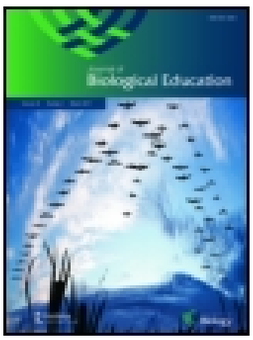

Routledge
Taylor & Francis Group

Journal of Biological Education

ISSN: 0021-9266 (Print) 2157-6009 (Online) Journal homepage: https://www.tandfonline.com/loi/rjbe20

Drama as physical role-play: actions and outcomes for life science lessons in South Africa

Martin Braund & Zaiboenisha Ahmed

To cite this article: Martin Braund & Zaiboenisha Ahmed (2018): Drama as physical role-play: actions and outcomes for life science lessons in South Africa, Journal of Biological Education, DOI: 10.1080/00219266.2018.1490799

To link to this article: https://doi.org/10.1080/00219266.2018.1490799

JOURNAL OF BIOLOGICAL EDUCATION, 2018
https://doi.org/10.1080/00219266.2018.1490799

Routledge
Taylor & Francis Group

Drama as physical role-play: actions and outcomes for life science lessons in South Africa

Martin Braund and Zaiboenisha Ahmed

Faculty of Education, Cape Peninsula University of Technology, Cape Town, South Africa

ABSTRACT

Two volunteer BEd student teachers in their fourth year of a BEd degree at a metropolitan university in the Western Cape of South Africa designed and taught lessons to two classes of the same age and ability in grade 7 (ages 12–13), using drama role-plays (intervention) and more conventional non-drama methods (control). Lessons were observed and video-audio recorded to identify episodes critical to successful learning. Learners (pupils) in both sets of classes were tested in associated content using tests designed by the student teachers. In both cases test outcomes were in favour of drama lessons (F = .56 and .55) but were not necessarily linked to the number of positive teaching episodes. Lack of interaction between student teachers and their learners, insufficient structure to the role-plays or a tendency to over-contextualise scenarios did not seem to have hindered conceptual understanding. Findings suggest a more nuanced and progressive programme of training in using drama for teaching science would be beneficial and that subject knowledge for planning activities must be particularly sound.

KEYWORDS

Role-play; drama; life sciences; teacher education

There is growing interest in drama to learn subjects such as biology. However, the field remains under-researched (Braund 2015a; Peleg and Baram-Tsabari 2011), particularly from perspectives of lesson structure and impact on learners. Drama use is part of wider international efforts in some countries for arts collaboration to enhance learning across the curriculum. For example in South Korea and some states of the US there are initiatives to provide development of the curriculum through the use of the Arts in the STEM curriculum, expanding it to a STEAM one (Science, Technology, Engineering, the ARTS and Mathematics) (Baek et al. 2011; Lunn and Noble 2008). These developments however should be set against rising concerns that in other countries (such as the UK and South Africa) the Arts and Arts collaboration (including the use of drama) have been side-lined in increasingly target and performance driven school cultures (Nompula 2012; University of Warwick 2015). In South Africa, where this study took place, the poor situation for drama and Arts is made more acute by continuing divisions between rich and poor schools exacerbated in the post-apartheid school system (Shalem and Pendlebury 2010).

The questions addressed by the study were:

CONTACT Martin Braund martin.braund@york.ac.uk

Research Question 1(RQ1): What are critical episodes, that positively or negatively affect learners' engagement or concept learning, of student teachers' lessons using drama role-play to teach Life Sciences content?

Research Question 2(RQ2): What is the knowledge and understanding of target concepts for learners in two similar classes taught using drama role-play (the intervention class) and using non-drama methods (the control class)?

The study explores the efforts of two student teachers at a University of Technology in South Africa to use drama, specifically physical role-plays, to teach concepts in Life Sciences (equivalent to Biology in other countries). Unlike some recent studies, the one reported is quasi-experimental in that pedagogical actions and outcomes for the same content taught using drama and more conventional methods are compared.

Drama use in science education

Constructivist approaches to learning biology and science have been advocated for some time (for example, Driver et al. 1994). However, teaching relying on transmission learning and practical work have often failed to realise hopes for constructivist learning (Abrahams and Millar 2008; Tytler 2007). This is particularly true for African countries where a lack of qualified teachers, books and practical resources results in much rote learning with very little group work and interaction between students (Hardman et al. 2011). Therefore it is worth considering more interactive methods such as drama that involve students learning biology content and processes through scripted and improvised plays, role-plays and dance/mime. Drama based pedagogy in science is part of a social constructivist landscape of learning whereby students' individual and collective understandings of concepts may be broadened, challenged, and/or confirmed through their interpretations of images, actions and narratives developed during drama-based tasks (Braund 2015a; Hendrix, Eick, and Shannon 2012).

Ødegaard (2003) offers three ways drama assists learning science: about *concepts*, about the *nature of science* and about *science and society*. As far as biology is concerned there is evidence that drama, particularly using physical role-plays, has helped concept learning for photosynthesis (Carlsson 2002), cell division (Ødegaard 2001) and ecology (Bailey 1994). It has been suggested that physical role-plays provide engagement in ways that provide immediate access to complex biological ideas (Colucci-Gray et al. 2006). In terms of learning about the *nature of science,* Ødegaard's second area*,* Aikenhead (2001) claims that science stories using drama help learners make border crossings between indigenous knowledge and accepted science. This is particularly important in African classrooms where indigenous knowledge can be a prominent part of learners' conceptualisation of the world around them, one that conflicts with the target concepts to be taught (Langer 2011; Semali 1999). Drama is particularly powerful in helping students appreciate ways in which theories in biology are constructed, contested and validated. The plays described by Braund (2015b) are examples in the area of evolution.

Using drama to teach about *science and society*, Ødegaard's final area for drama use, has positive outcomes for students' attitudes in biology. For example, the Y Touring Company in England used short online plays and scripts to stimulate debates about biotechnology and bioethics (Reiss 2010). In South Africa the authors developed argumentation lessons where role-plays helped learners debate the ethics of xenotransplantation and organ trade. A notable outcome was improvement in learners' content knowledge and argumentation use. Similarly, in Australia, Dawson noted improvement in argumentation levels for students involved in role-plays about who should have access to genetic information (Dawson et al. 2009).

According to Hendrix, Eick, and Shannon (2012, 826), 'activities associated with creative drama such as pantomime and improvisation can create a transactional learning pathway in order to help students build deeper understanding of concepts.' The 'transactional pathway' chosen for this study was for student teachers to use physical role-play, where learners act out with their bodies and limited props, the sequences, structures and processes associated with biological phenomena. Physical role-plays can be seen as examples of analogous learning. Harrison and Treagust (2006) note the particular

Table 1. The two student volunteers in the study and their teaching situations.

(Anonymised) student teacher's name	Ethnicity/student's home language	Placement school	Topic/content taught
Alice	White/English	Large school in an area of government and mixed private housing. Medium sized classes and reasonably resourced	The human ear/ how we receive and hear sound
Denise	Coloured/Afrikaans	Very large school with large classes in an area of government housing. Medium resourced	The structure of the cell nucleus

power of drama as an alternative to other forms of analogues such as diagrams, computer simulations and practical work because actions involve closer personal interaction with content. According to McSharry and Jones (2000) role-plays, both physical and scripted, are effective learning tools because they provide: a different narrative from written media, a sense of ownership through creation and performance, ways into debates and discussion of sensitive issues and a physical experience through which abstract material is made comprehensible.

Methods

The study is a small scale quasi-experimental case study of two student teachers using drama and non-drama methods to teach Life Sciences content to learners (as school students are known in South Africa) in grade 7 in schools in the Cape Town Metropole District of the Western Cape Province of South Africa. The student teachers were in the fourth and final year of a BEd degree course in teaching with Life Sciences as a specialism/major although, as is common in many countries, teachers of primary phase are required to teach most other subjects. All students in the Life Sciences 4th Year BEd class group were exposed to a half-day workshop explaining and practising some of the techniques to teach science content using drama, including the use of physical role-plays. Additionally, all teacher education students in the University had experienced a short course of one week in media and communication in their first year, which included some drama work.

The student teachers were volunteers and so they are not intended to be representative of the student cohort. Table 1 shows the participating student teachers, what they taught, and the characteristics of participating schools in which they practised.

In South Africa the language of instruction is often English, though this depends on regional and school policy. English was the language of instruction in the two schools featured in the study. Student teachers choose their final practice school in a community in which they feel most connected. Thus the home languages of the majority of learners in the practice schools often match those of the student teachers.

Data collection

Student teachers prepared two lessons, both to be taught to similar sizes and abilities of classes in grade 7 (ages 12–13) in their placement schools, one incorporating drama role-plays and the other using whatever non-drama methods they deemed appropriate. As a cross check on equivalence of the two classes, acting as intervention and control classes, performance data were collected from the most recent school science examinations carried out two months prior to the study.

Student teachers presented lesson plans to the researchers (the authors) who advised on the appropriateness, timing and organisation of tasks. In the absence of standardised national tests for this age group the student teachers each submitted test material to use as post-tests of related content for both intervention (drama) and control (non-drama) groups. Researchers reviewed this material and suggested changes so that the tests would examine substantive knowledge and understanding of associated content rather than only factual recall.

The two sets of lessons took place either on the same school day or within two days of each other. Lessons were video/audio recorded using two cameras so that simultaneous group role-plays or rehearsals could be recorded. Researchers independently recorded field notes for each lesson. Following both lessons student teachers were interviewed using a semi-structured schedule of questions and these were audio-recorded. Dialogue from the video-recorded lessons and interviews was transcribed for analysis.

A three stage ethical approval was followed for the study involving, the University Faculty Ethics Committee, the Western Cape Education Department and School Boards. One outcome of this was to guarantee that all video footage would remain secure and that no images from it would be published.

Data analysis

In line with our first research question, video footage, audio transcriptions and field notes were used to identify what we called 'critical episodes' in the drama lessons using role-play. We adapted a version of Tripp's (1993) critical incident methodology but, rather than track incidents of classroom and behavioural management as he did, we considered critical episodes to be ones representing decisions and actions by the student teacher that either progressed or detracted from learning biology content. The method was established in our work on argumentation and critical thinking in South Africa (Braund et al. 2007, 2013). We did not carry out the same analysis for the non-drama lesson as our purpose was to focus on pedagogical decisions and actions that affected the application of drama to teach biology. Each researcher carried out a separate analysis and we provided all the raw data to a colleague who carried out a blinded third analysis. Results were considered at a research team meeting at which differences between critical episode identification were resolved.

Quantitative data from student teachers' post-tests with intervention (I = drama) and control (C = non-drama) classes were entered and analysed along with school examination results for the same classes using SPSS15 (for widows 2007). Calculations of means (μ), standard deviations (SD) and t-tests (p values) of differences between the two classes for post-tests and school examination results were carried out. Effect sizes (F values) were calculated for differences in post-test and examination results between the two classes for each student case.

Summary of the lessons taught

To make sense of the results and ensuing discussion, a summary of lessons taught by each student teacher is provided.

Alice

Alice began her non-drama lesson demonstrating sound production using a xylophone. A question and answer (Q&A) session followed where ideas of differences between sound and noise (disorganised sound), sound as energy, vibrations to generate sound and sound travelling as waves were established. A flow chart on the chalk board was used to track learners' lists of sounds heard while, 'getting up and going to school'. Alice used a series of mini posters showing sources of sound, transmission and ear structure, asking learners to come to the front of class to place large red arrows onto posters and to order them telling the story of sound generation, transmission and reception. The final phase of the lesson concerned hearing impairment and how other senses such as touch compensate for hearing loss.

Alice's lesson using drama again began with mini posters to construct the 'story of sound'. She asked the class to organise as groups (6–10 students) and provided each with a written scenario for each group to act out the scenario to the rest of the class to show 'how we hear the sound' The four scenarios provided were:

Group 1: You are travelling with other astronauts to the moon in a spaceship. Demonstrate the effect vibrations would have on the body of the spaceship, as well as the bodies of the astronauts.

Group 2: You live in a forest far from your neighbours. One day a fire breaks out in the forest. The only way you can call for help is using a drum. Demonstrate how sending a message on the drum brings help from your neighbours.

Group 3: You are in a huge cave. You realise that when you shout your name you can hear it echo back. Demonstrate how an echo makes sound waves travel back to you.

Group 4: You are at a dance party. There are a few deaf people there. Demonstrate how deaf people can enjoy the music.

Twenty minutes was set aside for the groups to rehearse their enactments and then each group performed in turn to the rest of the class. Details of role-play performances appear later in the discussion.

Denise

The non-drama lesson began with elicitation of learners' knowledge of parts of the cell. Denise organised the class of 42 into seven groups (of 4–6 learners). Each group was given a hardboiled egg and some paper towels and Denise asked learners to feel the shell, peel the egg and cut it in half. She drew analogies between parts of the egg and components of the nucleus: the shell (nuclear membrane), egg white (chromatin) and yolk (nucleolus).

In the drama version of the lesson a class of 40 learners was organised in stages to simulate parts of the cell nucleus. Learners with jackets (17) were arranged as a circle to show the nucleus membrane, standing, 'a little apart because the membrane has pores ... so the proteins can go through.' Learners wearing green tops then travelled through the 'pores' into the centre of the circle, Denise saying, 'now you represent the chromatin and you are all jumbled up but now hold hands and you have to be compact.' She instructed the remaining learners wearing grey tops to go in and get tight together, 'like a ball …you are now the nucleolus.' Next, every other learner in the chromatin was asked to leave the nucleus through a pore in the 'membrane'. She asked these learners who had left the circle through the pores to get into pairs to represent (incorrectly) 'chromosomes'. The lesson closed by asking learners to use learning from the drama simulation to guide Denise's drawing of a nucleolus onto the chalk board.

Findings

Findings are reported for each research question.

RQ1. Critical Episodes in Teaching Life Science Lessons Using Drama Role-play

Table 2 shows critical episodes for each student teacher case. In line with the method of analysis these can be positive, where decisions or actions of the student teacher promoted learning, or negative where these were less likely to advance learning or even hinder it. Separate columns of Table 2 show positive and negative episodes given short phrases to denote what aspects of lessons they connected to.

RQ2. Comparison of Post-test and School Examination Results for Intervention (drama) and Control (non-drama) Classes

Table 3 shows analysis of results from student teachers' posts-tests and schools' examinations, carried out prior to the study. Column 1 shows the student case alongside maximum scores allocated, first to the post-test and second to the school examination. Columns 2–5 show means and standard deviations for post-tests and examinations separately for each treatment class; intervention (drama) and control (non-drama). The final two columns show the effect sizes (F values) and significance of differences between the intervention (drama) and control (non-drama) classes (p values calculated from results of t-tests). Where these values are in favour of the drama (intervention) class, they are shown as positive (+) and, in cases where differences where in favour of the non-drama (control) class, these are shown as negative (−) values.

For Alice there were significant differences favouring drama intervention with a large positive effect of +0.56. In education research an effect size is considered meaningful, especially in short one-off lesson interventions, above the 0.2 level (Lipsey and Wilson 1993). Although there was a slight difference

Table 2. Critical episodes for the student teacher cases of teaching Life Sciences lessons using physical role-play.

Case	Lesson focus	Positive critical episodes	Negative critical episodes
Alice	Sound/how we hear	1.Environment for drama 2.Modelling how to enact concepts 3.Supporting group rehearsals	1.Match of enactment to concepts 2.Weak subject knowledge about sound energy 3.Groups too large to portray concepts 4.Inclusion: some learners did not take part in the drama 5.Timing: too long for rehearsal and not enough time for portrayal 6.No linking or critique of actions/role-play to concepts
Denise	The cell nucleus	1.Environment for drama 2.Assigned clear roles for players 3.Support and linking in the role-play simulation 4.Gave holistic summary linking actions to concepts	1.Inclusion: some learners left out of the drama action 2.Weak subject knowledge (role of chromosomes)

Table 3. Post-test, school examination and effect sizes for drama and non-drama lesson classes.

	Drama (Intervention class)		Non-drama (Control class)		Effects (*F* values) and significance of differences (*p* values)	
Case (Max for post-test/Max school exam)	Mean (SD) Post-test	Mean (SD) School exam	Mean (SD) Post-test	Mean (SD) School exam	For drama/non-drama difference	For school exam difference
Alice (15/40)	4.7 (2.6)	20.2 (6.3)	3.25 (2.6)	18.9 (10.7)	+0.56 $p = 0.01$*	+0.15 $p = 0.34$ (ns)
Denise (100/100)	51 (9.5)	48 (11.3)	44 (16.2)	52 (14.4)	+0.55 $p = 0.038$*	−0.31 $p = 0.20$ (ns)

in the school examination results for the two classes ($F = 0.15$), t-tests showed the difference was not significant ($p < 0.05$ at $p = 0.34$).

For Denise there was a similar positive effect in favour of the drama class ($F = +0.55$) made more striking when the effect of the difference in the school examination results for drama and non-drama class, favouring the latter, is taken into account ($F = -0.31$), even though this difference was not statistically significant ($p = 0.2$).

Discussion

It appears, from the positive effects of drama intervention seen in post-test scores, that the lessons taught by Alice and Denise were successful. One might think these successes would be reflected in the extent of positive critical episodes compared with negative ones identified for their lessons. While this might be true for Denise, where four episodes were positive and two negative, it certainly was not so for Alice, where six negative episodes outweighed three positive ones. This raises the question of whether the drama experience for Alice' learners, though not particularly well-structured or supported in the lesson, was powerful enough to transcend relatively poor teaching and helped make the necessary cognitive connections allowing these learners to out-perform their non-drama peers on the post-test.

At a staff research seminar in our university where these results were presented it was commented that differences between drama and non-drama classes might be because student teachers just put more effort into planning and executing their teaching using drama. While we did not track the number of critical episodes for non-drama lessons, we do not think this holds true. In both cases non-drama lesson plans were as detailed, if not more so, for the non-drama lessons and the effort that went into teaching them was just as great as for the drama lessons. Indeed the tutors who have worked with these student teachers for four years remarked that their non-drama lessons showed signs of innovation they had not seen before. This was evidenced in Denise's non-drama lesson when she decided to introduce the activity to dissect a boiled egg and use this as an analogy for the cell nucleus. It was almost as if having to think deeper about analogous learning using drama sparked ideas on how other analogies might be made available to assist learning in non-drama situations.

Our first research question set out to explore critical episodes of student teachers' lessons using drama role-play to teach Life Sciences content that are likely to assist or hinder learning. Thus our intention was to use the study as an exploration that could shed light on what we might do to help future students (and teachers through INSET) and provide feedback to these student teachers and their peers to help them improve teaching. Bearing in mind that these students were volunteers and were not previously practised in using drama pedagogy, we think they did quite a good job. However, analysis of their lessons throws up three areas for consideration as to how this type of drama functions as a successful teaching method.

Linking actions and concepts

An issue faced by all biology and science teachers is trying to make abstract ideas evident and plausible to their learners so they can assimilate these into existing mental structures (Scott, Mortimer, and Ametller 2011). Role-plays, as physically acted out simulations, are effective in analogous teaching because they provide a physical experience through which abstract content can be made explicit and obvious to learners, lodging connections in longer term memory (McSharry and Jones 2000). However, for this to be a reality the choice of role-play scenarios must be appropriate and links made explicit between performed actions and concepts, sequences or processes. For example, even though Alice's drama lesson was successful in terms of post-test results for learners in the drama class, her choices of role-play scenarios did not address a key aim of her lesson, to show how a generated sound wave is received by the human ear and translated into a signal capable of being interpreted by the brain. Thus key linking of drama to planned content was missing. The drama role-plays acted out by the learners successfully addressed the effects of sound on the body (in the case of the space craft scenario) or of an echo in the cave example, but in two of her scenarios role-play outcomes were lost in Alice's attempt to contextualise the drama and anchor this to learners' real life worlds. At the interview immediately following the drama lesson we asked Alice why she had chosen the scenarios for role-play and for one of them, the people stranded by fire in the forest, she told us that she included this, 'Because many of my learners are from communities like from the Congo, so I thought maybe they would know about communication in the forest using drums'. This represents an admirable desire to contextualise learning, but we have seen before that in South African classrooms there is a tendency to over-contextualise at the expense of sufficiently embedding concepts to be learned (Braund et al. 2013).

A further aspect of linking from drama to concepts concerns the space made in rehearsal, the role-play itself or in debriefing activities for sufficient linking to occur. For example, positive critical episodes in the role-play used by Denise to show components of the cell nucleus showed she became part of the action showing learners, as the simulation progressed how each part was represented by their actions, but in a way that did not stop the action. A key aspect of drama for learning biology and science is that there ought to be a place in lessons for learners to reflect on what they have seen or portrayed and to provide critique on the extent to which actions, dialogue or story are realistic portrayals of concepts, sequences or processes.

Learner autonomy

We had hoped student teachers would have allowed some degree of learner autonomy in planning and teaching lessons using drama. We advised in our preparation workshops that over-directing learners might limit learners' capacity to experience and make links from the drama to biological content. Thus it was disappointing to see over-direction in Alice's lesson where she almost seemed to push learners to adopt roles and in Denise's lesson where she adopted the role of strong director within, and of, the action. However, we also noted that these lessons were not unsuccessful in helping learners make the required connections, as shown in the lesson summaries.

Subject knowledge

We noticed subject knowledge 'blips' with both student teachers, even though we advised and helped prepare them for these lessons. Such problems seemed more acute for planning and carrying out the drama lessons than for non-drama lessons.

We have noticed our student teachers often use books, worksheets and other text related activities almost like props to shore up poor subject knowledge. Perhaps using drama exposes a lack of subject knowledge more than teaching using conventional methods. There are fewer places in the drama process to hide deficiencies in subject knowledge.

Conclusion

A report of the US President's Committee on the benefits of arts integration suggests we still do not know enough about the conditions for and ways in which drama based pedagogy can be effective and supports learning (President's Committee on the Arts and Humanities's 2011). Although the study was small scale and explorative, never intended to produce generalisable results, there are valuable insights for biology teaching that may help address these gaps in understanding. The study highlighted opportunities for linking played out actions with target concepts, often fell short of what is required to maximise potential for learners, though this did not seem to markedly affect performance outcomes. The findings that over-contextualisation of drama can mask and hinder role-plays as analogues for learning of concepts and that very thorough subject knowledge is needed during planning role-plays are worth noting.

At the level of university course design, findings show there is still work to do to help teacher education students who are Life Sciences majors make sufficient border crossings from pedagogy of drama, in which they are less knowledgeable and practised, into their pedagogy for Life Sciences teaching. To successfully accomplish this requires concentration on planning and carrying out activities that allow learners more autonomy in planning and critiquing the effectiveness of their actions. It may be that a progressive programme of stages using drama that takes student teachers on a less challenging journey from structured drama use such as plays and scripts, through role-plays where roles are defined and supported, towards the more demanding self-structured and learner derived role-plays such as those intended in this study would be beneficial.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abrahams, I., and R. Millar. 2008. "Does Practical Work Really Work? A Study of the Effectiveness of Practical Work as a Teaching and Learning Method in School Science." *International Journal of Science Education* 30 (14): 1945–1969.

Aikenhead, G. 2001. "Integrating Western and Aboriginal Sciences: Cross-Cultural Science Teaching." *Research in Science Education* 31 (3): 337–355.

Baek, Y. S., H. J. Park, Y. M. Kim, S. G. Noh, J. Y. Park, J. Y. Lee, … H. Han. 2011. "STEAM Education in Korea." *Journal of Learner-Centered Curriculum and Instruction* 11 (4): 149–171.

Bailey, S. 1994. *The Ecogame*. Risley, Warrington and Cheshire: BNFL Education Unit.

Braund, M. 2015a. "Drama and Learning Science: An Empty Space?" *British Educational Research Journal* 41 (1): 102–121.

Braund, M. 2015b. "Darwin-Inspired Drama: Towards One Culture in Teaching and Learning Science." In *New Directions in Mathematics and Science Education: Darwin-Inspired Learning*, edited by C. J Boulter, M. J. Reiss and D. L. Saunders, 285–299. Rotterdam/Boston/Taipei: Sense Publishers.

Braund, M., F. Lubben, Z. Scholtz, M. Sadeck, and M. Hodges. 2007. "Comparing the Effect of Scientific and Socio-Scientific Argumentation Tasks: Lessons from South Africa." *School Science Review* 88 (324): 67–76.

Braund, M., Z. Scholtz, M. Sadeck, and R. Koopman. 2013. "First Steps in Teaching Argumentation: A South African Study." *International Journal of Educational Development* 33: 175–184.

Carlsson, B. 2002. "Jag Vill Vara Kol!-Ett Fotosyntetiskt Dramaspel." *Miljödidaktiska Txter, Lärarutbildningen, Malmö, Högskola* 4: 10–27.

Colucci-Gray, L., E. Camino, G. Barbiero, and D. Gray. 2006. "From Scientific Literacy to Sustainability Literacy: An Ecological Framework for Education." *Science Education* 90 (2): 227–252.

Dawson, E., A. Hill, J. Barlow, and E. Weitkamp. 2009. "Genetic Testing in a Drama and Discussion Workshop: Exploring Knowledge Construction." *Research in Drama Education: The Journal of Applied Theatre and Performance* 14 (3): 361–390.

Driver, R., H. Asoko, J. Leach, P. Scott, and E. Mortimer. 1994. "Constructing Scientific Knowledge in the Classroom." *Educational Researcher* 23 (7): 5–12.

Hardman, F., J. Ackers, N. Abrishamian, and M. O'Sullivan. 2011. "Developing a Systemic Approach to Teacher Education in Sub-Saharan Africa: Emerging Lessons from Kenya, Tanzania and Uganda." *Compare: A Journal of Comparative and International Education* 41 (5): 669–683.

Harrison, A. G., and D. F. Treagust. 2006. "Teaching and Learning with Analogies." In *Metaphor and Analogy in Science Education*, edited by P. J. Aubusson and A. G. Harrison, 11–24. Dordrecht: Springer.
Hendrix, R., C. Eick, and D. Shannon. 2012. "The Integration of Creative Drama in an Inquiry-Based Elementary Program: The Effect on Student Attitude and Conceptual Learning." *Journal of Science Teacher Education* 23: 823–846.
Langer, J. 2011. "Indigenous Knowledge and Western Science." In *Postcolonialism and Science Fiction*, 127–152. Basingstoke: Palgrave Macmillan UK.
Lipsey, M. W., and D. B. Wilson. 1993. "The Efficacy of Psychological, Educational, and Behavioral Treatment: Confirmation from Meta-Analysis." *American Psychologist* 48 (12): 1181–1209.
Lunn, M., and A. Noble. 2008. "Re-Visioning Science "Love and Passion in the Scientific Imagination": Art and Science." *International Journal of Science Education* 30 (6): 793–805.
McSharry, G., and S. Jones. 2000. "Role-Play in Science Teaching and Learning." *School Science Review* 82 (298): 73–82.
Nompula, Y. 2012. "An Investigation of Strategies for Integrated Learning Experiences and Instruction in the Teaching of Creative Art Subjects." *South African Journal of Education* 32 (3): 293–306.
Ødegaard, M. 2001. "The Drama of Science Education. How Public Understanding of Biotechnology and Drama as a Learning Activity May Enhance a Critical and Inclusive Science Education." Unpublished Dr. Scient. diss., University of Oslo, Norway.
Ødegaard, M. 2003. "Dramatic Science. a Critical Review of Drama in Science Education." *Studies in Science Education* 39 (1): 75–101.
Peleg, R., and A. Baram-Tsabari. 2011. "Atom Surprise: Using Theatre in Primary Science Education." *Journal of Science Education and Technology* 20 (5): 508–524.
President's Committee on the Arts and Humanities. (2011). *Reinvesting in Arts Education: Winning America's Future through Creative Schools*. Portsmouth, NH: RMC Research Corporation.
Reiss, M. 2010. "Science Education, Theatre and 'Y Touring'." Accessed February 10, 2017. www.theatreofdebate.com/ytouring21/Blog
Scott, P., E. Mortimer, and J. Ametller. 2011. "Pedagogical Link-Making: A Fundamental Aspect of Teaching and Learning Scientific Conceptual Knowledge." *Studies in Science Education* 47 (1): 3–36.
Semali, L. 1999. "Community as Classroom: Dilemmas of Valuing African Indigenous Literacy in Education." *International Review of Education* 45 (3/4): 305–319.
Shalem, Y., and S. Pendlebury, eds. 2010. *Retrieving Teaching: Critical Issues in Curriculum, Pedagogy and Learning*. Cape Town: Juta Press.
Tripp, D. 1993. *Critical Incidents in Teaching: Developing Professional Judgement*. London: Routledge.
Tytler, R. 2007. *Re-Imagining Science Education: Engaging Students in Science for Australia's Future*. Camberwell: Australian Council for Educational Research.
University of Warwick. 2015. *Enriching Britain: Culture, Creativity and Growth*. Warwick: The Warwick Commission/University of Warwick.