Science & Theatre

This page intentionally left blank

Science & Theatre: Communicating Science and Technology with Performing Arts

BY

EMMA WEITKAMP

University of the West of England, UK

AND

CARLA ALMEIDA

Oswaldo Cruz Foundation (Fiocruz), Brazil

United Kingdom – North America – Japan – India – Malaysia – China

Emerald Publishing Limited
Howard House, Wagon Lane, Bingley BD16 1WA, UK

First edition 2022

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-80043-641-1 (Print)
ISBN: 978-1-80043-640-4 (Online)
ISBN: 978-1-80043-642-8 (Epub)

ISOQAR certified Management System, awarded to Emerald for adherence to Environmental standard ISO 14001:2004.

Certificate Number 1985
ISO 14001

INVESTOR IN PEOPLE

Contents

List of Figures *ix*

List of Tables *xi*

About the Authors *xiii*

Acknowledgements *xvii*

Prologue

1 Introduction *3*
1.1 The Rise and Rise of Science-Theatre *4*
1.2 Brief History of Science Communication and Its Paradigms *6*
1.3 Structure and Organisation of this Book *9*

Act I

2 Conceptualising Science-Theatre *15*
2.1 Terms, Definitions and Categories *16*
2.2 A Plethora of Concepts, a Lack of Focus *19*
2.3 A Science Communication Lens *21*
2.4 Science-Theatre that Creates Dialogue *24*

3 Mapping Science-Theatre Practices *27*
3.1 Survey Design *27*
3.2 Profile of Respondents *28*
3.3 Institutions Involved with Science-Theatre *31*
3.4 The (Central) Issue of Funding *32*

4 Creating Science-Theatre: Who Participates and Why *35*
4.1 Who Collaborates? *35*
4.2 Reasons to Participate in Art-Science Projects *37*
4.3 From Education to Spectacle: Pragmatic, Personal and Fundamental Drivers *39*
4.4 Survey Respondents' Motivations *41*
4.5 Conceptualising the Motivations Behind Science-Theatre *47*
4.6 Creating Effective Collaborations *49*

5 Topics and Venues: Beyond Expectations *55*
5.1 Topics and Content: What Science Hits the Stage? *55*
5.2 A Survey of Contemporary Science-Theatre Topics *57*
5.3 Traditional Venues for Science to Meet Theatre *62*
5.4 Every Place Can Host Science-Theatre *65*

6 Formats: Unbounded Creativity, Experimentation and Interaction *69*
6.1 Science-Theatre Traditional Formats *70*
6.2 Adopting, Adapting and Creating New Formats *73*
6.3 Emerging Participatory Formats *75*
6.4 Opportunities for Participation and Science Communication Goals *78*
6.5 Interactions in Practice and Beyond Performance *80*

7 Spectators, Participants and Co-Creators *85*
7.1 Conceptualising Audiences *86*
7.2 Who Attends Science-Theatre? *88*
7.3 Audience Outcomes *91*
7.4 Measuring Audience Responses *95*

Act II

8 Actors with Agency: Immersive Science Theatre and Science Identity *103*
8.1 Overview of Science Theatre in UK Context *104*
8.2 Science Theatre: The SMASH-UK and SMASHfestUK Programme *105*
8.3 Space Plague *109*
8.4 Reflections, Lessons and Challenges *110*

9 Theatre Within a Research Institute: Addressing Shared Goals *113*
9.1 A Consistent Experience of Professional Science-Theatre *114*
9.2 Institutional Bonds That Go Beyond Science Expertise *116*
9.3 Approaching an Audience with Little Connection to Science or Theatre *118*

10 PAST's Walking Tall Science Theatre Project *121*
10.1 Overview of Science Theatre in South Africa *122*
10.2 Sharing the Social Value of Prehistory Through Walking Tall *124*
10.3 Walking Tall's Impact *125*
10.4 Challenges Encountered *130*
10.5 Lessons Learned *132*

11 The Voices and Bodies of Science: Theatre with Researchers *135*
11.1 Marionet's Work with Researchers *136*
11.2 Asking Questions and Creating from Scratch *138*
11.3 Science Though Researcher's Own Words *140*

12 Augmented Lectures: A Unique Resource to Inspire, Outreach and Understand Science *143*
12.1 An Art-Science Discourse *144*
12.2 Creating Augmented Lectures *145*
12.3 Factors Affecting the Outcome *146*

13 *Scenes of Aquatic Life*: Theatre, Dance, Music and Science *151*
13.1 Theatre as a Knowledge Bridge *151*
13.2 Collaboration to Transform *154*

14 Instytut B61: Translating the Invisible into Immersive Artsci Theatre *157*
14.1 The Artsci Model In Practice *159*
14.2 Science in Motion *161*

15 From Math Class to the Theatre: A 15-Year Chronicle of STEAM *169*

Epilogue

16 Conclusion *181*
16.1 Main Findings and New Frameworks *182*
16.2 Challenges to Overcome *186*
16.3 Future Directions *187*

Appendix 1: Survey Questionnaire *191*

Appendix 2: Example Research Protocol *197*

References *201*

Index *213*

List of Figures

Fig. 3.1. Global Distribution of Survey Respondents. 29
Fig. 3.2. Profile of the Survey Respondents Regarding Years of Experience (A), Workplace (B) and Employment Status (C). 31
Fig. 3.3. Role of Science-Theatre Within Participants' Institutions and Organisations. 32
Fig. 3.4. Funding Sources for Respondents' Initiatives in Science-Theatre. 34
Fig. 4.1. Respondents' Collaborators in Science-Theatre Projects. 37
Fig. 4.2. Ranking of Respondents' Priorities Regarding Their Main Science-Theatre Productions. 47
Fig. 5.1. Areas of Science Explored in Respondent's Science-Theatre Productions. 58
Fig. 5.2. Venues Where Respondents Have Presented Science-Theatre. 65
Fig. 6.1. Formats of Science-Theatre Used by Respondents. 74
Fig. 6.2. Forms of Audience Interaction Used in the Respondent's Science-Theatre Projects. 81
Fig. 8.1. SCENE Model Incorporating the Co-design Process. 107
Fig. 9.1. A Scene from *Cidadela* (2019), a Play About Structural Sexism with a Cast Entirely Composed of Black Women, Aligning with Institutional Policies for Gender and Race Equity. 117
Fig. 10.1. Walking Tall Performs in Rural and City Schools Where Facilities May Vary Greatly. 122
Fig. 10.2. Actors Use Physical Theatre and Minimal Props for Walking Tall Performances. 125
Fig. 11.1. A Scene from *As Moscas são Ratos que Voam*. 138
Fig. 12.1. A Moment from the AL *Lucienne, Perreca and the Gravitational Waves*, Which Premiered Live at the Teatro Della Meraviglia Festival in Trento, Italy, on 19 June 2021. 144
Fig. 13.1. A Scene from *Escenas de la Vida Acuática*. 152
Fig. 14.1. Map of the *Cosmic Underground* Journey Highlighting Performance Sites. 162
Fig. 14.2. The 'Stage' Extended Beyond the Freight Waggons into the Entire Space of Railway Stations. 163

Fig. 14.3. The Metaphor 'Time Is Water' Was the Main Structural Metaphor of the Narrative of *Cosmic Underground*. 164
Fig. 14.4. *So Far, So Good* Performed During *Cosmic Underground* by SOFA and Dominik Smużny Explored the Influence of Euphoric States on the Perception of the Passage of Time. 167
Fig. 15.1. A Scene from *Curie Me Away*. 173

List of Tables

Table 4.1. Respondents' Reasons to Work with Theatre in the Context of Science Communication. 42
Table 5.1. Science-Theatre Productions Divided by Broad Topics. 60

This page intentionally left blank

About the Authors

Pablo Aguilar is a Brazilian actor, clown and educator, with a degree in Performing Arts from the Federal University of the State of Rio de Janeiro, Brazil. He has worked with comedy and clowning since 2006 and is a founding member of Bando de Palhaços, a group that researches languages involving humour, clowning, comedy and musicality. In 2011, he joined Ciência em Cena, an area of the Museu da Vida/Fiocruz (www.museudavida.fiocruz.br) dedicated to art-science projects, where he is responsible for the production, direction and performance of the museum's plays.

Carla Almeida is a Science Communicator and Researcher at the Museu da Vida, Science Museum of the Oswaldo Cruz Foundation (Fiocruz), in Brazil, where she works in the areas of public engagement with science; science, media and society; and science and theatre. She teaches on Fiocruz's Diploma Course in Communication and Popularisation of Science and Masters in Communication of Science, Technology and Health. She is author of articles on science communication and science and theatre and co-author of the books *Cordel e Ciência: a ciência em versos populares* and *Ciência em Cena: Teatro no Museu da Vida*.

Héliton Barros has a degree in Biological Sciences and a Masters in Science from Oswaldo Cruz Institute, Brazil. Formerly, as Manager of Science and Technology (S&T) at the Minas Gerais State Health Department, he coordinated the Research Program for the SUS (Unified Health System) of the Ministry of Health. He has experience in Science Communication, working mainly on non-formal education, management in science museums and development of scientific exhibitions. He coordinated the Visit and Public Service of the Museu da Vida/Fiocruz between 2017 and 2018 and its Education Service between 2018 and July 2021, when he took over as Head of the museum.

Robert J. Blumenschine is the Chief Scientist of the Palaeontological Scientific Trust, an Emeritus Professor at Rutgers University, USA and an Honorary Professor at the University of the Witwatersrand, South Africa. He holds a PhD in Anthropology from the University of California, Berkeley. He has published extensively on the behaviour and ecology of human ancestors, and has conducted archaeological, palaeontological and wildlife research in Africa, principally in Tanzania as Co-leader of a human origins research project at Olduvai Gorge, Tanzania, since 1987.

Sadie Bowman (she/her) is a Theatre Artist, Songwriter and Co-founder of Matheatre, USA. She has presented at the Association of Science and Technology Centers conference, Theatre About Science: Theory and Practice conference, and performed for science education institutions worldwide, including Science Centre Singapore, National Taiwan Science Education Center and National Atomic Testing Museum (part of the Smithsonian Institution). Prior to collaborating with Matheatre colleagues Ricky Coates and Marc Gutman, she was a producer of comedy variety shows, a touring comedy musician and a musical theatre accompanist. She holds a BA degree in Theatre Arts from the University of Minnesota-Twin Cities.

Andrea Brunello has a PhD in Physics. Actor and playwright, he is the Director of Arditodesio Company and Jet Propulsion Theatre, a laboratory for theatrical creation connected to science, the people of science and the scientific tale, in coordination with the Laboratory of Communication of Physical Science at the University of Trento, Italy. He has written and performed plays all over Europe as well as Africa and the United States. His work centres on the idea that science shapes the way we look at the world and it can therefore become prime material for engaging storytelling and gripping dramaturgy.

Wyn Griffiths lectures in Product Design and Engineering, and his research involves inclusive design, Design for Planet, collaborative creativity, manifestations of the 'Civic University', immersion and narrative transportation. He co-founded the award-winning festival SMASHfestUK. His work spans many sectors and a disparate range of design, engineering and public engagement arenas, including event, installation, experience and exhibition design, build and management.

Lindsay Keith is a BAFTA-nominated Film-maker, Festival Producer, Writer and Research Fellow. Following a PhD at the Imperial College London, UK, she worked in broadcast television, founding The Refinery in 2011, and the award-winning immersive science and arts festival SMASHfestUK in 2014. She works as a Research Fellow at the University of Greenwich, UK, where her specialism is embodiment and behaviour change through immersive narratives.

Andrea Leenen has been employed by PAST, the Palaeontological Scientific Trust, South Africa, since 2000 in various management positions, currently as CEO. She holds an Honours degree (with distinction) in Archaeology and Anthropology and an MSc degree (with distinction) in Palaeontology from the University of the Witwatersrand. Her interests allow her to combine her passions for grassroots science education, nature conservation, the performing arts, the public understanding and communication of the palaeosciences and the advancement of African leadership in the field. Through PAST, she uses the science of our African origins to advocate anti-discrimination, conservation, a love of Africa and the betterment of our planet. Sadly, Andrea Leenen passed away in early 2022.

Mário Montenegro is a Theatre Director, Actor, Playwright, Professor of Performance and Theatre Studies at the University of Coimbra, Portugal, and Senior Researcher at the Centre for Interdisciplinary Studies. He is the Artistic Director of Marionet (www.marioneteatro.com), a theatre company focused on the interplay between theatre and science, where he has directed more than 40 plays. His research interests relate to the interactions between the performing arts and science, including science dramaturgies, worldwide production of plays related to science, research-based theatre, theatre with researchers and the performing arts in science communication.

Stefano Oss is a Professor of Physics at the Physics Department of University of Trento, Italy. He worked as an experimentalist in the field of low-energy atomic physics and as a theoretician in the area of dynamical algebraic symmetries applied to molecular spectroscopy and is author/co-author of about 130 scientific papers. He decided to contribute to the development and functioning of a Laboratory of Communication of Physical Science to support the physics education research area. He believes that scientists and science need specialists and new ideas in the communication arena to bring this enterprise to its highest level.

Javier Garcia de Souza is a biologist, actor and dancer with a PhD in Natural Sciences and a Diploma in Public Communication of Sciences. He is a Researcher of the National Scientific and Technical Research Council, Argentina, working in limnology and ecological aquaculture of native fish. He is also a Teaching Assistant at the National University of La Plata and Science Communicator on radio, TV social media and especially through scenic arts. He is a member of #Exploracuátic@s, a project focused on environmental education through games, of Poper Stand Up, a group of scientist-comedians that communicate sciences with humour, of the dance company Espiardanza and of GECE [science and scene studies group]. He is Author, Choreographer and Director of *Escenas de la Vida Acuática*, which combines science, theatre, dance and music.

Erik Stengler teaches at the Cooperstown Graduate Program, SUNY Oneonta, USA, situating science museums, science centres and planetariums in the wider context of science communication. As an Astronomer, he worked using data from space-based observatories: the International Ultraviolet Explorer and the Hubble Space Telescope. After moving into the field of science communication, he developed a practice-based research interest in science museums and in science in popular culture, specifically in TV and film. In both areas, he has published articles, book chapters and edited conference proceedings volumes, often in close collaboration with students whom he likes to encourage to present at conferences and meetings.

Jan Świerkowski is a curator, futurologist, artist and astronomer and holds an MA in Astrophysics from the Faculty of Physics, Astronomy and Applied Computer Science, Nicolaus Copernicus University, Poland. He is currently a

Researcher at the Research Centre for Communication and Culture in Lisbon. He is an Honorary Ambassador of Nicolaus Copernicus University in Toruń, winner of the Ministry of Science and National Heritage Science Populariser of the Year Award in Poland 2017 and holder of a patent US11024191B2 for a System for a multimodal educational display in a pop-up science centre. In 2012, he curated *Cosmic Underground*, an artsci immersive performance held in a freight train travelling from Tallinn to Lisbon, and funded by the European Commission.

Emma Weitkamp is a Professor of Science Communication at the University of the West of England, Bristol UK, where she co-directs the Science Communication Unit. Her current research focuses on the actors involved in science communication, specifically intermediaries in the process including artists and NGOs; and narrative as an engagement tool (both from the perspective of the communicators and wider publics for narrative forms of engagement). She has produced theatre (most recently, *Chaos Cabaret*) as well as researched audiences for science theatre. She is the author of numerous papers, and co-author of the book *Creative Research Communication* (Manchester University Press).

Acknowledgements

We would like to thank all those who completed our survey of science-theatre in the context of science communication and who shared the survey with their contacts. A special thanks goes to colleagues who participated in the pre-test of the survey questionnaire and helped us to improve it. We would also like to thank the anonymous reviewers of the proposal for this book, who, through their thoughtful suggestions, shaped the book that we offer to you, our readers.

This page intentionally left blank

Prologue

This page intentionally left blank

Chapter 1

Introduction

Although there is evidence of prolific dialogue between science and theatre since Ancient Greece, the interaction between the two fields has undergone a process of renewed and intensified interest since the early 2000s. During this period, we see a shift in emphasis within science communication, from one-way transmission oriented, or deficit model, approaches to more dialogic modes of communication and an increased enthusiasm for the arts within the field. At the same time, the theatrical world has shown a strong interest in science; Shepherd-Barr (2006) suggests that this may have been sparked by the success of the play *Copenhagen* (Frayn, 1998). A resounding critical success, the play uses a meeting in Copenhagen during World War II between physicists Werner Heisenberg and Niels Bohr as a jumping-off point to explore how memory, like quantum mechanics, is uncertain. One of the aspects of *Copenhagen* that makes it particularly interesting as an example of science-theatre is the way in which quantum mechanics is embedded in the structure and staging of the play, as typically the use of three actors is marked out physically to illustrate Bohr's conceptualisation of the structure of an atom (containing protons, neutrons and electrons). You can enjoy the play perfectly well without realising the role this structure plays; allowing audiences to engage with the content and symbolism on different levels is one of the clever aspects of the play and its original staging.

Copenhagen has been staged in several countries, won many awards and has become a landmark within the contemporary phenomenon that is science-theatre. The play seems to have captured the imagination of the science communication community in particular, even though its author, Michael Frayn, has not shown any particular commitment to communicate science through theatre, indicating instead that he was simply inspired by a particular scientific topic. In Brazil, for example, the play was first performed in 2001 by a theatre company from São Paulo at the suggestion of a science communicator. The show's success encouraged the company to continue working with plays addressing science (Palma, 2006). Today, the Núcleo Arte Ciência no Palco [Art Science on Stage Nucleus] is one of the main contributors to science-theatre in the country, with 19 plays in its repertoire, on various science themes, aimed at both adults and children.

Science & Theatre: Communicating Science and Technology with Performing Arts, 3–12

doi:10.1108/978-1-80043-640-420221001

Alongside a rise in theatrical productions focusing on science themes or scientists' lives, has come interest from academic communities, though this has been primarily concentrated in those disciplines traditionally associated with theatre, such as literary studies and applied theatre. However, from a science communication perspective, the literature on this new phenomenon remains scarce and poorly systematised. To our knowledge, this is the first book to examine science-theatre specifically from the perspective of science communication scholarship. This book engages directly with both practice and academic research in the space where science-theatre is created through dialogue between the arts and the sciences. Further, we are particularly interested in productions created for the purpose of communicating science, rather than purely as an art form. This focus allows the book to enter into the space where museums, universities and research centres operate, as well as the space of theatre practitioners. It draws on the diverse perspectives of education, communication and sociology, which form the core of the field of science communication.

The term 'science communication' is being used here in a comprehensive way to refer to a practical and academic field that mobilises a series of actors and means to bring science and society closer together. This encompasses approaches that enable the spread of information and knowledge between science and the wider society, including those approaches that seek to stimulate dialogue between scientists and different social groups. We argue that science-theatre is one such approach, but one which has received relatively little attention from the science communication scholarly community. Several other terms, such as public communication of science and technology and public engagement, have been used to refer to initiatives aiming to bring science and society closer together, but these may carry with them more specific meanings and objectives. We chose the term 'science communication' primarily with the goal of inclusion rather than restriction, that is to enable diverse concepts and motivations to be considered. Although we are talking about a particular type of theatre that develops in this context, we are not talking about a specific type of science communication.

1.1 The Rise and Rise of Science-Theatre

The recent boom in plays about science is also the result of growing interest, since the turn of the 21st century, from both science communication practice and academia, in the use of art as a strategy for bringing science and society closer together (Halpern & O'Rogers, 2021). The relationship between the arts and sciences can be a difficult one, particularly in a science communication context, where the arts might be seen as somewhat subservient to the sciences. For example, working with artists may be seen by researchers working in academic fields and science communication professionals as offering a mechanism to reach new audiences, make research attractive to different publics or translate scientific concepts into more easily digestible ideas (see also Chapter 4, Creating Science-Theatre: Who Participates and Why). There is also an expectation that the arts, through their ability to affect people aesthetically and emotionally, will engage the audience in a deeper and more sensitive way with scientific themes, which are

often seen as complex, arid and controversial, than more traditional methods of science communication (Ede, 2002; Friedman, 2013; Lesen, Rogan, & Blum, 2016). In this scenario, research institutions and philanthropic entities supporting science play a central role by investing in projects and new spaces for the integration of science and technology with different forms of art (Silveira, 2018). We flag the potentially problematic relationship between science communication and the arts not to advocate against working with the arts for science communication purposes, but rather to encourage practitioners to consider these relationships more deeply. There are plenty of examples where scientists and artists collaborate as equals in projects that produce works of artistic merit, as well as examples where such relationships produce new scientific knowledge (Halpern & O'Rogers, 2021). As we will see in later chapters, such projects also exist within the science-theatre realm.

Educational entities (including academic associations, such as the Royal Institution of Great Britain, cultural organisations, such as museums, zoos, heritage sites and schools, but also theatre companies with pedagogical orientations) also contribute to the phenomenon that is science-theatre, developing programmes that draw on pedagogical theatrical traditions, such as theatre in education and educational drama. These institutions argue for approaches to education that merge scientific and artistic disciplines through an approach known as STEAM (Science, Technology, Engineering, Art and Mathematics). This movement advocates incorporating art into the more traditional term STEM and the transdisciplinary educational model it represents (Maeda, 2013). One argument for the inclusion of the arts in more traditional science and technology education is that it opens up space for greater creativity and might highlight the innovative nature of scientific research. Other arguments for bringing art and particularly theatre into the science classroom include to help learners understand the social relevance of science (see Dawson, Hill, Barlow, & Weitkamp, 2009), challenge socially damaging concepts and help make the invisible visible (Braund, 2015; Weitkamp, 2021).

Several qualities of the performing arts make them particularly interesting for science communication. First, theatre is a narrative format that uses storytelling and dialogue to convey meaning. Narratives provide an alternative to more typical approaches to science communication which may focus on concerns about jargon in the presentation of factual knowledge. Instead, a narrative approach invites the reader, or in the case of theatre, the spectator, to enter a storyworld, a place where everyday language and lived experience dominate (Weitkamp, 2019). In this space, we can place scientific knowledge in a context familiar to the spectator, allowing her to draw connections between the story told and her own lived experience, potentially making it easier to integrate this knowledge into the existing schema. Put simply, narratives help to contextualise science (Lafrenière & Cox, 2012), thereby making it relatable and 'provid[ing] the structure to make meanings apparent' (Weitkamp, 2019, p. 241). Furthermore, theatre is an art form that encompasses several others (Lopes, 2005), such as literature, music and the visual arts. By combining different arts and languages, it offers a very particular way of seeing and reflecting upon the world, based on the mobilisation of senses and emotions (Fruguglietti, 2009). As a live event, the theatre has its own

dynamics, directly affected by the participation of the audience, who are also protagonists at the performances. Theatre creates new realities, triggers imagination and creativity (Hughes, 1998). Finally, theatre has a precious feature for science communication, which is its ability to mix affective and cognitive stimuli. This powerful attribute is central to achieving the various objectives that can underpin science-theatre in the context of science communication, whether they are teaching, arousing curiosity, changing perception or behaviour, stimulating debate and criticism, or empowering.

With all this potential to be explored, there has been a proliferation of science communication initiatives that merge scientific and theatrical elements. Many of them have gained visibility through networks and events that bring together the community of professionals and researchers in the field, such as the Network for the Popularization of Science and Technology in Latin America and the Caribbean (RedPop), the European Network of Science Centres and Museums (Ecsite) and the Public Communication of Science and Technology Network (PCST), and their respective periodic conferences. Through the aforementioned events and networks and the extant literature, we have spotted initiatives that bring together science and theatre in various parts of the world, including United Kingdom, United States, Australia, New Zealand, Vanuatu, Japan, Cambodia, Thailand, Vietnam, India, Nepal, South Africa, Kenya, Poland, Netherlands, Germany, Switzerland, Greece, Italy, France, Portugal, Spain, Mexico, Argentina, Peru and Brazil. Some of these countries (e.g., India, Brazil and Italy) also periodically organise science-theatre festivals, revealing prolific production in the field.

1.2 Brief History of Science Communication and Its Paradigms

As a dynamic field, which seeks to respond to the challenges of its space-time, science communication must reflect on its own theories and practices; it is only through this reflection that transformation occurs within the field. Despite sharing a common commitment to bringing science and society closer together, the area is driven by various goals and motivations that have changed and developed over time. Within this field of academia and practice, different views and conceptions now coexist. In this section, we present a brief history of the field of science communication and the different paradigms that mark its trajectory, to better situate the bases on which we will discuss the interactions between science and theatre throughout the book.

The history of science communication follows the trajectory of modern science, as communicating science to the general public, regardless of where, how and why, has always been an important part of doing science and building a scientific culture. Public discussion of science was common in many European countries in the seventeenth and eighteenth centuries and took place in diverse venues from coffee houses to private salons; it was only in the twentieth century that science communication activities began to be seen as a 'distraction' from the real work of being a scientist (Wilkinson & Weitkamp, 2016). Gascoigne and Schiele (2020) argued that the post-World War II period saw a significant

shift in emphasis on science communication, as science became seen as essential for national economic competitiveness in many countries. This period sees the Organisation for Economic Co-operation and Development (OECD) encourage governments 'to mobilise their population through the development of science culture by the implementation of programs to promote and propagate scientific knowledge and scientific thinking' (OECD, 1981, p. 5). As such, it is during this post-war period that academic reflection on the relationship between science and society really begins in earnest.

Recent literature on the history of science communication points to a division of the last six decades into more or less well-defined phases, though this trajectory varies with geography. Drawing on the British experience, which has served as a global model for science communication, Bauer, Allum, and Miller (2007) proposed dividing science communication into three paradigms, which they named: *Science Literacy, Public Understanding of Science* (PUS) and *Science and Society*. According to these authors,

> each paradigm has its prime time, more or less clearly defined, and is characterized by a diagnosis of the problem that science faces in its relationship with the public. […] Each paradigm defines particular problems and offers preferred solutions. (Bauer et al., 2007, p. 80)

In the first paradigm, referred to in the literature as *Science Literacy* and which runs from the 1960s until the mid-1980s, the public's deficit of scientific knowledge was considered to be the most serious problem in the relations between science and society. In this phase, a minimum knowledge of scientific facts was considered necessary for people to live in a society governed by science and to participate in political decisions. Surveys were carried out to measure and monitor the public's scientific knowledge, with quiz-like items – for example, 'the sun goes round the earth', 'electrons are smaller than atoms'… true or false? The results of these surveys were considered real catastrophes, increasing the concern of scientists and authorities that the public was scientifically illiterate. To solve the problem, programmes were designed with the aim of transmitting scientific knowledge to the public. However, these approaches failed to improve the results of the polls. In the scientists' and authorities' view, the public remained scientifically illiterate and, therefore, was unable to participate in science policy decisions.

Between 1985 and 1990, a phase marked by the influential Bodmer (1985) report[1], the apparent problem changed from being the public's lack of scientific knowledge to their attitude – not positive enough – towards science and technology. This is often referred to as the *Public Understanding of Science* (PUS) paradigm. The scientific community in particular was concerned about the lack

[1]Report published by the Royal Society of London in 1985, officially called 'The Public Understanding of Science', but most known by the name of the coordinator of the group responsible for the document, Dr Bodmer.

of public support for science and was convinced that this was directly related to a general lack of knowledge. Thus, within the PUS paradigm, the assumption was that if people understood science better, they would start loving it! Consequently, a series of initiatives were planned and financed to educate people and at the same time increase their enthusiasm for science. From a research point of view, the focus shifted from exploring public knowledge to public attitudes, and sometimes the correlation between them.

> Both the scientific literacy and PUS paradigm assume a public state of deficiency: citizens lack either enough or the right kind of knowledge, and thus fail to display sufficiently positive attitudes or 'reasonable' risk perceptions. (Bauer et al., 2007, p. 84)

The concept of science communication generated from this assumption and the strategies developed based on it became known as the 'deficit model', a continuing target of debate and criticism in the field (Gregory & Miller, 1998; Irwin, 2009; Lewenstein & Brossard, 2010; Miller, 2005; Wynne, 1991; Ziman, 1991).

A further and significant paradigm shift took place in the 1990s, when an inversion in the deficit idea took place. It was no longer the lack of public knowledge or support that was at stake, but society's lack of trust in science, and importantly, scientists were seen as at least partially responsible for this state of affairs. The public mistrust in science was then associated with scientists' lack of knowledge about the public, its interests and needs. For the first time, the focus of attention shifted from a public deficit to an expert deficit. The popular rejection of Genetically Modified Organisms (GMO) and the British mad cow disease affair are considered some of the main causes of what was then perceived as a crisis of confidence in science, and which urgently needed to be remedied.

Faced with the failure of previous predominantly top-down actions, first aimed at transmitting scientific facts and then trying to convince the public about the wonders of science, more horizontal strategies were conceived to improve relations between science and society. In this sense, the 'Science and Society' report, prepared and released by the House of Lords in 2000, despite pointing out the persistence of a crisis of confidence in science and a popular unrest related to GMOs, detected a cultural change in the position of British scientists in favour of outreach and science communication activities aimed at the general public, as well as a new willingness for dialogue (House of Lords, 2000). It was in this context that new kinds of participatory activities emerged, such as hearings, citizen juries, deliberative opinion polling and consensus conferences. Great hopes were placed in these new approaches, in the sense that they might reverse the perceived crisis and win back society's trust in science. 'Public deliberation and participation are the new "royal road" to rebuild public trust' (House of Lords, 2000, p. 85). In terms of research, a series of impact studies soon began to investigate the effectiveness of these initiatives, which ended up raising a whole new range of questions that are still under discussion.

This bumpy trajectory, full of misunderstandings and redirects, is often presented in the literature as one that went 'from deficit to dialogue', which we could