Tackling climate-science learning through futures thinking

SIMON TAYLOR and BEN JONES

KEY POINTS

- A future-oriented programme allowed greater student autonomy, ownership, and responsibility for their learning by enabling students to make decisions and develop personal understanding of climate change and alternative futures.
- Diorama construction enables the exploration of future-oriented scenarios.
- Meaningful integration of diorama construction requires teachers to have sufficient flexibility in curriculum design, and active planning to integrate and implement a cross-curricular inquiry.
- Future-oriented environment modelling can be a valuable pedagogy in supporting a cross-curricular approach to teaching and learning.

https://doi.org/10.18296/set.0183

This study examined the role of a future-oriented scenario with secondary school students using diorama construction which included climate-change knowledge and envisioning alternative futures. To explore the potential role of futures-thinking modelling, students from one class participated in a 12-week cross-curricular inquiry with their teachers. Jensen's (2002) dimensions of action-oriented knowledge are used to examine the climate-change knowledge developed by the students. Four common images of the future (Dator, 2014) are incorporated as models to forecast alternative futures. The findings suggest the value of future-oriented dioramas for developing climate-change understanding and futures thinking.

Introduction

School curricula have been criticised for lacking authenticity in terms of climate-change science (Wallace-Wells, 2019) and having little to do with issues that are of interest to the public (Roth et al., 2008). Dator (2014) argues that future-oriented thinking should be incorporated into environmental education, and that learning programmes ought to provide opportunities for students to connect with real-world socioscientific and technology issues which they will be interested in and find personally engaging.

Our research project set out to examine the knowledge developed by 13-14-year-old students and their subsequent actions during engagement in a future-oriented climate-science programme. Many schools in New Zealand provide environmental-education programmes (Ministry of Education, 1999), for example through field trips in natural settings such as bush and coastal locations, visiting museums such as Te Papa, and supporting sustainable practices in school and the local community. These environments can be used to develop students' understanding of climate change, and ability to envisage a sustainable future (Eames et al., 2008). However, there is evidence that creative construction of futuristic models, including three-dimensional dioramas, provides a springboard for effective student interaction, dialogue, and agency in an environmental issue (Dator, 2009; Meyer, 2015; Tunnicliffe & Reiss, 2000). We know that students come to school with pre-existing conceptions and misconceptions of climate change (Figueres & Rivett-Carnac, 2020), and new understandings can be developed when students share their views and knowledge about climate change (Evans, 2017). An inquiry process using a diorama emphasises communication and argumentation (Luft et al., 2008) and moves students' thinking forward through specific forms of talk. Diorama modelling locates the learner in an imaginary habitat, where personal perceptions of scale and role-play can be employed as a sensory experience (Pink, 2015). In this research our focus was to encourage student autonomy and agency, through physical co-construction of a diorama envisioning homes and a community in which students and their families would want to live in the future. This permitted the study to probe students' knowledge in a unique way, using talk and composition as a window into their developing knowledge about climate change.

Learning to model involves making meaning of representations, and engaging with symbolic depictions of real issues set in real contexts (Sterling, 2001). Diorama modelling is a competency argued by Allchin (2011) for learners to manipulate illusionary spaces and where they can develop new solutions through the process. This can afford a way to open conversations with teachers about the notion of students being climate-change citizens, where they have the opportunity to develop innovative solutions and initiate their own questions (Bolstad et al., 2014; Tolppanen & Aksela, 2018). These strategies provide students with increased opportunities to interact with teachers, peers, experts, and scientists, and hence contribute to a shift in power relationships between teachers and students (Ministry of Education, 2007). The researchers were interested in the way collaborative model-building might offer new and different ways for diverse students to engage with, explore, and communicate climate-science ideas. As researchers, we worked with the teachers to create a shared vision of cross-curricular inquiry, and to identify what knowledge, skills, and attitudes students need to develop to model future scenarios.

An action-oriented approach to environmental education underpinned the research (Jensen 2002).

Taking personal action for climate change as suggested by Fien (2000) is to acknowledge that action begins with personal reflection, and where there is awareness of alternative viewpoints through dialogue. One criticism of environmental education is that it can project specific ideologies (Birdsall, 2010) rather than give students an opportunity to explore a range of perspectives. Jensen (2002) claims that traditional environmental education in schools tends to focus solely on the science behind environmental issues, without properly equipping students with the ability to create meaningful action or change. More in-depth scientific knowledge of an issue does not necessarily create motivation to change a problem. This risk creating paralysis, a sense of hopelessness in students (Chankrajang & Muttarak, 2017). Table 1 is our interpretation of Jensen's (2002) four dimensions of action-oriented knowledge, all of which are needed for learners to develop competencies to create meaningful change toward environmental issues.

TABLE 1. INTERPRETATIONS OF JENSEN'S (2002) FOUR DIMENSIONS OF ACTION-ORIENTED KNOWLEDGE.

Effects—the "what" of the environmental issue	Students investigate problems, the "science", e.g. what is the cause of deteriorating air quality?
Causes—the "why" of the environmental issue	Students develop an understanding of the root causes of an issue. This often includes societal/cultural/economic factors, e.g. car-use behaviour/public transport perceptions.
Change Strategies—the "how" of the environmental issue	Students develop strategies for change involving community/collaborative input. Teachers explore with students opportunities to encourage cooperation, analyse power relations and link to political/sociological studies.
Visions—the "where to"	Students are enabled to develop an alternative vision of the future. Investigating how other cultures/places address issues, can motivate students to enact change close to home.

Early in the planning stage of the project, the teachers discussed the issue of rising student anxiety from the overuse of pessimistic environmental perspectives in previous programmes. Thus, four images of the future (Dator, 2009) were incorporated as models to forecast alternative futures. Rather than "doom and gloom" outlooks, students considered both climate-science knowledge and a wide range of future scenarios to emphasise that the future is not "fixed" or inevitable. Dator (2014) describes four common images of the future as shown in Table 2. He asserts that any scenario of what is to come will tend to fall into one or more of these high-level categories. One issue for teachers to address with students is the fact that contemporary and national economic systems are premised on the idea of continued economic growth, to keep the cogs of the economy operational. However, the planet's resources are limited, and the true environmental costs of current human economic activities, including the costs to future generations and to other species, are not accounted for, and are ultimately not sustainable. This suggests that students, and indeed all people, need support to collaborate, create, and envision their preferred futures, and develop their thinking around alternative models for humanity adapting and thriving in any scenario.

TABLE 2. INTERPRETATIONS OF THE FOUR IMAGES OF THE FUTURE (DATOR, 2014)

Future images	Description
Continued growth	Business as usual. This can be a dominant view where the same fundamental processes will still be operating in the ways they do today.
Collapse	Unable to carry on as is. Collapse of society, or country, or organisation where unknown consequences may occur.
Disciplined society	Tie ourselves to fundamental values that we must live by and we must discipline ourselves as we cannot have unrestrained economic growth.
Transformation	Unknown novel future. This is where we fundamentally change the way we live now. What this future will actually be like is impossible to define. Emerging technologies can help.

Research questions

The research questions for this study were:

1. What existing ideas, experiences, and visions do students have about climate change?
2. How do individual understandings change as students collaboratively engage in future-oriented model construction?
3. How does future-oriented model construction, where students and teachers can communicate using climate-science ideas, impact on a cross-curricular inquiry?

Research design

This specific case study involved a 12-week cross-curricular (science, social studies, health and technology) inquiry using a future-oriented scenario, with students working in pairs or threes. A scenario was established where students used a technological design process to construct a diorama which modelled their visions of a future community set in the year 2100. The students studied climate science, alternative futures, the local history of their community, and practical model making, as integrated topics during the inquiry. The secondary school was situated in a semirural community in the Bay of Plenty region, and the three teachers who taught the class together had specialist subject knowledge of science, technology, health, and social studies respectively. The Year 9 class (*N*=53), had a range of ethnicities and socioeconomic backgrounds, and the learning and teaching took place in a large open, multispaced room. Qualitative data were gathered through a series of professional-learning teacher workshops, where notes were taken and analysis of the planning documents undertaken. Semistructured interviews took place with the teachers and the students, these were audio taped, transcribed, and analysed according to themes (Braun & Clarke, 2006).

Findings

The findings from this study are:

1. Future-oriented inquiry coupled with diorama modelling can support students in: (a) developing personal understanding of climate change; (b) envisioning futures; (c) exercising agency; and (d) accessing and sharing their own and others' input.
2. Teacher enactment of environmental inquiry with a future-oriented scenario is both enabled and constrained by institutional and pedagogical factors.
3. Future-oriented inquiry can support different aspects of a cross-curricular inquiry/process.

Developing personal understanding of climate change

Jensen's (2002) dimensions of knowledge as a theoretical lens was used to analyse the students' responses in the semistructured interviews. The responses were categorised and placed in a time-ordered matrix to show the development of their understandings (see Table 3). The students' responses were grouped into three categories. The first category, *Limited, Incorrect, or No Ideas,* meant that a response had no understanding, or misconceptions existed, or simple and often unrelated ideas existed. Examples of this type were common during the preinquiry interviews when students were asked "What does climate change mean to you and why do you think this is happening?"

Student 7: The planet is warming up, we are getting much hotter summers.

Student 15: The snow on the mountains is melting, this is because the sun is hotter now.

Student 23: It means the weather is changing, heat is getting trapped inside the Earth.

Student 51: I know it's something to do with the weather but I'm not sure.

The second category, *Developing Ideas,* included responses that relate to the meaning and cause of climate change. This category identified simple explanations that lacked details such as scientific reasoning of the enhanced greenhouse effect, names of greenhouse gases, or explicit mention of the effect of climate change. Examples of such responses were found at each data-collection point and included:

Student 46: Climate change is about the big storms we are getting and these can destroy houses,.. years ago, the weather was calmer, it is getting hotter now, because of more factories and car pollution.

Student 52: It is to do with the extra greenhouse gases that cars and coal burning power stations, and the industries in the city are releasing, and this warms up the atmosphere because the heat gets absorbed in these gases and can't get out. I know we breathe out carbon dioxide too, this adds to it.

The final category was entitled *Competent Ideas*. For responses to be placed in this category, the students had to be able to express ideas that showed satisfactory understanding of scientific concepts of the enhanced greenhouse effect, using examples of gases, and mention of trapping of heat, and social and/or economic effects of climate change. Two examples of such a response were:

Student 3: The greenhouse effect is being affected by more gases entering the air, like nitrous oxide, carbon dioxide and carbon monoxide released by vehicles and air pollution. Our current way of life is producing more of these. This needs to stop, to help the planet recover. The extra greenhouse gases put strain on the environment, as the levels of these gases increase year after year, they trap heat in the atmosphere, and this of course changes the climate. With a hotter climate on Earth, this will go onto melt the ice caps in the polar regions and result in a rise in sea level. This will have a massive effect on people's lives who live by the coast because of the flooding.

Student 19: Climate change is about the changes to the climate, this is due to a rise in greenhouse gases in the planet's atmosphere because there are more cars on the roads and more burning of carbon from factories in China, and more trees being cut down in Brazil, this means a rise in carbon dioxide gas and this is like a blanket over the planet, keeping the warmth in and that is why the average temperature is hotter.

TABLE 3. MATRIX SHOWING THE DEVELOPMENT OF THE STUDENTS' UNDERSTANDING OF CLIMATE CHANGE OVER THE COURSE OF THE INQUIRY

	Preinquiry interviews	Midway interviews	Post-inquiry interviews
Limited, Incorrect, or No Ideas category	39	5	0
Developing Ideas category	12	40	20
Competent Ideas category	2	8	33

Findings shown in Table 3 demonstrate that, over the course of the inquiry, these students developed their understanding of climate change in relation to Jensen's first two dimensions (effects and causes). For example, in the preinquiry interviews 39 (74%) of the students had ideas about the climate-change question that were *Limited*, or had *No Ideas*, or sometimes incorrect ideas, however at the conclusion of the inquiry 20 (38%) of the students were *Developing* an understanding that was generally expressed with a definition and cause, and 33 (62%) of the students had developed a *Competent* understanding and were able to integrate the definition, cause and effect of climate change. During the programme, the students developed conceptual understandings about the enhanced greenhouse effect and its impact on climate change.

The students' responses about their understanding of climate change did not necessarily show evidence of Jensen's (2002) dimensions three and four, which identify the ability to have a vision of the type of world in which they and their families would want to live in, and importantly how to effect this change. However, when a different question was asked, "What action can you take to help minimize climate change?" 42 (79%) of the students could list 10 or more actions that could help to minimise climate change, whereas only two (4%) of the students could list six actions that could help to minimise climate change at the preinquiry interviews.

These results stress the value of climate-change education programmes providing opportunities for students to envision a desirable future and situate themselves in taking personal action. The nature of this is where students consider alternative perspectives using their own voice. The diorama inquiry permitted students to develop the range of Jensen's (2002) knowledge dimensions using role-play and negotiation in the construction phase and the final presentation. It also provided an opportunity to evaluate climate-change knowledge which could be developed with further research.

Envisioning futures

As Dator (2009) claims, the necessary components of a futures visioning process are in stages. Initially, students are required to have a common understanding of the history of the community and he argues that it is not possible to think usefully and creatively about the future until they reflect on the past and understand how things have come to be as they are in the present. Secondly, students need understanding of the present, so they can discuss the issues and concerns, or vent frustrations about what exists now. The next stage is forecasting aspects of possible futures. The fourth and most critical stage is experiencing alternative futures, where ideas such as Dator's (2014) four future images can be used to contemplate different scenarios (see Table 2). A final stage describes the ability to envision preferable futures, identifying what challenges lie ahead and proceeding to create one or more preferred futures for the group or community.

Visioning a preferred future was a key purpose to this study. Students' discussions with their peers, family members, and teachers added depth to their inquiry design, questions, and understanding. As some students reported:

> We thought about what the future could be like, we had discussions about each of the four future images and connecting them with a description of what day to day life could look like. I went home and talked to Mum about the futures and what it could be like at home, what we would do for food, how it would affect us. (*Student*)

Teachers also saw value in future envisioning as one said:

> The importance of studying the four images with the scenarios was immensely valuable. The students developing understanding of the past and future jumped to another level, some of them have had anxiety about the future, like it's all doom and gloom, but this gave them a chance to talk about a future. That would be where I see the visioning won through. (*Teacher*)

Exercising agency

Student ownership of, and control over, the design and collaborative construction of their dioramas meant they had increased autonomy in lessons, reducing their need to rely on teachers. In this way, model making supported the students in the exercise of agency. See Figures 1 and 2.

Students were often observed making choices about the order in which tasks were completed. These were student initiated, where different tools were selected and

FIGURES 1 AND 2. EXAMPLES OF STUDENT CONSTRUCTION OF DIORAMAS USING ALTERNATIVE FUTURES THINKING, WHERE STUDENTS EXERCISE AGENCY USING ROLE-PLAY, WHERE THEY NEGOTIATE STEPS IN THE CONSTRUCTION OF THE DIORAMA, AND WHERE THEY SHARE THEIR OWN AND OTHERS' INPUT.

manipulated to construct models for the diorama. There is an example of a student discussing the challenges of a disciplined future where the diorama design purpose fits restraints of lifestyle, such as community food production and restricted car use. Student comments about these experiences were:

> We talk about what we see and what needs to be done next. We talk, think and make, someone brings up a new idea and how it would fit, then we agree or disagree. If we like it, we talk about how we could make it, we work out what materials we need. (*Student*)

> We think that people will need to have self-control. We decided that to survive by the year 2100, just about everyone will have to grow vegetables and trees, people won't be allowed to drive petrol cars, if they do, they are fined. Our diorama has no cars, everyone walks on pathways crisscrossing the countryside or uses public transport. We've got a communal kitchen and dining area, like a food hall where families share meals, everyone helps to grow food and make it each day. (*Student*)

Learning environments that allow for flexibility in accessing different futures through diorama construction can empower and engage students, including their sense of ownership and responsibility for their own learning. Through this, students' learning experiences are broadened beyond transmissive pedagogy as they share their learning with their peers and teachers.

Accessing and sharing their own and others' input

The inquiry supported student sharing and communication of ideas and obtaining feedback of work in progress. The diorama construction was sustained during a school term, which meant that students could revisit and revise their thinking and make changes. Both teachers and students participated in this process. Teachers commented on the value of student reflection and dialogue.

> Students had flexibility with what they made, we gave them time to talk and make time to reflect on their own ideas and share ideas with others. (*Teacher*)

> It helped bridge the gap between the knowledge of climate change and actually doing something about it. Just knowing about it, is not enough, when I was in class, I could hear them chatting about the possibilities and actions of what they could do. It engaged the students, it gave them space to think and talk. (*Teacher*)

Enablers and constraints for teachers

Teacher enactment of environmental inquiry with a future-oriented scenario is both enabled and constrained by institutional and pedagogical factors.

The enabling factors are:

- flexible curriculum and assessment structures
- understanding of the affordances of different pedagogies
- planning to incorporate climate-science knowledge and futures-oriented thinking meaningfully in teaching.

On occasions, significant challenges arose from tensions between the practical realities of class time and curriculum pressures, and the need for flexibility in curricula to accommodate student pursuit of their own inquiry, as one teacher said:

> The future oriented inquiry took time to do, it's not something that can be done in a few lessons, it needs to be developed and planned for. Also, the students need to learn skills of model making, linking these with design features, and of course the climate science behind the scenario. We have had to rearrange curriculum objectives to fit across the subjects. This also creates an issue with assessment and timing of the topic, our tests have been mostly knowledge based, but now with this topic we have had to rethink the way we assess the students. (*Teacher*)

The way time is typically allocated for learning and assessment is a constraining factor. Planning had to value inquiry processes such as exploration, collaboration, co-construction, and the communication of climate-science ideas. The quotation from a teacher also highlights that changes in pedagogy need to be accompanied by changes in assessment.

Future-oriented inquiry can support different aspects of a cross-curricular inquiry

Teachers considered the inquiry to have been effective in supporting aspects of science, social studies, technology, and health curricula. The inquiry process of posing questions, exploring alternative viewpoints, collecting and analysing data, and reflecting on and communicating the findings meant that students, scaffolded by their teachers, were engaging with knowledge and processes from different learning areas. Two teachers commented:

> The scenario helped the inquiry process because we could accommodate the curriculum areas involved. We had to identify what subject was highlighted, fit it into the programme and plan how it was going to be incorporated. (*Teacher*)

> It gave the opportunity for students to ask questions about topics that would be suitable with say two curriculum areas, not just one. This was a highlight, as the students could see they needed to understand the science and technology, or the science and health. (*Teacher*)

Conclusion

This research highlights the value of a futures-thinking cross-curricular inquiry which enhanced the understanding and relevance of climate change for students. However, this value seems to be contingent on the interplay of teacher, student, and school factors.

There are several implications.

- Diorama construction requires additional resource and expenditure which some schools may not currently have.

- Teachers need support to develop confidence in theoretical understandings of future thinking and climate science.
- Teachers need time for planning and implementing an inquiry of this nature. Greater flexibility in curriculum and assessment structures is needed.

This study illustrated the benefits of planning for, and scaffolding, a future-oriented inquiry approach to climate-change education. Teachers and students developed better understandings of climate change and future thinking, as well as the confidence and capabilities in cross-curricular inquiry. This was a small study involving only one school and class. Future research could investigate the effectiveness of this approach across more schools, and follow the development of students' knowledge and capabilities over a longer duration. The research highlights the value of how integrating diorama construction with preferred future-oriented inquiry enhances student learning. The role played by the inquiry can be seen in the way the students act, developing their understanding of climate change and designing what a future may look like for them.

Acknowledgement

The study acknowledges the vital support of the teachers and students who have made this project possible. We would also like to express our gratitude of the support from Dr Paul Lowe, Myles Darrell, and John Lumby.

References

Allchin, D. (2011). Evaluating knowledge of the nature of (whole) science. *Science Education*, *95*, 518–542. https://doi.org/10.1002/sce.20432

Birdsall, S. (2010). Empowering students to act: Learning about, through and from the nature of action. *Australian Journal of Environmental Education*, *26*, 65–84. https://doi.org/10.1017/S0814062600000835

Bolstad, R., Hipkins, R., & Stevens, L. (2014). *Measuring New Zealand students' international capabilities: An exploratory study*. Ministry of Education. https://www.educationcounts.govt.nz/publications/ international/144533

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Chankrajang, C., & Muttarak, R. (2017). Green returns to education: Does schooling contribute to pro-environmental behaviours? Evidence from Thailand. *Ecological Economics*, *131*, 434–448. https://doi.org/10.1016/j.ecolecon.2016.09.015

Dator, J. (2009). The unholy trinity, plus one. *Journal of Futures Studies*, *13*(3), 33–48.

Dator, J. (2014). Four images of the future. *Set: Research Information for Teachers*, (1), 61–63. https://doi.org/10.18296/set.0319

Eames, C., Cowie, B., & Bolstad, R. (2008). An evaluation of characteristics of environmental education practice in New Zealand schools. *Environmental Education Research*, *14*(1), 35–51. https://doi.org/10.1080/13504620701843343

Evans, A. (2017). *The myth gap: What happens when evidence and argument aren't enough*. Eden project books.

Fien, J. (2000). Education for the environment: A critique—an analysis. *Environmental Education Research, 6*(2), 179–192. https://doi.org/10.1080/713664671

Figueres, C., & Rivett-Carnac, T. (2020). *The future we choose. Surviving the climate crisis*. Manilla Press.

Jensen, B. (2002). Knowledge, action and pro-environmental behaviour. *Environmental Education Research*, *8*(3), 325–334. https://doi.org/10.1080/13504620220145474

Luft, J., Bell, R., & Gess-Newsome, J. (2008). *Science as inquiry in the secondary setting.* NSTA Press.

Meyer, A. (2015). Does education increase pro-environmental behavior? Evidence from Europe. *Ecological Economics, 116*, 108–121. https://doi.org/10.1016/j.ecolecon.2015.04.018

Ministry of Education. (1999). *Guidelines for environmental education in New Zealand schools.* Learning Media.

Ministry of Education. (2007). *The New Zealand curriculum.* Learning Media.

Pink, S. (2015). *Doing sensory ethnography*. Sage.

Roth, W. M., van Eijk, M., Reis, G., & Hsu, P. L. (2008). Authentic science revisited. *Praise of diversity heterogeneity, hybridity. Authentic science revisited.* Sense. https://doi.org/10.1163/9789087906726

Sterling, S. (2001). *Sustainable education: Re-visioning learning and change*. Schumacher Society Briefing no. 6, Green Books.

Tolppanen, S., & Aksela, M. (2018). Identifying and addressing students' questions on climate change. *The Journal of Environmental Education*, *49*(5), 375–389, https://doi.org/10.1080/00958964.2017.1417816

Tunnicliffe, S. D., & Reiss, M. J. (2000). Building a model of the environment: How do children see plants? *Journal of Biological Education, 34,* 172–177. https://doi.org/10.1080/00219266.2000.9655714

Wallace-Wells, D. (2019). *The uninhabitable Earth: A story of the future*. Allen Lane/Penguin.

Dr **Simon Taylor** is a science-education lecturer at the University of Waikato, Division of Education. His teaching and research interests lies in the areas of student voice, student perspectives in inquiry learning environments, futurist learning, youth empowerment, and education design.

Email: simont@waikato.ac.nz.

Ben Jones is a student adviser at the University of Waikato in Tauranga. One of his many roles is engaging with staff and students in sustainable thinking and campus initiatives. His research interest is within sustainability education and evaluation.