters ensured the relevance and relatability to the lived experiences of both metropolitan and rural students. At the time of this study, the CSG mining was a current SSI issue that was featured regularly on the media, and it was chosen together with the topic of skin grafting by the Head of Science and Year 8 science teachers.

The context for the science unit in Term 3 was CSG mining. The unit explored concepts related to energy, energy transfer, measurement of energy and alternative energy sources. During the CSG unit, students were provided with a scenario about 13-year-old twins, Josh and Sarah, who grew up on their parents' cattle farm where the CSG mining was about to commence. The context for Term 4 was about skin burns and skin grafting. This unit explored concepts such as the structure and function of cells and function, skin structure, skin grafts and organ donations. In this unit, students were provided with a real-life scenario about a teenager, Zac, who suffered severe burns to his skin after a jet ski accident.

In both units, students were required to respond to the given scenario by writing a hybridised short story comprised of three sequential parts (Parts A-C). Students researched, drafted, edited and refined their stories in their classroom and on computers (in a computer room) over a series of six weeks. Parts A and B of the tasks required students to explain the science relevant to the SSI and explore the dimensions of the issue. For example, in Part A of the CSG scenario, students explained the process of CSG mining, how it is conducted, and the immediate implications of sinking a CSG well on the main character's farm in the story. In Part B, students wrote about why CSG mining was being developed as an alternative to coal mining for coal-fired power stations (i.e., advantages of CSG mining over coal mining; the advantages of using CSG to generate electricity, compared to coal; and any broad projected benefits). Finally, in Part C, students explored the consequences and impacts of CSG mining. In this part, students were called to draw on their research conducted for Parts A and B to develop and justify an evidence-informed position as to whether or not CSG mining should go ahead on the main character's farm. In-keeping with the tenets of SSI education, students were prompted to think about the moral and ethical dimensions of the problem by considering the viewpoints of farmers, CSG companies, consumers of electricity, and the sustainability of the environment. Students were also assessed on the systematic examination of the social and technological aspects of the issues that informed their decision-making related to organ transplantation or CSG mining, in accordance with the *Science as a Human Endeavour* strand of the Australian science curriculum.

Data Sources and Analysis

Three sources were employed in this study: an emotion diary, thinking prompts and semi-structured interviews. The emotion diary is a reliable self-reporting method for eliciting students' emotions, adapted from the work of Zembylas (2008) (see Ritchie et al., 2011). Students were prompted by Mr. Sim to complete a diary entry at the end of each lesson. Senka (Author 1) and Donna (Author 3) explained the emotion diary to students during the first lesson of the CSG unit (Term 3). After practicing a diary entry and engaging in a whole-class discussion, we were confident that the students understood how to recognise their emotions and complete the diary effectively. In this study, the emotion diaries were completed by students at the end of 49 lessons (i.e., 23 lessons in the CSG mining unit, and 26 lessons in the skin grafting unit).

The emotiondiary generates qualitative and quantitative data. Each diary entry is comprised of two parts. The first includes a table of 10 emotion labels: happiness/joy, sadness/disappointment, anger/irritation, anxiety, disgust, pride, wonder, enthusiasm, frustration, and embarrassment. Each label is accompanied by an illustrative emoji to help students identify and articulate the emotions they may have experienced. Students were asked to circle the most salient emotions they experienced during the lesson and explain what they were doing or what happened when they experienced them. They were also asked to rate the intensity of their emotions as low, medium or high. In the second part of the diary, students indicated their level of interest during the lesson on a 10-point scale (where 1='very bored', 10='very interested' and 5=neutral). The interest scale was used heuristically to identify salient classroom events, noting that some researchers dispute the classification of interest and boredom as emotions (Do & Schallert, 2004; Wosnitza & Volet, 2005). A mean interest score was calculated and graphed for each lesson by averaging students' responses. Collectively, students' self-reported emotions and interest across the duration of each unit were useful for identifying general patterns and salient classroom events that evoked heightened emotional responses.

In total, 1075 individual responses to the emotion diaries were analysed, drawn from 49 lessons. We counted individual self-reported emotions and graphed the average results across both terms (see Appendix 1 and 2). F- and t-tests were employed to statistically analyse differences in students' reported interest between two terms. The F-test was used to assess whether the levels of variability in the data sets were comparable or not. Conversely, the t-test was employed to compare the means of interest during both terms.

The second source of data employed in this study were thinking prompts. The thinking prompts were designed to elicit students' evolving understanding of each SSI. They were administered using a paper-based questionnaire at the beginning and end of each term to examine how students' responses developed over time. The thinking prompts were each comprised of eight questions related to the SSI. For example:

> What do you think are the main problems associated with using coal-fired power stations to generate electricity? What evidence do you have?
>
> Are there advantages associated with using coal seam gas to generate electricity, over coal-fired power stations? What evidence do you have?

What are the differences between first-, second- and third-degree burns?

What have you learned about skin grafting?

Students' responses to the thinking prompts were analysed qualitatively to gauge their conceptual knowledge and understanding of the different topics.

The third source of data were semi-structured interviews conducted in small groups of 3–4 students (approximately 30-minutes duration) at the end of both terms (note that all student names reported in the findings are pseudonyms). The interview questions were developed following a review of students' emotion diaries, as well as observations and field notes. Students were asked general questions about their experiences and perceptions of the unit of work and the topic (e.g., *Tell me what you learned about CSG (skin grafting) this term? How did you feel when you learned about some of the impacts of CSG on people or the environment?*); questions about completing the task (e.g., *How did you find writing stories in science in this term?*); and questions related to their emotions and emotion diary entries (e.g., *What was the strongest emotion you felt this term in science? Tell me more about what you wrote here in your emotion diary…*).

Findings

In the following sections, we present findings in support of three main assertions:

1. Students' self-reported interest was statistically higher in relation to skin grafting compared to CSG.
2. Interest and positive emotions reported by students in the skin grafting unit were associated mostly with the topic, while in the CSG unit, they were related mostly to pedagogical approaches.
3. Students could explain the scientific, social, moral and ethical dimensions of each SSI and an evidence-informed position at the end of both units.

These assertions support our thesis that the topic *does matter* when students write stories about SSIs. We argue that the topic of skin grafting was perceived more favourably by the students, eliciting higher levels of self-reported interest and positive emotions. We also argue that while our findings support the learning affordances of engaging students with SSIs (specifically, in relation to learning the social, moral and ethical dimensions of each issue), the teacher's choice of instructional approaches also matters in keeping students engaged when they perceive the topic to be less interesting (as was the case in this study with CSG).

Assertion 1: Students' Self-Reported Interest Was Statistically Higher in Relation to Skin Grafting Compared to CSG

Figure 1 illustrates students' self-reported interest for all lessons across both units. We found that students' interest fluctuated across both terms, with the highest interest score for CSG being 7.69 out of 10, compared to the highest interest score for skin grafting, which was 8.67; however, an upward trend in mean interest levels was observed throughout the entire

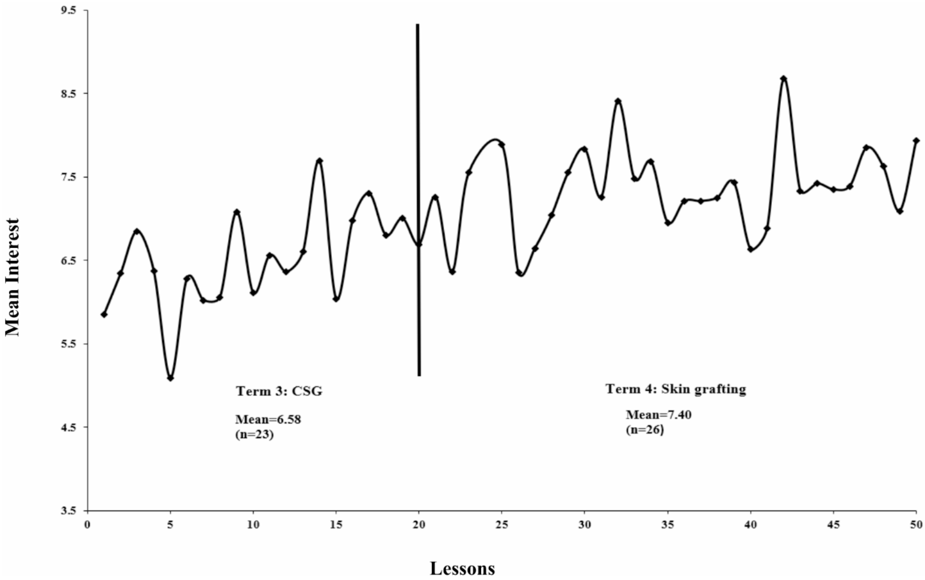

Fig. 1 Graph of mean interest as recorded by students for observed lessons for both topics in Terms 3 and 4

Table 1 Summary of statistics for F and t-test values for interest for CSG mining and skin grafting

Topics	Number of lessons (*n*)	Min.	Max.	Mean	SE	F-test	F-test range	*p* (>0.05)	*p* (T<=t) two tail
CSG mining	23	5.09	7.69	6.58	0.39	1.34104	-1.98415/ 1.98415	0.23820	5.61E-06
Skin grafting	26	6.58	8.67	7.4	0.38				

term for both topics. The lowest interest score for CSG was 5.09, and for skin grafting, it was 6.35. For both topics, higher interest was observed in lessons that were predominantly student-centred. For example, students were involved in hands-on activities, debates, role-play, decision-making activities, or research in a computer laboratory. Additionally, they participated in simulations and interactive online experiments.

Analysis of students' interest using F- and t-tests revealed a significant difference in self-reported interest in Terms 3 and 4 (Table 1). An F-test was used to compare if the levels of variability in the data test were comparable or not. The F value of 1.34104 falls within the range −1.98415 and 1.98415, with p value greater than 0.05 at 0.23820. Variance in both data sets was not significantly different. This is good confirmation that the significant differences in self-reported interest are linked to the topic since the two units of work had the same teacher and students during both terms.

A t-test was used to compare the mean interest scores in both terms. The dataset for each term is similar in its variability, representing the relative spread of differences in interest across each group of lessons. A statistically significant difference was observed [P(T<=t) two-tail 5.61E-06] which suggests that, overall, students reported higher levels of interest in the skin grafting unit compared to the CSG unit. This might indicate that students' interest increased because they were more familiar with the Biosories approach.

Assertion 2: Interest and Positive Emotions Reported by Students in the Skin Grafting Unit Were Associated Mostly With the Topic, while in the CSG Unit, they Were Related Mostly to Pedagogical Approaches

The emotion diaries were analysed by counting and graphing the frequency of the emotions reported by students in each lesson, for both terms (Appendix 1 and 2). The graphs show that students reported predominantly positive emotions in both terms; namely, happiness/joy, pride, wonder and enthusiasm. A comparable number of positive emotions per lesson was reported for both topics (30 positive emotions reported per lesson in Term 3, and 26 positive emotions reported per lesson in Term 4). Happiness (depicted in blue on the graph) and enthusiasm were reported most frequently (depicted by blue and maroon colours on the graph, respectively, Appendix 1 and 2). An average of 17 and 8.7 instances of happiness and enthusiasm were reported per lesson in Term 3, and 16.7 and 6.7 respectively per lesson in Term 4.

During both terms, learning activities such as laboratory activities, role-play, individual research on computers, practical work, group work and writing BioStories were recorded as more interesting by students and were associated with a greater number of positive emotions in comparison to lessons that were teacher-centred. It is noteworthy that a substantial proportion of lessons (65%) were student-centred (i.e., 15 out of 23 lessons in Term 3, and 13 out of 26 lessons in Term 4). In Term 4, six lessons encompassed a mix of teacher- and student-centred approaches, including a lesson featuring a guest speaker.

Interestingly, in the CSG unit, students' interest and positive emotions were associated mainly with learning activities (such as debates, working on computers or hands-on activities), rather than the topic. As reported in the emotion diaries and at interview, students expressed enthusiasm for conducting independent research for their BioStories, finding the experience "enjoyable" (Teddy) and "fun" (Mark). They also appreciated the opportunity to learn independently. At interview, students reported that they did not like the CSG mining topic, although they agreed that they learnt about the SSI and related energy concepts, and enjoyed their learning experiences, as exemplified by the following excerpt:

Excerpt 1	
Researcher:	What I'm especially interested in is your emotional journey this term and the things that you've learnt this term.
Sanjeev:	My favourite thing is um, what's it called? Energy is really hard to define. Like, the scientists. I thought it was easy to define because it's energy. It's like the ability to do work.
Researcher:	To do stuff.
Sanjeev:	I thought that … I thought that the scientists would have got it.
All:	[*laughing*]
Researcher:	What about coal seam gas? Was it an interesting topic?
Sanjeev:	Nah.
Brock:	Not much.
Levi:	No.
Researcher:	Did you enjoy the topic?
Neil:	No.
Sanjeev:	No, but I liked a debate.

An analysis of the lessons in which students reported heighted interest in the CSG mining unit revealed that students were most interested when they were learning outside of their regular classroom environment. Students were questioned about this at interview. In the following excerpt, a group of three students were asked questions about their heighted interest in relation to a science experiment. While one student (Maree) commented that the topic for the lesson (the enhanced greenhouse effect) was "important" rather than interesting, students enjoyed conducting an experiment outdoors and learning in a hands-on way:

Excerpt 2	
Researcher:	There was a week when you did a greenhouse gas experiment. You took some boxes outside and measured the temperature change in the boxes. Maree, your interest went up to 8. Was that an interesting lesson for you?
Maree:	Yes.
Chris:	Yes.
Maree:	I thought that it was important to take care of the planet. I thought that it was important and I still think it's important.
Researcher:	So that topic was interesting to you?
Maree:	No, it wasn't interesting. It was an important topic.
Researcher:	Okay. Did you enjoy the prac aspect of that day? Alison, do you like to do pracs?
Amanda:	Yeah, 'cause it was outside.
Researcher:	So, it was a different environment?
All:	*Yeah.*
Chris:	When I'm in here [in the classroom], I have this tendency to want to drift off and daydream. But like, when we're doing experiments and we're outside, there is more interest that I'm feeling.
Amanda:	More engaged with it.
Researcher:	Excellent.
Chris:	I want to be more involved.
Researcher:	Do you learn more on those occasions?
All:	*Yeah. Yes.*
Chris:	Yes, because I am paying 100% more attention.
Maree:	I think that like, when we're outside getting the fresh air and the sun, I think that we work better.
Researcher:	Okay, good point.
Chris:	And also, with the experiments, it's not just information that we're processing. We're actually proving it and putting it into action. It's probably a better way of learning.

In Term 4, analysis of students' comments in the emotion diaries revealed that the most common reason for experiencing happiness or joy was learning about the topic of skin grafting. For instance, students expressed their happiness with comments such as, "I really liked learning about burns" (Cassie), "I like learning about skin" (Tracey), "Learning new stuff" (Carrie), and references to topics such as "skin burns" (Emma) "skin grafts" (Teddy) and "organs" (Sarah).

At the interview, students were asked about the reasons for their heightened interest during the term. One student (Cassie) mentioned that while biology is not her "favourite area in science", she found learning about organ donation interesting. Another student revealed a preference for working with computers and learning about skin grafting. Despite her dislike for viewing images related to skin grafts, her interest and curiosity were heightened by her aunt's involvement in a car accident:

Excerpt 3	
Researcher:	You both have indicated in the majority of your [*emotion diary*] entries either high [*8*] or very high [*10*] interest. What do you think it was that your interest was so high?
Cassie:	I liked learning about organ donations, although Biology is not my favourite area in science. I was surprised how many people actually try to sell toddler organs through the years. And it is scary that people died trying to do stupid things.
Researcher:	What about you, Rachel?
Rachel:	Because we were often working on the computers, and I liked when we were learning about skin grafts.
Researcher:	That's interesting. Anything particular about skin grafts?
Rachel:	I didn't like images and skin grafting video that Mr Sim showed us, but I was curious to learn more about different types of grafts, as my aunt had a car accident long time ago and she got some type of skin grafts. It was interesting to see how grafting can heal affected areas. Never knew doctors use your own skin for a graft.

Like the CSG mining unit, students also reported feeling happiness or joy in relation to various learning activities, including hands-on activities, watching videos, completing worksheets, and creating posters.

Assertion 3: Students Could Explain the Scientific, Social, Moral and Ethical Dimensions of Each SSI and an Evidence-Informed Position at the End of both Units

The BioStories writing tasks afforded students opportunities to engage in moral and ethical reasoning, as they worked to develop a position on each SSI at the conclusion of each unit. Students were encouraged to challenge their own belief systems regarding social and moral phenomena (Zeidler & Nichols, 2009), such as the use of coal-fired power stations and organ transplantation. This process allowed students to engage in socio-moral discourses when confronted with ideas or evidence that did not immediately align with their past experiences or viewpoints. Analysis of thinking prompt and interview data suggests that this dissonance motivated students to negotiate, resolve conflicts and enhance the quality of their arguments.

At the end of Term 3, when prompted to discuss their understanding of CSG mining, students identified a range of concepts, drawing on evidence they had gathered from their teacher, classroom debates, internet searches, news sources and videos. Concepts included reduced air pollution and lower greenhouse gas and carbon dioxide emissions (compared to coal-fired power stations), increased job opportunities and a stronger economy. Students also identified tensions, such as concerns about taking farmers' land, and the controversial practice of fracking (including environmental impacts, such as groundwater pollution and land degradation). Importantly, analysis of students' thinking prompts demonstrated that their understanding of CSG mining improved across the course of the term (Table 2). At the end of Week 1, only 3 students in the class (13%) identified CSG-related concepts in their responses. By the end of Week 8, 13 students (59%) identified a range of relevant concepts, including the advantages and disadvantages of CSG mining, in their responses. For example, when asked about CSG mining in a thinking prompt, Emma did not record an entry in Week 1. By Week 8, however, her understanding had significantly improved. In response to the same thinking prompt, she wrote: "Yes. It is the extraction of coal seam gas (methane) and water from underground". This progression shows the development in Emma's understanding of CSG over the course of the term.

Table 2 Summary of concepts associated with CSG mining reported in students' thinking prompts in weeks 1 and 8 of term 3

Week	Number of students who identified concepts	Reported concepts
1	3/24 (13%)	Impacts on farmers, people's rights, land use.
8	13/22 (59%)	Water pollution from mining processes, impacts on famers, job creation, climate change, environmental impacts of fracking, illness int he community.

Table 3 Summary of the impacts of skin grafting reported in students' thinking prompts in weeks 1 and 8 of term 4

Week	Number of students who identified concepts	Reported concepts
1	15/26 (58%)	Skin grafting process, organ donation, treatment of burns
8	22/25 (88%)	Skin grafting process, treatment of burns, organ donation, organ harvesting.

At interview, students could accurately explain a range of concepts relevant to CSG mining, including the benefits and tensions associated with using CSG as a source of energy. For example:

Excerpt 4

Rachel: Coal seam gas is a natural gas formed millions of years ago from remains of animal and plant matter. It can power a city of 1 million for 5 thousand years. There is less CO_2 produced, but lots of farmers are concerned about CSG as some of them stayed without land because of drilling on their land. I am for CSG, but last week I watched on TV that there was a lady walking 120 kilometres in protest against CSG mining.

For the topic of skin grafting, more students could identify relevant concepts in their responses to the thinking prompts, such as skin grafting, organ donations and organ harvesting. As shown in Table 3, 15 students (58%) could accurately explain the social and scientific concepts related to skin burns and grafting at the end of Week 1. At the end of Week 8, 22 students (88%) could explain a broader range of relevant concepts. For example, in response to the thinking prompt, "Have you heard of skin grafts before? And what do you think it is?", Scott wrote, "No. A graph." In Week 8, Scott responded very differently to the same thinking prompt: "Yes. Healthy skin moved to unhealthy/burnt skin to help it heal. Can be turned to mesh". Again, this progression demonstrates the development in Scott's understanding over the course of the term.

At the conclusion of Term 4, some students expressed strong beliefs about organ donation at interview, drawing on their learning developed throughout the unit. In the following excerpt, a student emphasises the value of organ donation for improving the quality of life for others:

Excerpt 5

Tracey: I believe strongly in organ donation and am aware that my mum is on the organ donor list. When you are dead, your organs are no use to you, so there is no reason why they should be cremated or buried… They can provide increased quality of life to another person. I am also aware that there are religious beliefs around organ donation as my Nanna is totally opposed to organ donation, believing that you should go to heaven intact. I think this is nonsense.

Another student demonstrated their ability to critically examine complex social issues. At interview, they highlighted ethical concerns in relation to organ harvesting, pointing out global inequalities and condemning the illegal trade of organs, particularly within wealthier nations:

Excerpt 6.

Cassie: There are many inequalities in the world, and I think it is sad and unacceptable that poorer counties have to resort to selling parts of their body to make money. I believe that it is highly unethical for an Australian person to buy an organ from another country when it is illegal in our own country. This practice should be stopped.

Discussion

In this study, we investigated the affective and cognitive experiences of a Year 8 science class as they researched and authored a series of BioStories across two school terms about the SSIs of CSG mining and skin grafting. Our overarching research question was, *Does the topic matter for students when writing stories about SSIs in science?* Analysis of students' responses to emotion diaries, thinking prompts and end-of-project semi-structured student interviews led to the development of three assertions that support our thesis that topic *does matter* when engaging students in writing stories about SSIs, as it can elicit different levels of interest and emotional engagement. At the same time, while the results of this study confirm the learning affordances of SSIs, they suggest that the teacher's pedagogical decisions *also matter* in keeping students engaged when they are less interested in a topic. In this section, we discuss our three assertions, in turn, and consider implications for classroom practice.

Our first assertion is that students' self-reported interest was statistically higher for the topic of skin grafting than CSG mining. This finding suggests that students were more interested in skin grafting, noting that the topic was the only variable that changed across both terms. Drawing on Rheinberg and Engeser's (2018) definition of interest as an indicator of cognitive engagement rather than an emotional state, and Sinatra's work (2014) that shows students' high engagement is associated with processing content, the data indicate that the students were more engaged cognitively during Term 4. This is because students reported the skin grafting topic as more interesting on average than the topic of CSG mining, regardless of their self-reported emotions for each individual lesson (as discussed below).

The findings that lead to our second assertion (i.e., that interest and positive emotions reported by students in the skin grafting were associated mostly with the topic, while in the CSG unit, they were related mostly to pedagogical approaches) serve to illuminate the reasons why students were more interested in the skin grafting topic. While learning gains were identified in both units of work (refer to Assertion 3), students reported being less interested in the topic of CSG mining, compared to skin grafting. Nonetheless, relatively high levels of interest were reported in Term 3, and students' interest appeared to increase as the term progressed (mean = 6.58, Fig. 1). One explanation for this is that students' interest increased over time as they became more familiar with the BioStories approach and were more comfortable with the work that they were required to complete. Notwithstanding the observed differences in students' interest, students reported comparable positive emotions during both units of work. Students enjoyed writing BioStories about both topics and reported positive emotions such as happiness/joy, pride, wonder and enthusiasm. What differed, however, was the reasons for students' positive emotions. For skin grafting, the topic was perceived as more interesting and enjoyable to learn. The topic of CSG mining, however, was not viewed as favourably (Excerpt 1). Instead, it was the learning experiences in which they engaged that elicited positive emotions during Term 3. When asked about his interpretation of this finding, Mr Sim explained that the skin grafting topic was more relatable and elicited emotional responses such as excitement and shock:

> **Mr Sim**: The burns BioStory was more relatable to the students as the story was about a jet ski accident. There was a level of excitement and also shock when students were studying burns. The topic included a presentation from a medical professional. The coal seam gas story was not relatable to many 13-year-old students.

The characters and context of the skin grafting story were also likely more relatable to the students, as the main character, who lived on the Gold Coast, was involved in a jet skiing accident. It may be the case that the topic of CSG mining was less relatable to the metropolitan students who may not have visited rural areas and witnessed the impact of CSG mining on farmers, first hand.

Given that contemporary SSIs generate interest in the classroom because they "have the potential to affect the lives of individuals with competing perspectives" (Sadler, 2009, p. 11), Sinatra et al. (2014) posit that enjoyment of science may arise from topics that are relevant to an individual. This is significant to our study because enjoyment of science is also related closely to interest (Osborne et al., 2003). Ainley and Ainley (2011) found that there is a strong relation between an individual's personal value for science and their enjoyment of science, where a higher value is associated with a greater degree of enjoyment. Furthermore, they suggest that science enjoyment acts as a mediator between personal value and interest in science. In other words, "when students believe that the topics they are dealing with in science have personal relevance and meaning for their lives [*such as topic of skin grafting*] they are more likely to experience enjoyment and interest from engaging with science content" (Ainley & Ainley, 2011, p. 11). Multiple studies have also highlighted that physical science concepts are more difficult for students to learn (e.g., Kessels et al., 2006; Krogh & Thomsen, 2005) and are generally perceived as less useful or immediately relevant to students' out-of-school lives compared with biology, particularly by girls (Murphy & Whitelegg, 2006).

Positive emotions in the CSG mining unit were more frequently associated with the different pedagogical approaches that they experienced during class, such as experiments, group work, debates and learning outside (Excerpts 1 and 2), even though they thought the topic was 'boring'. Students particularly enjoyed student-centred approaches and the autonomy of researching and writing their BioStories on computers with their peers. In an earlier study conducted with Year 8 students, students experienced the emotions of wonder and surprise during science demonstrations, while during a laboratory activity, they experienced the intense positive emotions of happiness/joy (King et al., 2015). Importantly, these activities, which used engaging pedagogical approaches, evoked strong positive emotional experiences.

This study makes a significant contribution to research on topic emotions and SSIs as it is the first study that directly compares two SSIs taught by the same teacher and the same class, and analyses students' emotions. This study supports previous research that has shown that students express positive emotions when an SSI arouses interest (Tomas & Ritchie, 2012), and that the type of pedagogical approach that students experience can elicit different topic emotions (Heddy & Sinatra, 2013). A study by Tomas et al. (2016) also found that Year 8 students from a secondary school in North Queensland reported positive emotions while working in a small group to produce a short video about CSG mining. For these students, positive emotions were also elicited by the video production rather than the SSI itself. What is unique about this current study is that we have shown that engaging students with two different topics can elicit positive emotions for different reasons. Specifically, if a topic is more relatable to students' lives (e.g., skin grafting), it may be perceived as more interesting and elicit positive emotions; however, a topic that is less relatable to students, such as CSG mining, can still be perceived as positive if the teacher employs engaging pedagogical approaches.

Our third assertion is that students could explain the scientific, social, moral and ethical dimensions of each SSI and an evidence-informed position at the end of both units. Analysis of students' thinking prompt responses showed that more students could identify a broader range of concepts relevant to each topic at the end of each unit (Tables 2 and 3). At interview, students also could articulate informed positions on each topic, drawing on evidence they had learned through classroom experiences and their own research. Their positions demonstrated consideration of scientific and social aspects of the topics, but also the moral and ethical tensions associated with CSG mining and skin grafting.

Despite reporting lower levels of interest in CSG mining, a greater improvement was observed in the number of students who could explain relevant concepts in their thinking prompt responses (46%) compared to the more interesting topic of skin grafting (30%). At the same time, more students could explain concepts related to skin grafting (58%) compared to CSG mining (13%) at the start of each unit. These findings suggest that students had little prior knowledge of CSG mining at the start of the unit compared to skin grafting. This may be due to learning about biology in previous science lessons and their everyday experiences with burns.

These findings support a large body of previous research about the learning affordances of engaging students in SSIs (e.g., Ritchie & Tomas, 2013; Sadler, 2011; Zeidler & Nichols, 2009). In this study, writing BioStories about CSG mining and skin grafting developed students' understanding of relevant science concepts, as well as the broader social, economic, moral and ethics dimensions of each topic. They also developed an evidence-informed position on the topics that considered these dimensions, which students could articulate at interview (Excerpts 4–6).

Conclusion

This study presented a unique opportunity to examine the learning experiences of a single Year 8 case study class across two school terms, as they wrote BioStories about two different SSIs. The study context, in which the case study class and their teacher remained the same, enabled us to focus on students' engagement with two different SSI topics. While SSIs can stimulate interest and enjoyment if they are relevant to students' lives (Sadler, 2009), this study offers a new contribution to Sinatra and colleagues' (2014) work on topic emotions; that is, that topic *does matter* when selecting SSIs to serve as the focus of students' writing in science. While SSIs perceived by students to be interesting and relevant, such as skin grafting, can elicit positive emotions, so too can less interesting topics, such as CSG mining. In this context, however, teachers' pedagogical decisions *also matter* in engaging students' learning, interest and emotions. In this study, both topics led to desired learning gains, but it was the teacher's pedagogical choices, such as hands-on activities, group work, debates and learning outside, that elicited students' interest and positive emotions in the context of a less relatable and less interesting topic. While the results of this study support the inclusion of diversified writing tasks about SSIs in the science curriculum, such as BioStories, as a way of engaging students positively in the learning of science, they also suggest that a purposeful selection of both topic and pedagogy can serve to optimise students' cognitive and affective engagement.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11165-025-10239-z.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions
This work was supported by the ARC Linkage Project (LP110200368).

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

Ainley, M., & Ainley, J. (2011). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Contemporary Educational Psychology*, *36*, 4–12.

Anderhag, P., Wickman, P. O., Bergqvist, K., Jakobson, B., Hamza, K. M., & Säljö, R. (2016). Why do secondary school students lose their interest in science?? Or does it never emerge?? A possible and overlooked explanation. *Science Education*, *100*, 791–813. https://doi.org/10.1002/sce.21231

Australian, & Curriculum (2023). Assessment and Reporting Authority. (n.d.). Science Version 8.4. Retrieved November 8, from https://www.australiancurriculum.edu.au/f-10-curriculum/science/

Bellocchi, A., & Ritchie, S. M. (2015). I was proud of myself that I didn't give up and I did it: Experiences of pride and triumph in learning science. *Science Education*, *99*, 638–668.

Broughton, S. H., Sinatra, G. M., & Nussbaum, E. M. (2013). Pluto has been a planet my whole life! Emotions, attitudes, and conceptual change in elementary students' learning about Pluto's reclassification. *Research in Science Education*, *43*, 529–550.

Do, S. L., & Schallert, D. L. (2004). Emotions and classroom talk: Toward a model of the role of affect in students' experiences of classroom discourse. *Journal of Educational Psychology*, *96*, 619–634. https://doi.org/10.1037/0022-0663.96.4.619

Fredricks, J. A. (2011). Engagement in school and out-of-school contexts: A multidimensional view of engagement. *Theory into Practice*, *50*, 327–335.

Goodrum, D., Druhan, A., & Abbs, J. (2012). *The Status and Quality of Year 11 and 12 Science in Australian Schools*. Australian Academy of Science. Retrieved November 25, 2023 from https://www.science.org.au/supporting-science/science-sector-analysis/reports-and-publications/status-and-quality-year-11-and

Heddy, B. C., & Sinatra, G. M. (2013). Transforming misconceptions: Using transformative experience to promote positive affect and conceptual change in students learning about biological evolution. *Science Education*, *97*, 723–744.

Heddy, B. C., Danielson, R. W., Sinatra, G. M., & Graham, J. (2017). Modifying knowledge, emotions, and attitudes regarding genetically modified foods. *The Journal of Experimental Education*, *85*(3), 513–533. https://doi.org/10.1080/00220973.2016.1260523

Henderson S., & King D. (2021). "This is the Funniest Lesson": The Production of Positive Emotions During Role-Play in the Middle Years Science Classroom. In: White P.J., Raphael J., van Cuylenburg K. (Eds.), Science and Drama: Contemporary and Creative Approaches to Teaching and Learning. Springer, Cham. https://doi.org/10.1007/978-3-030-84401-1_11

Hufnagel, E. (2015). Preservice elementary teachers' emotional connections and disconnections to climate change in a science course. *Journal of Research in Science Teaching*, *52*, 1296–1324. https://doi.org/10.1002/tea.21245

Kessels, U., Rau, M., & Hannover, B. (2006). What goes well with physics? Measuring and altering the image of science. *British Journal of Educational Psychology*, *76*, 761–780.

King, D., & Henderson, S. (2018). Context-based learning in the middle years: achieving resonance between the real-world field and environmental science concepts. *International Journal of Science Education, 18*(38), 1–18.

King, D. L., Ritchie, S. M., Henderson, S., & M. Sandhu, M. (2015). Emotionally Intense Science Activities. *International Journal of Science Education 37*(12), 1886–1914.

King, D. T., Ritchie, S. M., Sandhu, M., Henderson, S., & Boland, B. (2017). Temporality of emotion: Antecedent and successive variants of frustration when learning chemistry. *Science Education, 101*(4), 639–672.

Krogh, L. B., & Thomsen, P. V. (2005). Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: Border crossing into the physics classroom. *International Journal of Science Education*, *27*(3), 281–302. https://doi.org/10.1080/09500690412331314469

Linnenbrink, E. A. (2007). The role of affect in student learning: A multidimensional approach considering the interaction of affect, motivation, and engagement. In P. A. Schutz, & R. Pekrun (Eds.), *Emotion in education* (pp. 107–124). Academic Press.

Linnenbrink, E. A., & Pintrich, P. R. (2004). Role of affect in cognitive processing in academic contexts. In D. Y. Dai (Ed.), *Motivation, emotion, and cognition: integrative perspectives on intellectual development and functioning* (pp. 57– 87). Lawrence Erlbaum Associates.

Lombardi, D., & Sinatra, G. M. (2013). Emotions when teaching about human-induced climate change. *International Journal of Science Education*, *35*, 167–191.

Murphy, P., & Whitelegg, E. (2006). *Girls in the physics classroom: A review of the research on the participation of girls in physics*. Institute of Physics Report. https://amit-cat.org/wp-content/uploads/doc/girls_in_Physics_classroom.PDF

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*, 1049–1079.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*, 315–341.

Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In S. L. Christensen, A. L. Reschley, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 259–282). Springer.

Pekrun, R., & Stephens, E. J. (2012). Academic emotions. In K. R. Harris, S. Graham, T. Urdan, S. Graham, J. M. Royer, & M. Zeidner (Eds.), *APA handbooks in psychology* (Vol. 31, p. 3). American Psychological Association.

Potvin, P., Hasni, A., Sy, O., & Riopel., M. (2020). Two Crucial Years of Science and Technology Schooling: A Longitudinal Study of the Major Influences on and Interactions Between Self-Concept, Interest, and the Intention to Pursue S&T. *Research in Science Education*, *50*, 1739–1761. https://doi.org/10.1007/s11165-018-9751-6

Program for International Student Assessment (PISA) (2022). Retrieved February 15, 2024 from https://www.oecd.org/publication/pisa-2022-results/

Pugh, K. J. (2002). Teaching for idea-based, transformative experiences in science: An investigation of the effectiveness of two instructional elements. *Teachers College Record*, *104*, 1101–1137.

Pusey, M., & Pusey, G. (2015). Using minecraft in the science classroom. *International Journal of Innovation in Science and Mathematics Education*, *23*(3), 22–34.

Rheinberg, F., & Engeser, S. (2018). Intrinsic motivation and flow. In J. Heckhausen, & H. Heckhausen (Eds.), *Motivation and action* (pp. 579–622). Cambridge University Press.

Ritchie, S. M., & Tomas, L. (2013). Designing an innovative approach to engage students in learning science. The evolvingcase of hybridized writing. In L. V. Shavinina (Ed.), The Routledge international handbook of innovative education (pp. 385–395). Oxford: Routledge.

Ritchie, S. M., Tomas, L., & Tones, M. (2011). Writing stories to enhance scientific literacy. *International Journal of Science Education, 33*, 685–707.

Rosenberg, E. L. (1998). Levels of analysis and the organization of affect. *Review of General Psychology*, *2*(3), 247–270. https://doi.org/10.1037/1089-2680.2.3.247

Sadler, T. D. (2009). Situated learning in science education: socio-scientific issues as contexts for practice. *Studies in Science Education*, *45*(1), 1–42.

Sadler, T. D. (2011). Socio-scientific issues-based education: What we know about science education in the context of SSI. *In Socio-scientific issues in the classroom: Teaching, learning and research* (pp. 355–369). Springer Netherlands.

Sinatra, G. M., Broughton, S. H., & Lombardi, D. (2014). Emotions in science education. In R. Pekrun, L., & Linnenbrink-Garcia (Eds.), *International handbook of emotions in education* (pp. 415–436). Taylor and Francis.

Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin, & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (pp. 443–466). Sage Publications Ltd.

Stets, J. E. (2010). Future directions in the sociology of emotions. *Emotion Review*, *2*(3), 265–268.

Toli, G., & Kallery, M. (2021). Enhancing student interest to promote learning in science: The case of the concept of energy. *Education Sciences*, *11*(5), 220. https://doi.org/10.3390/educsci11050220

Tomas, L., & Ritchie, S. M. (2012). Positive emotional responses to hybridised writing about a socio-scientific issue. *Research in Science Education, 42*(1), 25–49

Tomas, L., Ritchie, S. M., & Tones, M. J. (2011). Attitudinal impact of hybridized writing about a socioscientific issue. *Journal of Research in Science Teaching, 48*(8), 878–900. https://doi.org/10.1002/tea.20431

Tomas, L., Rigano, D., & Ritchie, S. M. (2016). Students' regulation of their emotions in a science classroom. *Journal of Research in Science Teaching, 53*(2), 234–260.

Turner, J. H. (2007). *Human emotions: A sociological theory*. Routledge.

Turner, J. H. (2009). The sociology of emotions: Basic theoretic arguments. *Emotion Review*, *1*, 340–354.

Wosnitza, M., & Volet, S. (2005). Origin, direction and impact of emotions in social online learning. *Learning and Instruction*, *15*, 449–464. https://doi.org/10.1016/j.learninstruc.2005.07.009

Zeidler, D. L., & Nichols, B. H. (2009). Socioscientific issues: Theory and practice. *Journal of Elementary Science Education*, *21*(2), 49–58.

Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science Education*, *86*(3), 343–367.

Zembylas, M. (2008). Adult learners' emotions in online learning. *Distance Education*, *29*(1), 71–87. https://doi.org/10.1080/01587010802004852

Authors and Affiliations

Senka Henderson[1] · **Louisa Tomas**[2] · **Donna King**[3]

✉ Senka Henderson
s10.henderson@qut.edu.au

Louisa Tomas
louisa.tomas@jcu.edu.au

Donna King
donna.king@acu.edu.au

1 School of Teacher Education & Leadership, Queensland University of Technology, Brisbane, Australia

2 College of Arts, Society & Education, James Cook University, Townsville, QLD, Australia

3 School of Education, Australian Catholic University, Brisbane, QLD, Australia