

Debra McGregor
Dayle Anderson *Editors*

Learning Science Through Drama

Exploring international perspectives

Contributions from Science Education Research

Volume 11

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Editors

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 Springer

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Foreword

For many teachers of science, it can be difficult to imagine that drama has much to contribute to school students' learning about science. And yet there are more similarities between drama and science than is sometimes supposed. Fundamentally, the discipline of science is about the production of models that attempt to explain the material world. So, for example, the particulate theory of matter is a very simple model that has quite exceptional generative power; it can help provide explanations of such apparently diverse phenomena as pressure, changes of state, chemical reactions and nutrient cycling in ecosystems. In science education what we are trying to do is to enable students to understand these models, to appreciate something about how scientists have come to hold them and to see their potential utility.

Above all, science and science education are about enabling people to have a new way of seeing the world. I was trained as a biologist and when I look at a wood, I see it differently as a result. Thanks to the Copernican revolution we realise that humanity is no longer at the centre of the solar system; the heavens do not revolve around us. Thanks to the theory of natural selection, we realise that even the most co-operative behaviours, such as the sacrificial behaviour of workers we see in the social insects, are, at another level of explanation, the direct result of intense competition.

In a dramatic performance, humans act out roles to help others see things in new ways. Mostly, of course, playwrights, directors and actors are principally concerned with human relationships or with existential questions about existence, meaning and purpose. Sometimes, though, their content is more directly focused on the concerns of science (Bertolt Brecht's "Life of Galileo", Tom Stoppard's "Arcadia" and Michael Frayn's "Copenhagen" are outstanding examples). Setting aside such examples, drama can be used to illuminate science in other ways – to help provide new approaches to understanding the material world and appreciating the scope and implications of science. However, it is only relatively recently that the science education literature has begun seriously to explore the lessons that drama might have for science education. When I trained to be a school teacher, there was almost nothing available; we were simply enjoined to try role play when teaching contentious issues in science.

This invaluable volume brings together as authors many of those who have helped develop the field of Learning Science through Drama (LStD), whether this is by appreciating drama, performing drama or making drama, to use an existing classification that is explored and developed in this book. The book's chapters provide both detailed conceptual analyses of the issues concerned with LStD and a rich set of examples of the field from around the world. It will clearly be the benchmark for years to come. My hope is that it helps enliven pedagogies in school science teaching so that it deepens students' thinking and means that fewer young people reject science in the mistaken belief that, unlike many other subjects, it doesn't require imagination and gives little scope for creativity and embodied learning.

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Michael J. Reiss

Preface

This book has emerged as a result of the coming together of minds, usually at international conferences. The authors are each educational researchers who have been enthused about, and concerned with, the way that drama (in its many forms) could be employed effectively for the teaching and learning of science. Each of the various international studies presented and discussed at various research conferences have culminated in the writing of the chapters included in this book.

In particular, there have been three international drama and science symposia that many of the contributors to this book have engaged with. The first was chaired by Dayle Anderson and Delia Baskerville (at the ESERA conference in Dublin 2017) with papers presented by Anderson, Baskerville, Braund, McGregor and Verhoeff with Ødegaard as discussant. The second was chaired by Debra McGregor (at the International Organisation for Science and Technology Education in Malmo 2018) with papers presented by Branscombe, Braund, McGregor and Walan with Frodsham as discussant. The third symposium was presented at the ESERA 2019 conference in Bologna. This was chaired by McGregor with papers from Braund, McGregor, Odegaard and Verhoeff with Frodsham as discussant. Rich and varied reflective discussions ensued after each of the paper presentations in the three symposia. From these conversations the ideas regarding the content and focus of this book were subsequently conceived.

Thank you to everyone who contributed to this exciting project that exemplifies participatory and active learning. All of the projects described are located within a science; Science, Technology, Engineering and Mathematics (STEM) or even Science, Technology, Engineering, Arts and Mathematics (STEAM) context.

Happy and informative reading!

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Contents

1	Introduction: Examining Contrasting Ways That Drama Approaches Can Be Applied to Support Learning Science.	1
	Debra McGregor	
Part I Reviewing What We Already Know about the Ways that Drama, Performing Arts and Theatrical Approaches Contribute to Learning Science		
2	Re-thinking Theorising About the Use of Drama, Theatre and Performance in Learning Science	11
	Delia Baskerville, Debra McGregor, and Amy Bonsall	
3	Towards a Theorisation for Physicalized Drama to Learn Science	27
	Martin Braund	
4	Epistemic Contrasts of Different Drama Conventions: A Content Analysis of the Range of Affordances Variations of Role Play Offer for Learning Science.	43
	Debra McGregor and Dayle Anderson	
5	Using Drama in Science Education and for Sustainability Issues	69
	Marianne Ødegaard	
Part II Providing Rich Case Studies of Projects that Describe How Drama has been Applied in Many Different Contexts, Countries and Across a Wide Variety of Scientific Disciplines to Promote Learning		
6	Crossing Borders. Studies with Student Teachers Using Physical Role-plays in South Africa	89
	Martin Braund	

7	Integrating Science and Drama to Support Learning About the Nature of Science in New Zealand Primary Classrooms	103
	Delia Baskerville and Dayle Anderson	
8	Scripting, Performing and Reflecting: Adopting Drama to Engage Secondary Students with National Environmental Concerns	119
	Roald P. Verhoeff	
9	Embodied Learning: A Case Study of Tableau and Writing in Role to Represent Main Ideas About the Solar System	137
	Margaret Branscombe	
10	Drama for Teaching Controversial Issues in Science	155
	Peta J. White and Jo Raphael	
11	Reflecting on Performance and the Audience: Lessons from Practice	175
	Zacharoula Smyrniou and Eleni Georgakopoulou	
Part III Illustrating How a Multitude of Research Approaches, Utilising Different Data Collection Methods, Contribute to the Complexity of Evidential Impact of this Kind of Innovative Pedagogy		
12	Analysing and Applying Different Theoretical Frameworks to Make Sense of Dialogue in Science Lessons Using Drama	195
	Sarah Frodsham and Debra McGregor	
13	Using Drama Conventions as Data Collection Tools	213
	Dayle Anderson and Delia Baskerville	
14	Researching the Value of Using Multiple Dramatic Conventions: A Case Study Approach	229
	Carolyn Swanson	
15	Impactful Drama: Using Mixed Methods Approaches for the Evaluation of Drama in Science	249
	Bethan Claire Stagg	
16	‘Act-Like-A-Scientist-Test’: What Does a Deductive Content Analysis Show?	267
	Jaakko Turkka, Maya Kaul, and Maija Aksela	

**Part IV Plenary: Concluding Reflections Considering
the Focus, Findings and Future Implications
of the Studies Presented in this Book**

**17 Reflective Discussion on Teaching and Learning Science
with Drama: Emerging Themes. 287**
Brian Edmiston, Debra McGregor, and Dayle Anderson

**18 Conclusion: A Synthesis for Now and Possibilities
for the Future 301**
Debra McGregor

Index. 321

Chapter 1

Introduction: Examining Contrasting Ways That Drama Approaches Can Be Applied to Support Learning Science



Debra McGregor

This book is innovative in that it includes a wide range of international perspectives that examine the varied ways that different forms of drama can support learning in science. Learning science by adopting (and adapting) theatrical techniques, being involved in a performance or engaging ‘in-role’ to represent something scientific offers many inclusive ways that learners can relate to science. The processes by which subject matter can be introduced, thought about, discussed, transformed, performed and disseminated are endless. There is emerging evidence, too, of the different ways that drama pedagogies can actively involve and engage learners to promote scientific understanding of both a conceptual (Abrahams & Braund, 2012; Dorion, 2009; McGregor, 2012; Ødegaard, 2003) and procedural nature (McGregor, 2017). There are approaches adopting drama techniques that can enhance students’ understanding of the Nature of Science (NoS) (Anderson, 2004; Ødegaard, 2003; McGregor et al., 2019), recounting and recollecting (biology, chemistry and physics) science concepts (Abrahams & Braund, 2012; Otter, 2020), considering science in society (Ødegaard, 2003; Verhoeff, 2017), stirring positive emotions about, and developing empathy (Turkka et al., 2018) with science and scientific concepts as well as promoting learners’ scientific identities (Swanson, 2016; McGregor, 2017).

There are studies, however, that claim that used unimaginatively drama can be deemed ‘uncreative’ (Stylianidou, 2014). This book, therefore, presents many varied ways that drama processes have been implemented and have evidenced positive learning outcomes as well as offering suggestions about, as yet untested, possibilities.

The use of drama in science education does not have a long tradition. Dorion (2009) implies it began to be more widely utilised in the 1990s. He also indicated

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that there was a relatively narrow interpretation of the use of drama, informed largely by drama pedagogy rather than science *and* drama pedagogy. The former, usually taking the form of role-play (Smith, 2015), or simulations. More recently, there has been a notable increase of papers reporting research projects at international science conferences. 15 years ago there would have been no presentations at all sharing and discussing ways that drama conventions or performing arts approaches could contribute to science learning and pedagogical development(s). The lack of adoption across European classrooms (Stylianidou, 2014) as well as a view that drama did not promote creativity (Stylianidou, 2014, p. 10) could explain why there are still relatively few research studies focused in this cross-disciplinary area. However, longer held antipodean interest (O'Toole, 1992) and recognition of the value of drama education (Gain & Aitken, 2022; O'Toole et al., 2009) in generating engaging and active learning opportunities that promote creative ways of teaching and learning in science (White et al., 2021) has more recently re-gained momentum.

Although there have been an increasing number of recent projects evidencing the positive effects of using drama as a pedagogic strategy in science education (White et al., 2021), it has been scantily adopted over the last two decades. This may be due to teachers' lack of confidence in using drama (Darlington, 2010; McGregor & Precious, 2015) or concerns about the veracity of the science that may perpetuate erroneous understandings (Braund et al., 2015; Nicholas & Ng, 2008) or misconceptions. Abrahams and Braund (2012) also suggest that designing effective science lessons using drama requires expertise from two contrasting disciplines and consequently reduces its use. They argue that many science teachers may find it difficult to incorporate drama as an effective pedagogic strategy in their teaching. This aligns with Dunn and Stinton (2011), who assert that knowledge of the curriculum *and* pedagogical content knowledge is needed for teachers to feel confident and 'know-how' best to use drama approaches for learning science. Braund et al. (2015) suggest that teachers' employment of drama as a pedagogy in science could be supported by progressively introducing them to drama techniques and have them consider the appropriateness for learning science content. Supporting unthreatening and supportive professional development opportunities for teachers to practice alternate ways of using drama with others can build confidence and pedagogic repertoire (McGregor, 2012).

This book is, therefore, an international collection of chapters that are designed to contribute to, and consolidate, what we know from research about the use of different forms of drama to support both teaching and learning in science.

The use of drama varies across the countries where each of the authors contributing to the book are based. In some nations there is little or no reference to the ways that drama could support learning science in the national policy documents. In England, for example, drama is seen as part of the curriculum (related to aspects of teaching English) and primary pupils should be 'enabled to participate in and gain knowledge, skills and understanding associated with the artistic practice of drama' as well as 'devise and script drama for one another' to 'rehearse, refine, share and respond thoughtfully to drama and theatre performances' (DfE, 2014, p. 15). At

secondary level it is usually taught as an integral aspect of the English curriculum for 11–13-year-olds, to appreciate English literature, such as that written by Shakespeare) and be able to ‘understand how the work of dramatists is communicated’ (DfE, 2014, p. 83). It can also be chosen from a range of Arts disciplines, as an optional separate subject course from age 14 to 16 years (DfE, 2014, p. 8). Contrastingly, in New Zealand, drama is part of the arts learning area (along with dance, visual art and music) in compulsory education, and it is a discrete curricular subject in post-compulsory education (New Zealand Ministry of Education 2007). In Australia (Australian Curriculum, 2020), too, there is much curricular guidance that suggests how students could ‘make’ drama that involves ‘improvising, devising, playing, acting, directing, comparing, contrasting, refining, interpreting, scripting, practicing, rehearsing, presenting and performing’. Students are ‘encouraged to use movement, voice, language and ideas’ to ‘explore roles, characters, relationships and situations’. This more active and participatory approach to learning is increasingly used for learning in science, evidenced through the “Learning Science through Theatre Initiative” (LSTT) (Smyrniou et al., 2017). Employing theatrical or performance pedagogy for science education, however, is often achieved through collaboration between science and drama educators (Abrahams & Braund, 2012; Braund, 2015; McGregor, 2012; Smyrniou et al., 2016), rather than science teachers working alone. As Peleg et al. (2018, p. 18) indicate though, “drama is far from reaching its full potential” within science education. They suggest that the skills required to include drama as a learning medium are demanding and that more examples of the ways that educators can employ drama pedagogies to benefit science education is needed. They also call for more training and/or professional development for teachers so that they feel more able to use drama as a means for learning in science classrooms.

This book responds to these additional concerns by also bringing to the fore, evidenced suggestions about ways that drama can be utilised as an innovative approach to teach and support active, participatory and even inspirational learning in science.

A further purpose of this book is to consolidate the many, often small-scale, projects in the research field illustrating how drama (performance arts and theatrical conventions) can be effectively employed in science education. The wide variety of ways drama pedagogy can be adopted and adapted will become apparent through the collection of chapters disseminating how theory and practice have been inter-related to promote learning in different contexts, across a host of age ranges in different countries.

To frame the discussion for readers who may be concerned with science or drama teaching or, indeed, educational inquiry, the book attempts to address the following research questions (in sequential order). Finally in the conclusion there is a synthesis of the findings across the studies presented.

1. What characterises the current use of drama, performing arts and theatrical approaches, across at least six different countries, to teach science?
2. What do the international case-studies suggest about the extent, and usefulness of, drama to teach and learn science?

3. What kinds of research approaches and tools can be applied to assess the impact (both implicit and explicit) of drama pedagogies?
4. What does a synthesis of the research evidence suggest about the benefits and challenges we should pay attention to in future?

The various international projects presented will contribute to addressing these questions through experienced educational researchers describing and sharing their expertise accrued from within their national contexts. The contrast of practice and ways of researching the impact of drama on teaching and learning within and between six different countries (Australia, England, Netherlands, New Zealand, Norway and South Africa) is included. This collection of international projects is written to provide readers with insights, illustrations, evidence and ideas about how to employ and evaluate drama approaches to teach science. The various sections of the book will focus on three particular aspects related to the use of theatrical techniques, performance and dramatised events to teach science. These are:

Part I: Reviewing what we already know about the ways that drama, performing arts and theatrical approaches contribute to learning science.

Part II: Providing rich case studies of projects that describe how drama has been applied in many different contexts, countries and across a wide variety of scientific disciplines to promote learning.

Part III: Illustrating how a multitude of research approaches, utilising different data collection methods, contribute to the complexity of evidential impact of this kind of innovative pedagogy.

Part I is designed to offer chapters that present different theoretical and conceptual perspectives drawn from the literature that relates directly to drama and science education.

The second chapter (Baskerville, McGregor and Bonsall) considers the ways that drama in science education is understood and defined. There is discussion about terms such as, 'drama in education', 'drama as education', 'educational drama', 'theatre in education', 'performance', and even the role of 'audience'. Each of these are introduced and discussed in turn. Readers are consequently invited to consider more carefully the ways that they use and apply terms describing practice and enactment in teaching and learning arenas so that there is more clarity for both practitioners and researchers alike.

The third chapter (Braund) introduces and theorises the way that constructivism and Expectancy Value Theory (EVT) can inform dramatised learning of scientific concepts. Braund discusses different ways and worlds of knowing in his theorisation of learning through drama. He also considers the application of different drama methods for specific science content and relates this to teachers' pedagogical content knowledge (TPCK) in choosing and designing drama tasks.

The fourth chapter (McGregor and Anderson) draws on O'Toole's elements of drama to examine how role play is used in science education. Comparative content analysis of different studies provides insights about the prominence of different elements (Dramatic Context; Roles and Relationships; The Drama Space; Language,

Movement and Gesture; Tension and Audience) in three epistemologically distinct types of role play.

The fifth chapter (Ødegaard) includes exploration of different types of learning that can result from drama as proposed by Neelands and Goode (2000) and Sæbø (2009). She combines Leinweaver's (2015) typology of stories to change the world and Neelands and Goode (2000) model of dramatic action to suggest how different types of role-play could develop different sustainability competencies and achieve environmental citizenship goals.

Part II of the book provides illustrations of the use of drama from empirical studies. These case studies from different projects offer a range of perspectives of the successful and varied ways drama has been adopted by practitioners to promote and support learning science.

Chapter 6 (Braund) explores how student teachers from both science and drama programmes in South Africa, engage their learners in role playing to learn about science concepts. The quasi-experimental study suggests how pedagogic challenges differ for science and drama specialists.

Chapter 7 (Baskerville and Anderson) extends the professional expertise debate between drama and science specialists. It describes how collaboration between two teacher educators [one an experienced drama specialist, the other an experienced science specialist] results in offering principles to be considered when designing a drama-science process for learning about the nature of science (NoS).

Chapter 8 (Verhoeff) presents an approach that utilises students scripted role-plays to address social and ethical issues that emerge as a result of scientific advancements. The purpose to promote enactment, audience consideration and participatory discussions and debate about real-life situations (particularly in relation to the environment).

Chapter 9 (Branscombe) presents an approach that emphasises the use of 'tableau' and 'writing in role' when learning about the solar system. Photographic illustrations, transcripts and excerpts of students' writing illustrates what they learned through engaging in the project.

Chapter 10 (White and Raphael) echoes some of the discussion in the earlier Chaps. 6 and 7, whereby a science and drama educator collaborate to produce an approach for students to learn about stem cell research. The participants in this project context are pre-service teachers (like those in Chap. 6) rather than students in school or college.

Chapter 11 (Smyrniou and Georgakopoulou) discusses the ways that secondary students' authored scripts, depicting aspects of the particulate nature of matter, are imaginatively performed through plays on stage. The impact of (different kinds of music and choreographed routines) developed in these performances is described and considered.

Part III of the book is designed with a somewhat different orientation, that is, describing the different research approaches that could be adopted (to collect a range of different forms of data) to assess the nature of the impact of using drama pedagogy in science classrooms.

Chapter 12 (Frodsham and McGregor) illustrate why paying attention to dialogue is important and they also discuss the challenges of capturing that form of data. They present evidence that suggests how various different drama strategies (Miming Movement [MM], performing, Mantle of the Expert [MotE]: Working in Role [WiR]) can support the emergence of distinct kinds of dialogue.

Chapter 13 (Anderson and Baskerville) examine how drama conventions naturally provide data collection opportunities. They describe how Role on the Wall (RotW), Writing in Role (WriR) and Conscience Alley (CA) each provide nuanced insights into students' developing understandings of the nature of science, the practices and values of scientists, and the work they engage in.

Chapter 14 (Swanson) describes how various forms of data can be collected through adoption of the MotE approach. The evidence of impact includes dialogic exchanges, assessments, observations and interview data.

Chapter 15 (Stagg) discusses the different ways that many studies have used mixed methods to measure the impact of their drama interventions. An illustrative example of the impact of a biological intervention designed to improve students' botanical knowledge is also included.

Chapter 16 (Turkka, Kaul and Aksela) presents a fresh approach to assessing students' understanding of the nature of science and the work scientists do. Turkka discusses how they successfully developed, and assessed the impact of, an approach entitled, 'act-like-a-scientist' (ALAST) for undergraduate and postgraduate students.

Chapter 17 (Edmiston, McGregor and Anderson) presents a transcript of three educators (one specialising in drama and two specialising in science) considering the process and outcomes from the studies presented in this book.

Conclusion: Chapter 18 (McGregor) considers the nature and extent of research evidence presented to summarise the benefits and challenges of drama pedagogy we should continue to pay attention to in future.

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Professor Debra McGregor, Oxford Brookes University, has worked in primary and secondary schools and higher education for over 30 years. She has taught across a range of disciplines that include science, thinking skills, information technology and physical education in primary and secondary schools to research methodology and methods in the UK and USA to masters and doctoral students. She is currently involved in various research projects related to science, creativity, learning in informal spaces and school leadership and management. She has supervised doctoral students researching in each of these areas. She has been actively involved in the European Science Education Research association for several years. Her research work centres on teaching and learning processes that span subject disciplines and emerge in contrasting formal and informal locations. As a former primary and secondary teacher, teacher educator and now researcher her educational experiences inform the multiple ways that she considers, examines and articulates pedagogical enactments and the relational nature of practice and learning. She has won various awards for her teaching, research, service to science education and her students' academic performance.

Debra is particularly interested in the ways that learning tasks can be framed so that learners are afforded opportunities to engage in meaningful activity that promotes talking, thinking and learning about science concepts and processes. The application of drama conventions to enter an 'as if', imagined or even a reconfigured [classroom] world, can be a powerful pedagogical approach that extends ways for students to engage in dramatised inquiries and even rehearse inquiry practices that encourage thinking scientifically and even wanting to become a scientist. She has written many publications, including books, chapters and peer reviewed journal articles that examine and exemplify how students might be positioned in dramatized contexts to learn about science, scientific concepts, the Nature of Science and inquiry processes. She has also demonstrated how teachers' professional development can impact on students' learning in multiple ways.

Part I
Reviewing What We Already Know about
the Ways that Drama, Performing Arts
and Theatrical Approaches Contribute to
Learning Science

Chapter 2

Re-thinking Theorising About the Use of Drama, Theatre and Performance in Learning Science



Delia Baskerville, Debra McGregor, and Amy Bonsall

2.1 Introducing Views About Drama and Performance

The use of drama and performance implies that there is a transformation of self, time, and space, that can occur in front of an audience or within a classroom that is shared for others to observe (Neelands, 2008). In this context, O'Toole considers the contentious issue of audience (1992, p. 34) by discussing a central dilemma related to conventional 'performance drama' and 'drama in education'. Historically the function and/or involvement of the audience has affected the nature of a drama performance. Drawing on Theatre in Education (TiE) he explains three key considerations; (i) whether the audience are expected to participate; (ii) how involving the audience impacts on the performance, and (iii) what meaning the audience can make of experience of the performance. The concern about involvement or not of the audience, therefore, informs the debate around drama activities that concern both 'process' and 'product'. This chapter has been written to examine and clarify these terms so they may be used more consistently by science specialists to understand how different notions of drama can be applied. Learning experiences in the drama classroom and theatre rehearsal spaces are different (Morgan & Saxon,

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1987). Performing is about making and doing, developing skills and understanding for the implementation of a drama episode (Neelands, 2008) and “Theatre is one aspect of the cultural field of drama” (Neelands, 2008, p. 2). Heathcote’s work highlighting the six dimensions of the dramatic imagination, sound/silence; light/dark and movement/stillness, illustrate ways core theatre elements can shape dramatic imagination and activity. According to O’Toole and Dunn (2002), most drama experiences in primary classrooms involve children participating in role play and improvisation rather than performing in plays following scripts. Such experiences in primary classroom drama enable children to play; to be in a fictional world, enter a role, step into someone else’s shoes, see and enact things from that perspective and make sense of that particular world. In the drama classroom there are different ways of working within these role experiences (Neelands & Goode, 2009). Dorothy Heathcote first developed the Mantle of the Expert (MotE) drama approach in the 1980s (Aitken, 2021). In this dramatised way of working, Heathcote shared power with students, positioning them to *play* confident experts, using role and drama conventions to investigate and resolve a commission (Heathcote & Bolton, 1995). Cecily O’Neill developed another approach from this work; process drama (O’Neill, 1995). This is “a form of drama in which the purpose is to participate in learning, inquiry, or discovery rather than to present drama to an audience” (Ministry of Education, 2000, p. 49). In process drama, students and teachers are participants, who are involved in what Morgan and Saxon (1987) describe as a “collective enquiry and collaboration” (p. v). In this kind of collaboration, learning is facilitated by the teacher in a vibrant, reciprocal teaching and learning relationship.

Contrasting ‘theatre’ with performance and drama activity in classrooms highlights how terms applied for learning may become confused. In theatre there are live performers, usually actors presenting the experience of a real or imagined event. The actor is the artist at the centre of this work, capturing and communicating the complex spirit of the times (Neelands & Dobson, 2000). This performance of an existing script, which is interpreted, rehearsed, and performed, takes place before a live audience in a specific place (Dinham, 2020). Often rehearsals are perceived by students as opportunities to read the play, learn lines and perform. However, rehearsals are designed to open different opportunities; to trial different ideas and interpretations (Bennathan, 2001). These public performances may be presented for different purposes, for example to entertain, or to challenge the audience’s perceptions of an issue. This resonates with the different purposes of various forms of theatre outlined in Table 2.1. Just as contrasting forms of theatre serve different purposes, audiences can be reached in different ways; through stage performances, television, cinema, and radio (Neelands & Dobson, 2000). Similarly, during the preparation or rehearsal time for a dramatised classroom activity, the theatre learning experience is also directed by the teacher. As performers and as receptive audience members, students rehearse, present, and reflect on their work in different ways: through informal sharing, through structured presentations, through watching live drama or viewing and listening to drama on radio, film, and television. This suggests a further aspect in relation to performing, viewing and responding to drama and theatre (Ministry of Education, 2000). Performances provide opportunities to

Table 2.1 Contrasting theatre forms

Types/forms of theatre	Purpose	Features
Shakespeare	Plays were more overtly a 'performance' to entertain the audience. Performed in large outdoor playhouses, indoor theatre, and royal palace settings. Audiences often had their favourite performers, looked forward to hearing music with the productions and relished the twists in the story.	A raised platform stage, without a front curtain or a proscenium arch; a permanent facade at the back. Men and boys played female and male characters. The stage itself was relatively bare: Luxurious costumes for leading characters. Playwrights used vivid words instead of scenery to picture the scene onstage. Attractive to a wide variety of people.
Bertolt Brecht Epic theatre is a type of political theatre that addresses contemporary issues.	The aim is to raise awareness of an issue, change audience perspective and have the audience leave thinking about the 'messages' communicated through the theatre performance.	Techniques to break down the fourth wall, the barrier between the audience and the performers, making the audience directly conscious of the fact that they are watching a play. Harsh lighting rendering actors and transitions visible. Use of a narrator, songs or music, technology, and signs. Minimal set.
Boal's Forum theatre "Theatre of the Oppressed"/"Theatre for Development" is an interactive theatre form invented in the early 1970s by Augusto Boal.	Boal's aim was to help audience members recognise and communicate their views and perspectives (also seen as 'internal oppressions') to engage with, and critique challenges presented.	Forum theatre begins with a short rehearsed or improvised performance, by an acting troupe. Involving demonstrations of social or political problems, the usual process was to ask audiences for stories of oppression. The audience told their stories; these were then performed by actors. The presentations include one person who acts as the 'joker', who facilitates for the forum theatre session. Storyteller has the opportunity to clap, enter scene, and 'act out' a different outcome.

interpret, respond and critically analyse diverse dramatic forms and styles, their function, and value of one's own and others' work and cultures (Ministry of Education, 2000). These theatrical representations take different forms, typologies, structures, or broad categories, which may include within it several styles. For example, puppetry is a form of theatre, and glove puppets, marionettes, and shadow puppets are styles (Ministry of Education, 2000). Devising may also be adopted for performance, however it is developed in collaboration with others without a script and with a specific intent and audience in mind, although a script may be developed as part of the process, (Ministry of Education, 2000; Neelands & Dobson, 2000). As

Neelands (2008) indicates, there are many different traditions, forms and histories in theatre.

2.2 Developing Ideas About Drama and Theatre

In this section the notion of theatre forms in drama education and what this means for advancing the field of drama pedagogy in science learning are more specifically considered. To attempt this in a systematic way the purposes and some features of different theatre forms, such as Shakespearean, Epic and Forum are compared. Contrasting forms of theatre can provide illustrations of the varied ways that they may be adopted or adapted for teaching and learning. Shakespearean theatre, for example, is a form historically performed in large outdoor playhouses with male actors, who spoke prose and verse, and played roles in comedies and tragedies to entertain their audiences (Burton, 2004). In contrast, Brecht's Epic political theatre form (Brecht, 1964), designed to raise awareness of societal issues and challenge audience members, adopted features such as harsh lighting, song, narration, and direct interaction with the audience to influence change. Contrastingly, Boal's Forum theatre features involved an acting troupe in a short performance, based on audience stories. The spectators influence and engage with the performance. This opportunity for audience participation, communicating thoughts and emotions, has resulted in the evolution of the term 'spect-actors' (Boal, 1995, p. xviii). Spectating as an audience member, it is possible to identify whether a performance is designed for entertainment or to engage onlookers in thinking about social change. These different purposes of performance, then, demonstrate particular forms of theatre. This is because particular features presented (as summarised in Table 2.1) can be seen in a performance representing that theatre form. In drama in the classroom students study theatre forms to understand the social and historical nature of performance. This is to distinguish the origins and development of theatre over the ages, and to be able to identify features specific to that form. It is important, therefore, that science educators and researchers acknowledge these differing forms of 'performance' and recognise how they each can support particular teaching and learning in science.

2.3 Thinking More Specifically About Drama, Theatre and Performance and Science Education

Drama, theatre, performance, fictional writing, painting or performing music are all activities commonly deemed to be 'creative' (Glaveanu, 2018). Learning through these kinds of media offer expressive forms of communication, arguably in tension ontologically (Glaveanu, 2018) with more objective scientific ways of knowing. As

Fels and Meyer (1997) suggest ‘drama and science’ are like ‘water and oil’, two immiscible liquids. They argue that the artistic world of drama and associated disciplines that value more open exploration of possibilities, is in tension with the more factual domain of science. However, they go on to discuss how the two domains overlap more than might at first be conceived:

... another look reveals themes in doing science that overlap with ones in drama. Far from a common view of science as an accumulation of formal laws, the dynamic exploration of natural phenomena, for example, is enacting conditions of possibilities, interruptions, interpretations, and play(ing) with variable relations. It is the fascination with phenomena (like the presence and absence of light, sound and motion) that motivates both metaphoric and explanatory response (Fels & Meyer, 1997, pp. 75, 76).

Indeed, O’Toole (1992, p. 1) introduces drama as “a dynamic event which is always part of its context” and that can certainly be the case when scientific discoveries are made. Consider, for example, the ‘Eureka’ moment when Archimedes, leaps from his bathtub as he realises how mass and volume can be theorised to explain why something floats or sinks or the somewhat fictional story of Issac Newton being hit on the head by a falling apple. These dramatic moments can illustrate how scientific discoveries emerge. Peleg and Baram-Tsabari (2015), also consider the link between informal learning environments, such as those that utilise theatre, and the ways that these can expose students to science, spark positive attitudes and even influence choices to learn science.

Interestingly, though, despite discussion about the potential of theatre and dramatic explorations supporting learning science, views about the processes and nature of learning and its location differ. This has consequently resulted in a wide variation of drama pedagogies that can be adapted and adopted to support and mediate science learning.

In fields, like this, of a relatively new and emerging area of academic work, there is often much adoption of drama (in many and varied forms) that can be misappropriated, or misunderstood. This chapter, therefore, attempts to consider how practitioners and researchers may have discussed or applied theatre or performance in contrasting ways. Peleg and Baram-Tsabari (2015) in reviewing learning outcomes about evolution when considering science museum theatre, for example, discuss how ‘performance’ is related to the “production and staging of a theatrical event” (p. 3) or indeed, as their paper goes on to discuss, how “different components of a performance come together to create a whole” (p. 3). Peleg et al. (2018) liken professional theatre plays to science theatre where the learners do not participate in the creation process and are only exposed to the final product (p. 71). However, McGregor (2012) discusses performance quite differently. She describes how students, working in small groups, would mime how they understood something scientific worked for the remainder of the class to observe. This kind of informal ‘performance’, would be much less frequently rehearsed than a theatrical event of the kind Peleg and Baram-Tsabari (2015) describe. Akin to Varelas et al. (2010), McGregor’s students did not follow a specific script or stage direction of any kind, but in preparing to ‘perform’ it was reported that learners asked each other many previously un-thought about things that arose during the practice enactments

(perhaps there is a parallel here with rehearsals for formal performances [Bennathan 2001]). An example, offered in McGregor (2012), concerned the life cycle of a frog. Students of any age miming the process of development from frog spawn to adult frog may encounter such dilemmas as, ‘When do the tadpoles develop their tails?’; ‘Do all four legs appear before or after the internal or external gills?’; ‘When does the diet and method of eating change from spawn jelly to weed and then insects?’. These queries emerge as the groups consider how they can accurately reflect the frog life cycle changes through their improvised enactments performed to their peers and teacher. Another interpretation of in-class ‘performance’ in science education is offered by Archila (2017, p. 346). He suggests that in presentational drama, a small group of students dramatizes a feature of science in front of spectators (e.g., teacher, peers, or parents). However, in experiential drama, the students adopt a motivation, opinion, or attitude (e.g., a role-play with role cards about ethical issues in genetic engineering, for example). Abrahams and Braund (2012) extend the ways that pedagogically drama conventions (Farmer, 2011) and techniques (Neelands & Goode, 2015) can inform strategies for activities in science lessons encouraging engagement with scientific concepts (in biology, chemistry and physics). Each of these interpretations and applications of ‘performance’ contrast starkly to Schechner’s (1977) theory of performance. For him, it is interpreted quite differently. As he suggests below how we define it is not straight forward and a multiplicity of factors influence the nature of a performance:

The boundary between performance and everyday life is arbitrary; different cultures mark the boundaries differently...However, where ever the boundaries are set, it is within the broad region of performance that theatre takes place; at the centre of theatre is script, sometimes the drama. Just as drama may be thought of as a specialized(sic) kind of performance. (Schechner, 1977, p. 39)

He has also discussed in detail (Schechner, 2003, p. 16) the range of factors that influence the nature of a performance; who actually performs; the location or space where the performance takes place; the size of the audience; the use of a script; the adoption of established rituals; the value of particular artefacts etc.

In developing further the discussion about pedagogic and research-led collaborations between two distinctive fields of education there is a need to engage with the ways that terms, definitions and descriptions of practice are communicated for practitioners (Table 2.2).

This chapter is a call for educators and researchers from two distinct fields to communicate clearly their implicit assumptions about theatre and performance to engage in dialogue about the implementation of them pragmatically so that there might be clearer understanding to advance the field of drama pedagogy in science learning. The intent of this chapter to lay bare more clearly how terms and interpretations differ across (and within) the two disciplines, so that in acknowledging what has been done, how and why, researchers might engage in discourse that exposes interpretation and mis-understandings of other’s purpose and methods. More clarity and consideration about the nature of different kinds of ‘performance’ is needed. Recognising the processes by which a performance (either formalised for the stage

Table 2.2 Contrasting views of drama educationalists who define theatre for learning and suggest how learning takes place

	Theatre	Suggestions about the nature of learning
Neelands and Goode (2015)	“theatre is essentially concerned with the sweep of human experience, it tends to prompt new levels of questioning rather than to promote answers” (p. 157).	“The diversity of conventions within each style [of theatre]” (p. 157).
O’Toole, (1992)	“Privilege the aesthetic power and entertainment value [...] over instrumental objectives” (1992, p. 124). It is often an ‘abnormal interruption’, not a normal part of a school day. It is likely to be “promoted as a special event” (1992, p. 125). “Theatre in Education means education through theatre and theatre means performance” (1992, p. 126).	This can vary, it may be when the participants in the [potential] audience discuss what is to come [be watched] or consider what was communicated by the performance afterwards. There were also examples of the audience [unexpectedly] becoming involved in performances too.
Farmer (2011)	In theatre it is usually the actors who perform the drama, but “Forum theatre provides an opportunity for audience members to explore how a dramatised situation can have alternate outcomes by taking over the role of one or more of the characters”.	Description of alternate theatre approach involving audience member learning through participation in the performance.

or theatre or in informal small classroom groups) could be best supported to mediate learning science, for example, is urgently needed. Alongside this use of commonly used terms that conjure quite different understandings in drama or science education need to be thought about further. Without the cultural ‘tools’ of a common language, drama and science educators will struggle to collaborate to develop and examine practices that could most effectively inspire would-be scientists or scientifically aware citizens. Concepts such as, ‘theatre in education’ or ‘theatrical processes’ or ‘dramatic conventions’ need clarification for practitioners and researchers alike to research the nature and extent of impact of particular forms of dramatic learning in science classrooms.

2.4 Purposeful Categories: Appreciating, Performing and Making

O’Toole (1992, p. 123) contrasts drama in education with theatre in education and considers them distinct genres. Although, he suggests, there are similarities, the difference is to do with ‘expectations aroused by the event’. He discusses how ‘drama in education’ is concerned with recognisable school learning and that often the ‘subsidiary’ role of drama emphasises a less rigorous, more playful mode of

education. He even goes so far as to mention how it might be disparagingly known as “wet Friday afternoon” approach (p. 124). Expectations of theatre in education, however, are, he suggests, ‘subtly different’. He describes how this would entail ‘performance’ work aimed at large passive audiences, not required to participate during the show.

In considering performance art, O’Toole et al. (2009, p. 129) highlights a “Paradigm of Purpose” and discuss three categorisations; Appreciating Drama; Performing Drama and Making Drama. The point of considering this nomenclature is to illustrate how theatre and drama can be utilised to promote science learning differently. The first category, ‘Appreciating Drama’, is demonstrated through a theatrical production generally assumed to entertain (aesthetically) largely passive audiences as consumers. Examples of this kind of theatre production might include “Copenhagen” written by Michael Frayn or “Galileo” written by Bertolt Brecht, each providing performances that demonstrate aspects of the life and scientific work of Niels Bohr and Galileo Galilee respectively. Peleg and Baram-Tsabari (2011) highlight how when students watch a theatrical production of a scientific play, in this case “Atomic Surprise”, there are educational impacts. They argue there is evidence that scientific knowledge and understanding is improved. Interestingly, the aesthetic elements of the production such as; the narrative, the props and the characters all influence recollections and can have a positive impact on cognitive outcomes. The second category, ‘Performing Drama’ involves students (and adults), in an educative sense, participating or acting in some kind of performance, perhaps even on school premises, for example. Dorion (2009) delineates the nature of talk involved in preparation for a performance and the dialogue in a performance itself. He recognises that there appears to be more potential for learning in the preparatory discussion prior to either a more informal improvisation or a more tightly scripted enactment of a model or phenomena. This is also recognised by McGregor (2012). The third category, ‘Making Drama’ includes generating or writing a play. As quoted by Maisie Cobby, cited in O’Toole et al. (2009, p. 134):

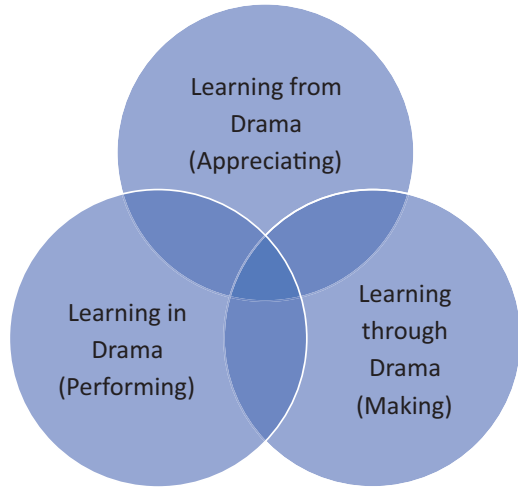
...from watching plays at the theatre, the cinema or on television, that drama is a subject which covers a wide and varied range of activities. For the majority, acting a part in a play is most popular, but on the other hand, there are some to whom other aspects of drama make a stronger appeal. They may be interested in writing and producing their own plays, designing the scenery or the costumes ... etc (1956: vii).

This third category also includes improvisation, which O’Toole et al. (2009, p. 136) describe as emphasising play rather than performance. They cite Maisie Cobby (1955) to illustrate this:

[The child] wants to unravel situations which puzzle and interest him, to know more about the world and the people and strange places and things he sees in picture books. Above all, he needs to understand the relationship which exists between himself and these activities Always it should be remembered that dramatic play and not dramatic performance is the intention throughout (1955: 4).

Improvisation, may therefore, include the many and various ‘conventions’ described, adopted or adapted in the later chapters in this book. These different ways of

Fig. 2.1 Suggestion about the way that each of the three categories may overlap and are **not** necessarily mutually exclusive



‘improvising’ offer a range of learning opportunities that could be deemed ‘a natural part of play’, enabling ‘imaginative exploration’ of any situation (Farmer, 2011, p. 95) and possible outcomes. In contrast to performing from a script, this kind of drama does not require lines to be learned. Farmer (2011, p. 95) suggests that improvisation can develop students’ confidence, encourage them to be creative, learn how to negotiate and work collaboratively and in so doing rehearse speaking and listening skills.

Reconsidering, though, these three categories of Appreciating, Performing and Making (as suggested in Fig. 2.1) alongside the earlier discussion about interpretations and implementations of ‘performance’ it becomes obvious that there are overlaps between these and that perhaps it cannot be resolved easily here in this chapter. However, what this book endeavours to do is promote discussion about what each of these means to encourage practitioners and researchers in future to be more precise and clear about their interpretation and implementation of particular forms of drama for learning science.

2.5 Relating Appreciating, Performing and Making with ‘Learning from...’; ‘Learning Through...’ and ‘Learning in...’

In striving to develop the debate about the nature of drama pedagogy in science learning this section introduces what we hope will be a useful and pragmatic nomenclature for future research and development. As drama is both an embodied (multi-sensory) art form and an incredibly complex discipline to define it follows that encapsulating the nature of Learning Science through Drama (LStD) is similarly multifarious. However, to assist and clarify our considerations, we have simplified