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ARTICLE

Dramatic science teaching: a case study of Canada's Evergreen Theatre

Lynn Everett

School of Education, University of New England, Armidale, Australia

ABSTRACT

Evergreen Theatre provides educational theatre and drama with a focus on science of the natural world. Based in Canada, the company offers a best practice model for the effective use of drama as a teaching tool for science education that is embedded within a context of environmental sustainability. Evergreen offers a comprehensive approach to 'science drama' including science-based theatre shows and in-house school programs. This article will report on a case study of Evergreen Theatre. It will provide indications for how the company's approach might inform science learning using theatre and drama techniques.

KEYWORDS

Environmental awareness; science education; theatre in education; TIE company

Introduction: Where have all the scientists gone? Long time passing …

In Australia, several major reports have pointed to a crisis in science education over the last fifteen years (Batterham, 2000; Goodrum, Hackling, & Rennie, 2001; Kennedy, Lyons, & Quinn, 2014; Lyons & Quinn, 2010). The crisis can be seen in the declining numbers of students taking science in the post-compulsory school years and is expected to lead to shortages of scientists and science teachers in the future, both at secondary and tertiary level. The decline is partly due to students' general dissatisfaction with the content and delivery of educational material. It is also partly due to a lack of resources and professional development support for teachers (Goodrum et al., 2001, p. viii; Lyons & Quinn, 2010, p. 110). Significantly, the declining numbers reported in Australia are also occurring 'to various extents in a number of countries across the globe … thus suggesting that the causes of the changes may go beyond national and cultural borders' (Kennedy, et al., 2014, p. 34). While there are no easy solutions, these reports make a number of recommendations that focus on support for resources and professional development to help teachers deliver science lessons in ways that are more engaging. The reports also note that in order for science lessons to be engaging, they need to be personally relevant to students and the content needs to be contextualized (Lyons, 2003, p. 203; Lyons & Quinn, 2010, pp. iii, 111).

The use of drama as a pedagogical tool can help to make the science syllabus more interesting and relevant to students and, ultimately, may contribute to an increase in student

CONTACT Lynn Everett leverett@une.edu.au

numbers at the post-compulsory level. Research has indicated that drama is a particularly effective pedagogical strategy for teaching science (Arieli, 2007; Çokadar & Yilmaz, 2010; Hendrix, Eick, & Shannon, 2012; McGregor, Anderson, Baskerville, & Gain, 2013; Taşkın-Can, 2013). Ødegaard (2003, p. 97) has found that 'Drama can successfully be used for making simulations of the real everyday world … it offers students the possibility of experiencing cognitive, affective and active aspects of learning in an integrated way'. Drama can be gainfully employed for teaching both the conceptual and social contexts of science. Drama, by its very nature, necessarily contextualises the content of science education. Through simulation of people and processes, students are able to 'get inside' the ideas and the feelings around scientific investigation, and to critically explore the relationship between humans and the natural world. As Pantidos, Spathi, and Vitoratos (2001, p. 107) observe, 'Physical Sciences become more accessible, comprehensible and familiar through dramatization'.

Evergreen Theatre, in Canada, offers a best practice model for the effective use of drama as a teaching tool for science education. It uses a comprehensive approach that involves both theatre and drama in a variety of educational programs including full length science musical theatre shows, science demonstrations, and residency programs where students create their own science theatre show. The company is based in Calgary, Alberta, Canada, and was formed in 1991 as a non-profit collective of business professionals, naturalists, teachers, musicians, writers and actors. It is a touring, educational theatre company with a focus on teaching science of the natural world. Since it began, Evergreen has toured over 29 original productions to schools in Alberta, reaching more than 67,000 students each year. It has won multiple awards for excellence and achievement in environmental education (Evergreen Theatre, 2015a, 2015b).

Background to the study

This project has taken ten years to 'ripen'. My interest in using drama as a pedagogical tool to teach science and environmental education grew largely from my background in environmental theatre in Armidale, rural NSW. In the 1970s, the Armidale Tree Group was formed as a community action group to combat dieback, a plant disease that was devastating the trees in the New England region. In 1997, I joined a musical band that was formed to help raise funds for the Tree Group. Called 'Tree Los Lantana', the band evolved to become an environmental cabaret group, writing songs and original material about environmental issues. The troupe had nine members: five drama teachers, three ecologists, and a carpenter. In 2004, myself and two other members travelled to Canada to give a joint paper about our theatre work at the IDEA conference. Arriving in Vancouver, we headed east and drove through a mountainous region covered in coniferous forest. We noticed that some of the trees were dying and discovered there was a type of dieback starting to develop here too. The local pine bark beetles were increasing in number due to warmer winters and fire suppression, which interrupts the natural cycle of forest regeneration. The beetles carry a blue stain fungus that kills the trees. We continued on to Calgary in the province of Alberta, home of Evergreen Theatre and this was my first meeting with Tara Ryan, a founding member of the company. I was inspired by the work being done by Evergreen and so in 2006 I again travelled to Canada to undertake field work. Since this time, the dieback in Canada has become worse and Evergreen has a Theatre-in-Education show that explores this very issue. The current political climate is hostile to the idea of environmental sustainability. The Conservative

federal government has abandoned the Kyoto Protocol. The Canada Revenue Agency is conducting an audit campaign of registered charities, targeting those involved in advocacy that is deemed to be 'political'. Efforts have been directed towards environmental groups, among others, with charitable organizations facing the possibility of losing their charitable status and forfeiting their assets. Alberta's oil sands is the third largest crude oil reserve in the world, earning billions of dollars in government revenue but with considerable impact on the environment and health risks to local communities, particularly First Nations people. On these issues, Evergreen comments:

> Evergreen Theatre has always maintained a strict apolitical stance. We present young audiences with scientific fact about their natural surroundings, and we encourage them to make informed, empowered decisions about their choices and actions as global citizens. We do not shy away from challenging topics, including climate change, deforestation, and human impact on water systems. (V. Goggin, Artistic Producer, Evergreen Theatre, personal communication, 19 March 2015)

Evergreen views its work as one step towards creating a sustainable culture. Its programming has expanded considerably since it first began and now includes a Big Green Puppet Bus, home school programs, custom workshops, presentations, activities for conferences and organizations, as well as commissioned works for zoos, science centres, museums, and corporations. The company has developed along with the 'go green' movement itself which, as Evergreen notes, has grown to the point where awareness of environmental sustainability has become part of everyday consciousness, permeating many aspects of society including business, government, and education (Evergreen Theatre, 2015d). In 2013, the Armidale Tree Group celebrated its 30th anniversary, with Tree Los Lantana re-forming to perform at the festivities. In 2016, Evergreen will celebrate its 25th anniversary and is looking forward to the next 25 years.

The research process

The methodology for this study is embedded in an interpretive paradigm using a constructivist theory of knowledge. Constructivism proposes that learners actively construct their own knowledge through collaboration with others in a particular socio-cultural, historical, and environmental context (McInerney, 2002, p. 4). Learning is a dynamic, interactive, reciprocal process that occurs between the learner and their social and physical environments. Knowledge is not a fixed 'product', but is a process in a state of flux that changes according to the experiences of the learner (O'Toole, 2006, p. 13). Vygotsky emphasizes that the construction of knowledge and thus learning is an inherently social process and is created through the reciprocal relationship between the individual and the people they encounter (McInerney, 2002, p. 45).

The study explored the ways Evergreen Theatre uses theatre/drama to design and implement science education programs. The aims of the research were to investigate the following questions:

(1) What is Evergreen's philosophy and approach to teaching science using theatre/drama?
(2) What theatre/drama forms, techniques, strategies, and processes does Evergreen use in its programs?
(3) What factors contribute to the pedagogical effectiveness of Evergreen's programs?

The research used qualitative case study methods. Cohen, Manion and Morrison consider one of the strengths of case studies is that they 'can establish cause and effect' and 'they observe effects in real contexts, recognizing that context is a powerful determinant of both causes and effects … a case study is a study of a case in context and it is important to set the case within its context' (Cohen et al., 2011, p. 289). Field work was conducted in Calgary for a period of two weeks. Data collection instruments consisted of observation, field notes, semi-structured interviews, documents, drama scripts, photographs, video recordings, and websites. Interviews were conducted with staff of Evergreen Theatre and primary school teachers who were involved with Evergreen programs. The researcher accompanied Evergreen staff to observe primary school programs involving a science musical theatre show, a science demonstration, and a residency program.

Evergreen's Science Theatre shows: Roll up, roll up! See the greatest show on earth! Now playing! Science of the imagination!

> Deep in the middle of the forest something dark is lurking. The trees are dying … the ecosystem is in trouble and a little boy named Ash is lost. Fortunately there is someone else in the forest, a pinecone named Jack. As Ash struggles to find his way out of the forest Jack Pinecone teaches him about all the diversity that is alive in the forest. Using this knowledge, Ash begins to navigate the forest with ease … but the dark shadow is growing larger. (Mason, J. & Delano, S., *Invasion of the Pine Beetles*, Evergreen Theatre, 2014)

Evergreen's signature program is the science show. These Interpretive Theatre pieces run for 50 minutes and are based on a theme or topic from the science curriculum. Productions tour to schools throughout Calgary, Edmonton, and rural Alberta. Each show is written and produced according to Evergreen's artistic, educational and organizational values. These guide decisions about content, scriptwriting, and theatrical style of production. Evergreen aims to be current and relevant, not only in terms of the issues it addresses but also by incorporating references to popular culture so that students can relate to the material. In all of the programs there is a principle of fact-to-fiction, whereby the scientific facts form the basis of the artistic work. The programs present both sides of an issue in a balanced way. At the same time, they advocate for positive environmental change and individual responsibility (Evergreen Theatre, 2015c).

In creating the science shows, Evergreen consciously uses popular theatre forms and acting styles that will appeal to a school audience. The shows include music, singing, dancing, and sometimes incorporate puppets or mask work. Characters, sets, costumes, and props are always scientifically accurate but at the same time they are highly theatrical. Characters are larger-than-life and presented using broad physical characterisations in an almost cartoon style. Costumes & props are bigger than life-size, bright and colourful. They are often made of foam rubber, giving the effect of outdoor theatre done indoors. Evergreen uses a presentational style of acting with no fourth wall and incorporates audience interaction. Each show is performed as a two-hander by professional actors playing multiple characters and assisted by student volunteers. After the performance, the Evergreen actors ask the audience questions about the content in order to reinforce the science learning. The use of popular theatre is an important pedagogical choice. Strategies such as direct address, audience participation, and larger-than-life production elements all serve to involve the audience so they are interested in the show and remember the science behind it (Evergreen Theatre, 2006, 2015c).

During field work in Calgary, I watched a performance at a local primary school of an Evergreen show called *Pond Scum Inc*. (Holt, Abramovitch, & Enright, 1995). It was February and the snow was thick on the ground. The school gymnasium was packed with children and had been transformed into a 'theatre' with a simple screen, three metres wide, made of two poles and a painted backdrop depicting a colourful pond scene. The play was about wetlands and explored relevant topics such as flora and fauna, the food chain, and photosynthesis. Before the play started, there was a flurry of activity. Two Evergreen staff members were teaching the audience to yell out 'FOOD!' whenever they heard the word 'sun'. One of the classroom teachers entered from the change rooms dressed in a duck costume. The children roared with laughter and the teacher 'hammed it up', with both parties enjoying this change in status. The teacher proceeded to help organize a small group of student volunteers who were learning to sing the chorus of the opening song and rehearsing some choreographed actions. When all was prepared, the show began with a brief prologue that set the scene, followed by the entrance of two duck characters: Wally M. Mallard, the pond foreman, and his trusty assistant named Fred. With the aid of the chorus, the ducks sang the first song 'Going to the Pond'. As with all the songs in the piece, it included lines that were both witty and informative: 'Good morning, Mr Water Flea. Snackin' on some algae I see! Too bad he won't be 'round for long – He's the favourite dish of the rest of the pond' (Holt et al., 1995, p. 4). Into this idyllic setting enters the antagonist, Ms Pamela Pave-It, sent by head office to observe and evaluate this wetland as a potential site for a dump or a carpark (Fig. 1). Pamela is fast-talking, cynical and hard-edged. Her motto is: 'Don't save it, pave it!' After some humorous vaudeville-style banter, Wally is forced to co-operate. He gives Pamela a pair of rubber boots and proceeds to show her around the pond, beginning with a duet, in which Wally serves as tour guide and gives friendly advice about caring for the local fauna: 'Don't touch that chick, even if you're quick, a mother bird might abandon her nest. And that amphibian breathes through his skin. Hands off and Eyes on for that frog would be best' (1995, p. 11). The pre-show rehearsals now come into play with the audience yelling 'FOOD!' every time they hear Pamela or Wally say the word 'sun'. As the scene is played out, Pamela starts to feel more and more unnerved: 'It's the algae, duck! Through some twisted deal they've got going with that ball of fire up in the sky, the algae have power. Power! Power to make FOOD!' (1995, p. 14). Wally responds by singing a song that explains all about algae and photosynthesis while the audience yells 'food!' on cue, and the duck/teacher is busy attaching chloroplasts to a volunteer chorus of algae:

Its name is algae, green and bright
You'll find it where there's water and light
The simplest plant on earth, my friends
But on this plant the pond depends …
Like all green plants, he works like this
His trick is photosynthesis
He's full of stuff called chlorophyll
When sunlight hits, he gets a thrill …
But food's not all this cell can make
We owe him for our air intake

Figure 1. Characters of Pamela and Wally in *Pond Scum Inc*.

> While making food, our friend the cell
> Produces oxygen as well
>
> (Holt, Abramovitch, & Enright, 1995, pp. 15–16)

Pamela continues to encounter more creatures that call the pond their home, including a moose, and a Spanish wetland signorita called *Daphnia Cladocera* (small aquatic crustaceans commonly called water fleas because of the way they swim). But the more Pamela learns about the wetlands, the more depressed she becomes, until finally she begins to cry. Wally asks her what's wrong, and she replies:

> The pond! You're right, duck. It's just one big happy family! All of these plants and animals all living together, depending on each other, all interacting … I can't stand it! … I'm so alooooooooone! All, all alone. Nobody needs me. Nobody wants me. (Holt et al., 1995, p. 24)

Wally tries to comfort her, explaining that it's not all fun and games in the pond since it is often 'an eat-or-be-eaten experience!' But Pamela doesn't care; she just wants to be part of an ecosystem where she belongs. And so it all ends happily, with Pamela reassured that there is always room for people in the pond, as long as they care for it and protect it for the future. After the play, the audience showed their appreciation with loud applause and cheers. They had been fully engaged for the duration and, as they filed out of the gym, they talked excitedly about the performance. A young girl walked past me on her way out, absent-mindedly singing one of the songs she had just heard in the show.

Tara Ryan was a founding member of Evergreen and scriptwriter from 1995 to 2006. Her seminal work continues to shape the company's programs. With university degrees in both science education and theatre, Ryan was uniquely placed to create highly effective science drama and wrote a number of award-winning pieces (Evergreen Theatre, 2015b). Ryan developed a very specific approach to writing scripts in terms of structure, plot, and character creation. The scripts typically include seven scenes, with original music and five to

six songs that focus on the key science facts or issues explored throughout the piece. Ryan's approach also draws on educational theory, particularly Gardner's multiple intelligences by using techniques that address visual, auditory and kinaesthetic learning styles (Evergreen Theatre, 2015c). Ryan also employs repetition as a pedagogical strategy:

> Tell them what you're going to tell them, tell them in the song, then tell them what you told them afterwards. Use repetition a lot so the kids remember. Don't forget the facts – keep asking, 'Is it about the facts?'. (T. Ryan, personal communication, February 10, 2006)

Each script is developed from a scientific viewpoint on the one hand, and a humanistic viewpoint on the other. This is achieved by working with the over-arching science concepts that are relevant to the content and exploring how these concepts operate within a human context. As Ryan comments:

> Energy flow, cycles, diversity, communities, interrelationships, change, adaptation – EC, DC, ICA – everything goes back to this for me. A lot of times that helps me with the show because no one is going to leave remembering the name of an endangered wildflower. It's about the big picture … So with farming for example, it's about the soil cycle – two biofeedback loops. What is it about from a science perspective? Wheat and cows or sheep – crops and stock. What is it about from the human perspective? Protein and starch. So they're the two main characters. Then, what's the big picture? Again, take a step out – I go in and then I go back out again – 'food, farming and fitness' – where does food come from, where does it go, and what does it do while it's there? (T. Ryan, personal communication, 10 February, 2006)

Ryan employs one of two possible plot structures: either 'the evil villain' or 'the buddy road-trip'. Both options rely on the strategy of using opposition and contrast as a plot device, such as 'good versus evil'. Developing characters is a central part of the scriptwriting process. One of Ryan's key strategies is to anthropomorphize biological or chemical processes and create suitable characters that the audience can relate to:

> It's about the big picture and also about picking characters because of their situation or what they have going for them. The audience has to be able to connect with them … With the show 'JUNK! The Musical,' for example, the characters of Tin Can and Leaf just want to be useful again. They have to have a human need, a human quality. They have to be someone the audience can identify with and empathize with. The human element is vital so that you're not just coming in and doing a science experiment out of context. Theatre does give you an emotional and empathetic connection to otherwise dry, abstract, uncontextualised material. (T. Ryan, personal communication, 24 February, 2006)

Examples of metaphorical characterisations can be seen in Evergreen's shows. In a piece called *Full of Hot Air!*, the gas methane was personified as Dr Methane, who conspires to rule the world by capturing the characters of the Sun, Earth, and Water (Fig. 2). In another show on the topic of water pollution, called *Up the Creek*, the plot revolved around an oilcan spill in a local river (Fig. 3). The characters of A.J. Algae and Moz Skeeter are elected to journey up the river and find a solution. In *Going to Extremes*, a show about climate change, Dr Carbon is the evil villain pitted against a benevolent tree character. Here again, the chemical processes are played out as antagonist and protagonist by using 'characters as metaphoric devices' (Hatton & Lovesy, 2009, p. 28). Notably, this metaphorical practice is in line with the call from some environmental education scholars to 'locate the human animal within the environment' (Heddon & Mackey, 2012, p. 163), and to 'shift away from anthropocentric views of the world … to a bigger, more inclusive picture in which I feel my connectedness as a human to other organisms, other life forms, other species and other beings' (Forgasz, 2013, p. 325). Evergreen's shows make a point of adopting metaphoric characterisations as a way for the students to enter into the reality of environmental situations. They create the conditions where students

Figure 2. Characters of Airhead and Dr Methane in *Full of Hot Air!*

have the opportunity, not to 'walk in *someone* else's shoes', but to walk in *something* else's shoes. This is an important distinction, since drama used in education for sustainable development is often focused on playing out situations only from the human perspective, rather than from both human and environmental perspectives (e.g., see McNaughton, 2010, p. 297). On a number of levels, Evergreen's theatre shows combine the conceptual, social, emotional, and ethical considerations that are relevant to scientific enquiry in an integrated way.

At home with Picasso: Evergreen's artist-in-residency programs

Another cornerstone of the Evergreen repertoire is its artist-in-residency, called Grow-A-Show. In this program a team of Evergreen staff members work within a primary school where they guide the students in the development, rehearsal and performance of an original science based theatre show. Before the residency, the school or class teacher can use Evergreen's 'Teacher's Resource and Activity Guide' as part of their preliminary work covering the topic. Depending on the school's requirements, the program can cover a period of one week or ten weeks, and might include the whole school or individual classes. The Evergreen team works with each class for an hour per day during the one week program, and half a day a week for the ten week option. These sessions also serve as professional development for the class teachers in that they observe and actively participate during the sessions and support the process by guiding additional rehearsals outside the residency time-slots: 'As a teacher, learning different ways to engage students in content and scientific processes is very valuable. I am hoping to incorporate some of the drama strategies Mariee used so skillfully on a smaller scale on my own' (teacher, personal communication, 15 February, 2006). Commonly, a school will see an Evergreen show before booking a residency program and some schools book a

Figure 3. Characters of Oil and Water in *Up the Creek*.

residency twice a year so students develop skills (M. Devereaux, Evergreen Residency Manager, personal communication, 14 February, 2006). During field work, I interviewed teachers at a school where Evergreen was conducting a Grow-a-Show program. Their comments suggest that Evergreen's programs are highly effective in terms of both drama and science learning:

> This is the third year we've had Evergreen here and we would be disappointed if we couldn't get them back. The shows are very beneficial because 80% of the science outcomes are being met. You can take a really yucky unit like 'Trees and Forests' and it sticks with the students because of the drama. (teacher, personal communication, 16 February 2006)

> The advantage of the Evergreen program is that it has high interest for the students and so it is high motivation. It covers the program in a really user-friendly way. It is a very hands-on approach and so it keeps everyone busy and it's meaningful for the students … The students

> often have these 'Aha!' moments in terms of the material being covered. (teacher, personal communication, 16 February 2006)

Students' responses to the programs also indicate their effectiveness in terms of student engagement with the science content, as an introduction to drama performance, and as a stimulus to writing about science, as the following feedback indicates:

> I learned an enormous amount of information about trees … and how to save them like preserving the environment, re-forestation, sustainable yield management, biodiversity, and the food chain. I also learned about myself, I never knew that I could act like I did … I never knew how fun acting is … If I was to do it again I would make some changes. First, I would spend more time on script writing, and maybe a bit more time on research to make the scene or the play better … For me, this was a life time experience. This experience will follow me to Junior High and maybe High School, university and the rest of my life. (student, personal communication, 2006)

As with the science theatre shows, Evergreen uses a fact-to-fiction approach for its residency programs. They are strongly curriculum focused and meet learning outcomes in both science and the performing arts. They employ inquiry-based learning where students are challenged to 'discover meaning and relevance in curriculum-linked topics pertinent to natural, scientific and environmental issues' (Evergreen Theatre, 2015a). The process starts with science learning and moves into co-operative drama games, character creation, scene building, scriptwriting, songs and choreography. At the end of the residency period, the work culminates in a theatre show that the students have created themselves using the science they learnt during the process. Evergreen provides the set, sound system, and costuming for all the students. In the whole-school version, the students perform the show to the entire student body, including staff, parents, and invited members of the community. The approach is socially sustainable because it builds positive feelings of wellbeing within the school community as a whole:

> The parents are pleased by the performances and the performance is very much a community building event. It brings the community of the school together. The young kids see what the older kids are doing so it provides an opportunity for a mentoring relationship to develop. (teacher, personal communication, 16 February, 2006)

The programs are not only inclusive in terms of the performance, but also in terms of the process used to create it. The teachers I interviewed felt they were especially inclusive for children with different learning styles and abilities:

> The program also really addresses itself to children who are in the 'non paper and pencil' group. It creates a situation where students can really shine and it gives them confidence … It's particularly strong with the ESL kids and the [special needs] kids because they're getting the information in an alternative form. And this really comes out in assessment. (teacher, personal communication, 16 February, 2006)

> I have higher needs kids in my class and two grade 6 classes at our school. My class did the Evergreen residency and the other did not; we found a significant difference in their final assessment tests; my students scored higher on terminology, vocabulary, and short answer questions! (Teacher, personal communication, 14 February, 2006)

In essence, the Grow-a-Show is a tightly focused playbuilding exercise with an emphasis on transforming scientific information into dramatic storytelling. Hatton and Lovesy (2009, pp. 11–12) note that the majority of theorists in educational drama have focused primarily on drama learning in relation to process drama rather than playbuilding. Significantly, Hatton and Lovesy consider playbuilding to be an important dramatic form that has key aspects in common with process drama because it also enables participants to generate new knowledge:

> Playbuilding is the interplay between the actual and the fictitious in the drama class-room and drama and theatre educators use the term *metaxis* to describe this type of learning … *Metaxis* is a mental attitude, a way of holding two worlds in mind, the real and the dramatic fiction simultaneously … *Metaxis* enables students to engage in the *make believe* of dramatic playbuilding contexts and links to what Vygotsky referred to as the dual effect of play. It is the interaction of the real and fictional that generates the learning for students as they work through their playbuilding. They learn as they craft scenes that allow them to walk in someone else's shoes. In this way, the playbuilding can provide the aesthetic space for challenging ideas and practices and can offer students new ways of knowing, seeing and being … Essentially the identification generated through playbuilding enables participants to make discoveries and draw meanings significant for them and their community. (Hatton & Lovesy, 2009, p. 12)

During field work I accompanied Evergreen staff to observe a five-day residency in action. The curriculum topic being investigated was 'Trees and Forests'. The curriculum links were trees and forests, seasonal changes, needs of animals and plants, animal life cycles. It began within a conventional science learning framework, using key questions that would be considered during the program: What is a forest?, What are major challenges for our forests today?, Why is it so important to maintain a bio-diverse forest ecosystem?, What actions are needed to sustain our forest ecosystems? Evergreen staff presented a slide show and lecture on the question of 'What is a forest?' Discovery learning was then used, with students working at different stations on the following topics: what tree-rings reveal about their past and forest history; users and uses of forests; carbon/oxygen cycle/photosynthesis experiment; tree identification using needles and leaves. After the station work, the students were involved in a mind-mapping session around their discoveries, before being asked the question: what are the most important or interesting topics on the map? Importantly for the playbuilding process, these topics would later become the focus for each group's scene development. Before the drama work began, however, students started researching their topic on the Internet. They were asked to write up their findings in their response journal, where they would record all of their research, learning, and reflective responses each day.

The first main drama learning activity was a dramatic simulation called 'build a tree'. Here the students created the different parts of a tree in movement and sound, including heartwood, sap, cambium, and phloem cells. Playbuilding began by looking at how to turn facts into fiction using the popular movie *Antz* as a stimulus for discussion. The process of turning factual information into a character was then explored using the Sun as an example of a dramatic character, with factual information and creative ideas listed under 'fact' and 'fiction' columns. Some of these metaphorical transformations were: hot – hot tempered; big – big ego; source of life for all – motherly. The science learning continued with students reviewing what they knew about their given topics and then conducting further research in a session called 'catch the facts'. They were asked to choose six of the most important facts they have discovered and present them to the group. Students could now start thinking about how they might transfer this process to the research they have done themselves: how can we apply it to the development of a scene or character?; Who is the bad guy?; Who is the hero?; What is the challenge/struggle/conflict?; What kind of story could we make out of it?

The next step is for the class to choose a movie or TV show that they will use as an imaginative starting point for their play. As Evergreen facilitator Mariee Devereaux notes: 'We really want to work from a popular culture perspective because then the kids are using what they already know to frame their new knowledge about science' (personal communication, 14 February, 2006). The students I observed decided on the movie *Star Wars*, changing the

title to 'Tree Wars: the Evergreens Strike Back'. They were asked to summarize the top ten important facts that they wanted to get across to the audience in the show. The facilitator oversees this process, checking and approving the fact sheet before the students begin to develop characters. Evergreen staff then gave a focused lecture on character creation and a demonstration of how to write a fact/fiction sheet with characters from the Harry Potter movies as examples. Using their own research, the students then applied this learning by choosing two characters within the forest ecosystem that would have potential conflict and write a fact/fiction sheet for them. Students also began to write their scenes using a set of questions to guide them and an emphasis on the facts:

> Start with the information! Always go back to the information. Your scene needs to be based on your research … always be thinking about what will be the best, most important facts for you to include in your character and scene building. You are gaining the ability to look and listen to facts and begin to think about the potential story that they tell. (Mariee Devereaux, Evergreen Residency Manager, 14 February, 2006)

To help develop the students' own work, Evergreen staff give an example of a scene outline, using the character of Fireman Fred who is obsessed with putting out fires. The scene begins with the trees standing in the forest when, suddenly, a fire comes through. The trees are scared until Fireman Fred arrives to put out the fire. The trees are singed, but new seedlings grow up from the burnt soil. In a similar vein, the students I observed created a scene with characters like Luke Tree Walker, a young Lodge pole Pine who lives in the Northern Boreal Forest, and Flame Vader, who wants to destroy the forest with fire. Each group was given the challenge of showing their scene in four to six tableaux that presented the basic plot of the scene. There was discussion and activities around the question of 'What makes a good story?' and an example involving a retelling of *The Three Little Pigs* through tableaux. A number of common playbuilding activities were then used in the development of characters and storyline, such as a story skeleton sheet and a full character profile for each of the characters in the scene. Students were asked to write six to eight sentences of dialogue between two characters in the scene. Afterwards, students introduced their characters to the class in role. During later sessions this initial work on character, dialogue, and scenes was again revisited, with a focus on the three questions posed previously: Who are the bad guys?; Who are the heroes?; and What is the conflict? After developing these further, students were asked to present their scenes again in four to five tableaux. When the scripts were at a more developed stage the groups presented their work in Readers' Theatre format, with peer critique given so they could continue to write and improve their pieces before the dress rehearsal and final performance (Evergreen Theatre, 2006a).

Discussion: Cleaning up our act with Evergreen?

> In the end we will conserve only what we love
> We will love only what we understand
> We will understand only what we are taught.
>
> (Baba Didum, Evergreen Theatre, 2015)

As a model for science drama in the context of environmental sustainability, Evergreen Theatre provides exemplary practice on many levels. Anecdotal evidence suggests that

its programs are highly effective, and there are a number of factors that would seem to contribute to its ongoing success, particularly in relation to the Grow-a-Show. In order to provide a framework of exemplary planning for teachers, the following key aspects of the company's approach have been identified and might be gainfully employed for science drama learning in classroom contexts. Also included are recommendations informed by current research in the field regarding some aspects of Evergreen's methods that might be modified or developed further.

Firstly, there is an equal emphasis on learning in both science and drama. To date, field literature around science-drama has shown an emphasis on using drama largely as a pedagogical tool for achieving learning goals in science. Evergreen's work, however, positions drama as an equal partner and the drama learning itself as being a vital component of the learning process. Importantly though, research also warns against allowing the drama to dominate over the science or environmental aspects of the learning (Gale, 2008, p. 174). Further, Evergreen's approach also gives equal weight to both the science learning and the environmental learning. Education for sustainability is not taught separately, but is firmly embedded in the social and ethical contexts of scientific investigation. Importantly, Evergreen's content addresses global issues but through exploring the local environmental context, making the learning immediately relevant to the students' everyday lives and experience. For example, learning about Canadian Boreal Forests on the one hand and how these are affected by global warming on the other.

Secondly, the process is methodical and highly structured. Students are periodically revisiting activities in order to build up knowledge and dramatic material over a period of time. In a process of 'essencing', students are continually challenged to reduce and distill their material to the most essential and important, in both science and drama. Tight constraints and limits are placed on them, within which they have the freedom to create, such as 'use four to five tableaux' and 'choose the best ten facts'. The tension between freedom and constraint has been identified by drama education specialists as a necessary ingredient in effective drama work (see O'Neill, in Heathcote & Bolton, 1995, p. ix; Neelands, 2003, p. 8).

Thirdly, the process is solidly based on factual information and knowledge. The approach begins with, and continues to check the students' science learning throughout the play-building process. Key questions and learning structures are in place to focus the research. Perhaps more importantly, the programs go beyond information gathering to encompass fostering of values related to environmental sustainability: 'research has shown that having knowledge is not sufficient to create behavioural change. What is also needed is an awareness of our connections with and in the world, and an attitude of caring' (Everett, Noone, Brooks, & Littledyke, 2015, p. 221). Österlind (2012, p. 36) has shown that a focus on factual knowledge at the expense of values can result in students losing interest in subject material related to environmental sustainability. The Arts have been identified as one of the major vehicles for helping to engender a disposition of care for the environment because they connect the emotional with the cognitive by engaging both the heart as well as the mind. When I interviewed Evergreen's Residency Manager I asked her why the students needed to do the drama at all, given that the science was so well covered. She gave the following reply: 'Because it starts to matter to them. It becomes real. They make it physical and they make it musical. All of a sudden they start to see trees as an essential part of their lives. How is a tree like your body?' (Mariee Devereaux, 14 February, 2006). This response supports the idea that drama can contribute to embodied knowledge through experiential learning.

Fourthly, the process is well grounded in effective drama practices, techniques and conventions commonly used in playbuilding. Consideration is given to students' skill level, workable time frames, narrative frameworks, and approaches to character creation. The context in which Evergreen operates means that they are sometimes working with students who have little or no experience in drama or in playbuilding, and often operating under tight time constraints. Hatton and Lovesy (2009, p. 40) suggest a maximum of five weeks for a beginner playbuilding sequence, with four by fifty minute lessons per week. Although there is no indication for a minimum time frame, it is recommended that an adequate period of time be allocated in planning for classroom playbuilding to ensure appropriate exploration and development of material. Evergreen's ten-week residency provides an adequate time frame that allows for in-depth exploration. By contrast, the one-week residency offers a very limited time frame, and this is likely to limit the scope of both the playbuilding process and the end product. However, most schools do not book Evergreen's programs as a one-off event, but book regular visits, usually twice a year (M. Devereaux, Evergreen Residency Manager, personal communication, 15 February, 2006). This means that, to a certain extent, the students are developing skills over time and Evergreen staff can work at a more advanced level in line with the students' skill base. In these terms, the one week residency functions more as an introduction to drama and playbuilding. For classroom playbuilding, Hatton and Lovesy (2009, p. 31) recommend a progressive developmental sequence that will build on students' prior drama experiences. A comprehensive program of drama learning is one that integrates and develops practical and theoretical drama knowledge over time.

Evergreen's playbuilding process is structured around narrative models derived from popular culture to scaffold the drama learning. Hatton and Lovesy (2009, p. 31) emphasize the importance of using suitable scaffolding that matches the skill level of learners. Given that the students have little drama experience, the use of popular culture provides a safe place to work in because it offers something familiar as a starting point. The models thereby help to create a situation of 'playbuilding with trainer wheels'. It is possible, however, that the quality of the resulting dramatic performance might be compromised by the use of these models. Hatton and Lovesy (2009, p. 42) emphasize the importance of ensuring the playbuilding process is open-ended at the beginning and not constrained within a fixed storyline: 'Keeping the work open early on allows a whole range of creative ideas to emerge and be tested out on the floor'. By contrast, using popular film narratives as the starting point means that the groups are likely to develop similar pieces, rather than engaging in a genuinely creative and explorative process from the outset. As Hatton and Lovesy (2009, p. 44) note, developing multi-dimensional characters takes time and exploration. On this point though, Evergreen's aim is, in fact, for the students to develop broad characters, which Hatton and Lovesy (2009, p. 44) suggest is appropriate for beginner playbuilders at the start of the playbuilding process. Further, the science content itself places a constraint on the material and limits its open-endedness since the characters and plot will develop in a particular direction according to the science context. It is recommended, however, that teachers do plan for students to build their characterisation skills during subsequent playbuilding sequences. With Evergreen, students do have scope for creative imagination through the use of metaphoric devising in developing their characters. Hatton and Lovesy (2009, p. 28) highly recommend teaching students how to employ metaphor as part of their playbuilding process, especially in relation to characterisation, such as 'Captain Envy versus Princess Ego'. This is precisely in line with Evergreen's approach, where the students are asked to create a character that is a metaphor

for a natural phenomenon or process within the forest eco-system. One of the students created the character of 'Flame Vador', for example, who represented the important action of fire in forest regeneration. This is also the approach Evergreen uses in its science shows, with characters like A.J. Algae. As Hatton and Lovesy (2009, p. 28) comment: 'Metaphoric characterisation enlivens the feelings, thoughts and subtext of a number of characters in the work'. While students might start with the facts and a popular film, what they end up with is something substantially original and engaging.

Finally, there is an important social context to the learning on a number of levels. Adult and peer modeling are used, for instance, with Evergreen's professional actors providing an example in terms of theatrical performance and older students providing peer modeling for younger students. This creates a culture of science drama learning and provides valuable drama/theatre role models for the students. In addition, the students are working together to perform the play for peers, family, school, and community. As O'Neill has noted, 'The significance of the social dimension of this kind of teaching should not be overlooked' (in Heathcote & Bolton, 1995, p. viii). Performing a play that students have created themselves means that the stakes are high, but so too is the social capital. The students are not learning about context-less facts as isolated learners. They are in a real social context and an imaginative context where the drama performance appears to be the primary motivating factor in the learning experience. In colloquial terms, it is a huge carrot involving a great sense of excitement and achievement. In some respects, the science learning occurs as a by-product of the performance context. As Bolton has noted, 'The participant's mental set in entering drama is not an "intention to learn". It is an intention to create or take part in or solve something' (Bolton, 1984, p. 153). For some students 'the over-riding feeling quality may be one of sheer pleasure at role-playing' (Bolton, 1979, p. 57). This means that the science learning itself might very well be secondary in the students' experiences of the process and, as Bolton has observed, there is often a tacit aspect to learning in most drama work (Fleming, in Bolton, 1984, p. 155). The teachers I interviewed made comments that support this idea in some respects, especially in terms of the songs: 'Kids remember the facts through the interpretive songs. They remember the songs in tests. You can see them singing in their head' (teacher, personal communication, 16 February, 2006). There is also a *conscious* learning process, though, in the constant focus and re-iteration of scientific material.

The social and communal aspects seem to be a key factor in Evergreen's success. Bolton has highlighted this as a primary characteristic of drama work, but one that is often overlooked. He notes that there is a tendency to focus on,

> drama as a medium for education at all levels and in all directions. But this is to ignore the 'other face' of drama: drama as celebration. Drama, it seems to me, is not always about change in understanding. It is also about celebrating a community's existence … festivals and rituals are not about change but about a collective identity. The 'other face' of drama shares this communal purpose. (Bolton, 1984, p. 161)

If one of the main reasons for Evergreen's success is because it provides an environment where the school can celebrate its communal identity, then the work might not be so much pedagogical, as anthropological. Perhaps it is about celebrating our humanity together. As Vygotsky has observed: 'In a sense we become part of the community and the community becomes part of us in the sharing of knowledge' (McInerney, 2002, p. 45).

While conducting field work in Calgary, I visited the Glenbow Museum and spent some time in an exhibit about the local indigenous people called the Blackfoot. One piece of commentary seemed especially relevant to this study and the importance of community:

> In the old days, we kept our children with us all the time. We did not send them to school for their education. Instead, our education was holistic and integrated with the family as part of everyday life. During the day, children used adults as role models in their play or helped adults with their daily chores. At night, children listened as adults told stories. Stories are for everyone, not only children. The lessons from stories can change as a person grows throughout life. (Glenbow Museum, 2006)

Storytelling has been called the oldest art form and many traditional folk tales are a kind of 'fundamental science' where humanity began to ask the big questions, like how the earth was made. But for a long time now, the 'story' and the social context have been left out of science teaching in order to present an objective, rational, scientific approach. Perhaps what Evergreen Theatre has done is to enliven science by putting traditional storytelling contexts back in place to create a vibrant learning environment.

Conclusions

This study has found that both theatre and drama can be effectively employed as a core pedagogical strategy in relation to science education in a context of environmental sustainability. It demonstrated that theatre and drama can positively contribute to the learning of science content and contexts by their ability to convey information in metaphorical and visual forms, by their active engagement of students, and by their high motivational quality. The results have implications for pedagogical approaches to science teaching and contribute to the current literature in the field. They are especially relevant to the crisis situation of declining student enrolments in science education at the post compulsory level, reported as occurring in a number of countries around the world. The findings offer a possible way forward for science education because they directly address a number of the recommendations made in the reports, such as the need to contextualize the content of science learning, as well as the need to make science lessons more engaging and personally relevant. The findings may contribute to increased numbers at the post compulsory level by providing a solid foundation in science education at the primary school level. The study makes a particular contribution to the limited literature on drama and science education specifically related to environmental sustainability. The research indicates that both science and drama learning can be enhanced when drama is positioned as an equal partner in the learning process, rather than being viewed only as a teaching methodology. The study also found that the social contexts which drama and theatre provided were an important ingredient for achieving the outcomes relevant to science and environmental education. The idea of drama as a celebration of communal identity was key in terms of student wellbeing and social sustainability. This appears to be one of the major contributing factors to the success of Evergreen Theatre. Looking ahead, the study opens up further areas of investigation. It highlights the use of playbuilding as a core strategy for teaching science but, at the same time it raises questions about effective ways of scaffolding the learning in this context. In addition, there is scope for further studies to explore other organisations around the world that are conducting similar work on science drama.

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Notes on contributor

Lynn Everett is a lecturer in drama education at the University of New England, Armidale, Australia. She is also a community theatre artist, with projects including a multi-arts youth project, a folk opera for the Australian Maritime Museum, an environmental cabaret, and a Japanese cultural exchange project. Her research interests focus on drama and environmental sustainability, popular theatre, traditional storytelling, and movement-based theatre pedagogy.

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