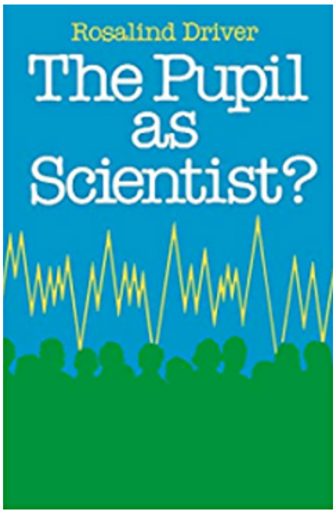
Pioneers of Science Education #15 Rosalind Driver (1942-30/10/1997): ‘The pupil as scientist’

Dr Peter E. Childs

In this series in *Science* we are looking at some of the important pioneers of science education in the last 200 years, and taken together the series provides an introduction to some of the important themes and key people in the development of science education. You can access back articles in previous issues of the journal available at www.ista.ie and also at www.cheminaction.com .

Introduction

***The Pupil as Scientist*, 1983**



One of the names which frequently occurs in science education when constructivism and pupil misconceptions are mentioned is that of Rosalind Driver, even after over 20 years since her death. She died relatively young in 1997, but left an indelible impression on science education. She spoke at the 3rd ChemEd-Ireland conference in 1984 on ‘Mixed-ability teaching in science’, an important topic then and now. I had heard of her work in listening to students’ ideas in her book *The Pupil as Scientist* (Driver, 1983) and thought she would be a good speaker. She gave the Thomond Lecture in Science Education on ‘Students’ alternative frameworks and the learning of science’ (Driver, 1984). This was an open lecture on the Friday night and during the main conference on Saturday she also spoke on ‘Pupil’s skills and abilities in science’. In PoSE #15 we will look at her contribution to science education. She wrote or contributed to several influential books, which can still be found in libraries and second-hand. The title of this article is taken from one of her books (figure above).

She died from cancer at the peak of her career, having recently moved from the University of Leeds to King’s College, London, and several obituaries appeared at the time, including one by her ex-colleagues Jonathan Osborne, John Leach and Phil Scott.

“Rosalind Driver was one of the pre-eminent figures in science education of her generation. She was a major presence on both the national and international stages, attracting interest and respect both from science education researchers and science teachers. Throughout her professional career she displayed an enduring passion for science education. She took very seriously the responsibility of seeking to improve our understanding of what is involved in teaching and learning science and, indeed, what might constitute an education in science.” (Osborne *et al*., 1997, p.1)

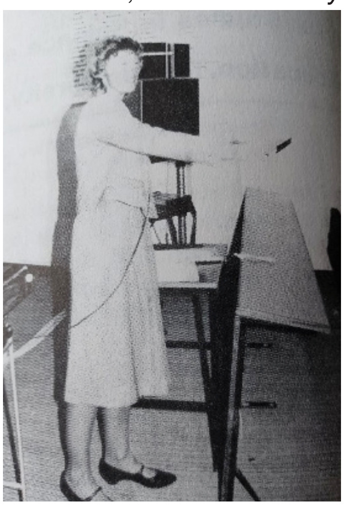
Rosalind Driver (1941-1997)

This article includes recent appreciations of Rosalind’s work from John Leach and Jim Ryder, her former colleagues in Leeds.

Peter Fensham (P0SE #14) gave a lovely tribute to her in a book chapter in 2001.

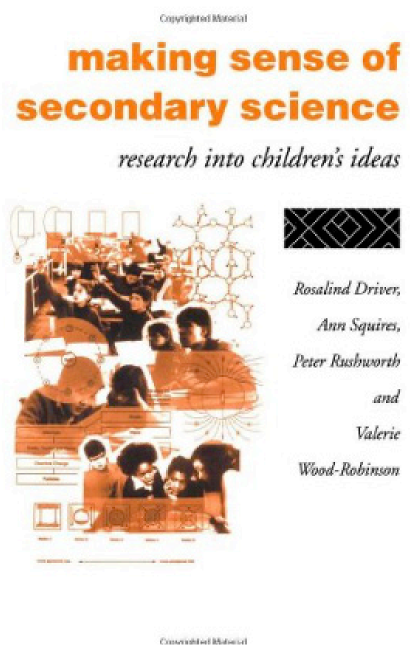
“There are many persons in science education who have been influenced by Ros Driver’s published work which, for 25 years, contributed so much to defining the frontiers of our field. There will also be a number, like me, who had the good fortune to work with her in Leeds or elsewhere. Others, will be able to feel again, the pulse of walking with her and Geoff in those Yorkshire dales they loved so much, or, as we once did, on the moors of Derbyshire, ablaze with purple, despite a glowering sky. More still, will remember being with her at conferences and other professional meetings. In any of these ways of close encounters, we were all touched by her honesty, enthusiasm, warm humanity and amazing commitment to furthering science education.” (Fensham, 2001)

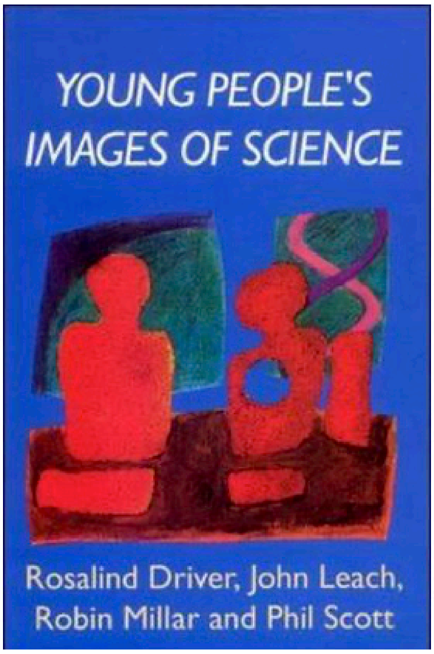
The obituary by Osborne *et al.* (1997) available online gives a very good summary of her life and work, one of a number of appreciations which appeared after her early death (See also Leach & Scott, 1998; Scott, 1998.)

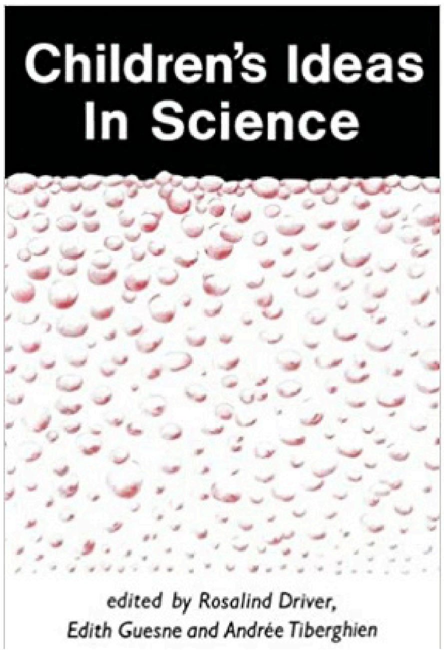


Speaking at ChemEd-Ireland 1984

The main features of her life are described here. She was brought up in Nottingham and attended Nottingham High School







Some influential books in science education

for Girls. She went on from there to study Physics at the University of Manchester, and after graduation taught science and physics for several years. During this time she met and married her husband Geoff. She then moved to the University of Illinois for a number of years, obtaining a PhD under the supervision of Jack Easley in 1973. The thesis was a study of the cognitive behaviour of children and through interviews she investigated their thinking about science. This study was to form the basis of her life's work and broke new ground. Returning to the UK she was appointed lecturer in Physics and Science Education at the University of Leeds in 1974. In 1977 she was made Senior Research Fellow, in 1986 Reader in Science Education and in 1989 Professor of Science Education.

During her time in Leeds she was involved in a number of important projects. From 1979-82 she was Deputy Director of the Assessment of Performance Unit (APU). From 1982-89 Director of the Children's Learning in Science project (CLISP), which led to the Children's Learning in Science Research Group (1990-95), and from 1991-93 was involved in the research project on 'The development of pupils' understanding of the nature of science'. Along the way she published many important research papers and a number of influential books: *The Pupil as Scientist* (1983, Open University Press), *Children's Ideas in Science* (1985, Open University Press, with E. Guesne and A. Tiberghian), *Making Sense of Secondary Science* (1994, Routledge, with A. Squires, P. Rushworth & V. Wood-Robinson); *Young People's Images of Science (*1996, Open University Press, with J. Leach, R. Millar and P. Scott).

While at Leeds she was involved in organising the European Conference of Research in Science Education in 1995, which led to the founding of the European Science Education Research Association (ESERA). She was able to attend its first conference in 1997 in Rome. In 1995 she moved to King's College. London as Professor of Science Education, succeeding Paul Black. Her work was recognised in 1997 by the recognition for Distinguished Service to Research in Science Education by the National Association for Research in Science Teaching (NARST). Just before her death she was about to initiate a project into argumentation, which has since become an important area of research.

Science education research

Rosalind Driver's recommendations in 1984 at the 3rd ChemEd-Ireland conference in relation to mixed ability teaching, still have relevance today, 38 years later.

Implications for science education (Driver, 1984, pp. 23-25)

".. studies of students' ideas document more than the odd facts that children 'get wrong'. They reflect major underlying differences in assumptions and ways of construing the world.

In this.. section.. I suggest a number of important implications that adopting a constructivist view of learning may have for curriculum, teaching and learning.

1. *We may need to reconsider the assumptions wew currently make about where students start from in their thinking in science courses. At the moment we are making unwarranted assumptions about the ideas that students have and what we can therefore take for granted and build on in lessons (for example, ideas of conservation of matter or atmospheric pressure.)*
2. *The ideas students bring to a course will influence their activities; the observations they make, the interpretations they give and even the design of experiments they perform. This implies that there is a need to go beyond simplistic views of students learning from experience in designing science courses.*

3. *Experiences themselves are not enough to change students' conceptions and we may need to consider a new range of pedagogical strategies to encourage conceptual change.*
4. *Such strategies may include such approaches as:*
   i. *encouraging students to make their own ideas explicit;*
   ii. *presenting them with events which challenge their ideas;*
   iii. *encouraging the process of hypothesising and the generation of alternative interpretations or models;*
   iv. *giving students opportunities to explore these alternatives in informal and unthreatening ways, particularly through small group discussion;*
   v. *giving opportunities for students to use new ideas in a wide range of situations so that they can appreciate their utility.*
5. *A constructivist view of learning suggests that we may need to consider the content of a science curriculum from a more developmental view. Such as approach would recognise that students do not necessarily construct a 'complete' understanding of a conceptual area when they are first introduced to it; their thinking may change progressively towards a more sophisticated formal and coherent knowledge structure and they may have to 'unlearn' in order to continue to learn.*
6. *Lastly perhaps we need to look again at the conceptions which are useful for students. In introductory science courses, we are happy if students understand electric current in circuits in terms of fluid flow through pipes. Later, we suggest this conception is modified to become the drift of a cloud of charged particles through a lattice structure.*
7. *If we agree not accept a lower-level interpretation of say electrical flow in conductors, would we be willing to accept, for example, the notion of vacuums sucking or a caloric notion of heat? If the ideas students work for them, why change them?*
8. *The question I am raising then, particularly for the average student, is what level and type of conceptions is going to be useful to them not just in interpreting the experiences given in science lessons, but in terms of the activities they will be involved in and the decisions they will need to make in their adult life."*

Rosalind Driver published many important papers on her research, but she also wrote or contributed to several books listed above, still in print or widely available second-hand. She is mainly known for her work on applying constructivism to science learning and on students' misconceptions.

Some quotes:

These extracts from Driver's work give a flavour of her thinking and clarity in writing.

"If we wish children to develop an understanding of the conventional concepts and principles off science, more is required than merely providing practical experiences. The theoretical models and scientific conventions will not be 'discovered' by children through their practical work. They need to be presented. Guidance is then needed to help children assimilate their practical experiences into what is possibly a new way of thinking for them." (Driver, 1983, p. 9)

"If the orientation of science in general education is to help pupils develop a theoretical understanding which enables them to interpret and make sense of everyday experiences, to make pupils more 'at home' in the natural and man-made world they inhabit, then this may mean reassessing the science curriculum at two levels. It means selecting illustrative phenomena not simply because of the support they give to a theoretical idea, but because they are of practical use and everyday interest in their own right. It also means bringing the theoretical ideas within the compass of pupils' understanding."
(Driver, 1983, p. 80)

"There is an important argument that school science, if it is to contribute effectively to improved public understanding of science, must develop students' understanding of the scientific enterprise itself, of the aims and purposes of scientific work, and of the nature of the knowledge it produces. Such an understanding, it is argued, is necessary for students to develop an appreciation of both the power and the limitations of scientific knowledge claims, an appreciation which is necessary for dealing appropriately with the products of science and technology as informed citizens who can participate fully in a modern democracy."
(Driver *et al.*, 1996, p. 1)

"Our contention is that, to provide adequate science education for young people, it is necessary to reconceptualize the practices of science teaching so as to portray scientific knowledge as socially constructed. This change of perspective has major implications for pedagogy, requiring discursive activities, especially argument, to be given greater prominence. Traditionally, in the UK (and other Anglo-Saxon countries), there has been considerable emphasis on practical, empirical work in science classes. Reconceptualizing the teaching of science in the light of a social constructivist perspective requires, among other matters, the reconsideration of the place of students' experiments and investigations. Rather than portraying empirical work as constituting the basic procedural steps of scientific practice (the 'scientific method'), it should be value for the role it plays in providing evidence for knowledge claims."
(Driver *et al.*, 2000, p. 289)

"Teaching science with children's thinking in mind depends upon careful planning in which continuity of curriculum is designed for progression in pupils' ideas.

..
In designing a science curriculum, as in designing a lesson, it is important to have children's starting points as well as intended science learning goals in mind.
…
Teachers should not feel obliged to take explanations too far with younger pupils. The purpose of particular bits of teaching is to help pupils to take small steps towards a greater understanding." (Driver *et al*., 1994, pp. 12-13)

"This perspective on learning suggests that it is important in teaching and curriculum development to consider and understand children's own ideas as it is to give a clear presentation of the conventional scientific theories. After all, if a visitor phones you up explaining he has got lost on the way to your home, your first reaction would probably be to ask 'Where are you now?' You cannot start to give sensible directions without knowing where your visitor is starting from. Similarly, in teaching science it is important in designing teaching programmes to take into account both children's own ideas and those of the scientific community."
(Driver, 1994, p. 42)

"The more simplistic interpretations of the discovery approach to science suggest that we only need to give pupils the opportunity to explore events and phenomena at first hand and they will be able to induce the generalisations and principles themselves. The position suggested here is that children do make generalisations from their first-hand experiences, but these may not be the ones the teacher has in mind. Explanations do not spring clearly or uniquely from data."
(Driver, 1994, p. 47)

"The slogan 'I do and I understand' is commonly used in support of practical work in science teaching. We have classrooms where activity plays a central part…. To what end? In many classrooms, I suspect, 'I do and I am even more confused'.
This process of 'making sense' takes on even greater significance when considering children's alternative frameworks. Not only do children have to comprehend the new model or principle being presented to them, but they have to make the intellectual leap of possibly abandoning an alternative framework which until that time had worked well for them.
To use the language of philosophy of science, children sometimes need to undergo paradigm shifts in their thinking. Max Planck suggested that new theories do not convert people, it is just that old men die. If scientists have this difficulty in reformulating their conceptions of the world, is it a wonder that children sometimes have a struggle to do so?"
(Driver, 1994, p. 48)

Constructivism

Rosalind Driver and her co-workers were pioneers in developing the ideas of constructivism applied to students' learning of science. Rosalind Driver and Beverley Bell gave a short summary of constructivism in relation to student learning (Driver & Bell, 1986, pp. 353-354).

"Learning outcomes depend not only on the learning environment, but also on the knowledge of the learner.
Learning involves the construction of meaning. Meanings constructed by students from what they see or hear may not be those intended. Construction of a meaning is influenced to a large extent by existing knowledge.
The construction of meaning is a continuous and active process.
Learners have the final responsibility for their learning.
There are patterns in the types of meanings students construct due to shared experiences with the physical world and through natural language."

These ideas are now commonplace thanks to Driver's research work in books and courses on science education, although constructivism has come under criticism.

Misconceptions/alternative conceptions

An overlapping area where Rosalind Driver did important work and initiated a field of research was into children's ideas, uncovering their misconceptions or alternative conceptions. As science teachers we want to promote understanding rather than just memorisation of facts, but we underestimate the challenge this brings to teaching.

"However, this transition to teaching toward deep conceptual understanding often sounds deceptively simple, when in reality it presents a host of significant challenges both in theory and in practice. Most importantly, few if any students come to the subject of biology in college, high school, or even middle-school classrooms without significant prior knowledge of the subject. It is no surprise, then, that students can never be considered blank slates, beginning with zero knowledge, awaiting the receipt of current scientific understanding. Yet, there is often little time invested by instructors in finding out in depth what students already know and, more specifically, what they do not know, what they are confused about, and how their preconceptions about the world do or do not fit with new information they are attempting to learn." (Tanner & Allen, 2005, p. 112)

Tanner and Allen give credit to Rosalind Driver for opening up this fertile area of research.

"A key strategy for gaining insight into the nature of understanding and how to facilitate conceptual change in a classroom is to investigate just the opposite, the nature of misunderstanding. Research pioneered almost 30 years ago by the late educational researcher Rosalind Driver laid the groundwork for literally hundreds of studies on students' understanding and lack of understanding of major concepts in many scientific disciplines. In her methodological approach to studying misunderstanding, Driver and her colleagues' key insight was to look in detail at individual students' explanations of scientific phenomena through in-depth interviews in which the students' ideas could be probed and prodded much more extensively than any paper–pencil assessment ever could. Through this approach using detailed student inter-views, Driver

revealed student conceptions that were surprising to most experts in the sciences, including conceptions about the essence of living things; the movement of the earth in space; the nature of light, water, and air; the relationship between heat and temperature; and the processes of chemical change, to name but a few."
(Tanner & Allan, 2005, p. 113)

"Rosalind Driver made a huge contribution to the field of understanding student misconceptions in science. She believed students construct their understanding of the world through their observations and interactions with their peers, creating a coherent set of 'alternative conceptions' based on common sense, but wrong, logic.
Driver recognised that students need teacher guidance if they are to make sense of the world. Students are unlikely to give up their alternative conceptions easily, so lessons must be carefully designed to help them make this leap; those who champion discovery-based learning beware! Students need opportunities to make their current thinking visible, be presented with alternative ideas, and should be given time to assimilate these into their thinking.
Driver proposed that a number of issues make it difficult for students to discover meaning for themselves.

- *Students are unclear about what to focus on. For example, they may focus on the magnetic stirrer when the intended outcome was to focus on the solution inside the beaker*
- *Students hold preconceptions about what they will see, such as expecting smoke to move randomly in air*
- *Students are unclear of the meaning of scientific conventions. For example, an arrow can refer to a force in physics, moving from reactants to products in chemistry or energy transfer in biology"*

Misconceptions and conceptual change in science education | the science teacher

Personal appreciations and evaluations

"Her [PhD] thesis presented an argument that was radical at the time. Students' everyday knowledge of natural phenomena was viewed as a coherent framework of ideas, based on a commonsense interpretation of their experience in living in the world, rather than as 'misunderstandings' or 'mistakes'. These arguments, published in an article in Studies in Science Education in 1978, were to offer a new language for the description of children's thinking. No longer were their ideas 'naive notions' but rather 'alternative frameworks' or 'interpretative models'. Furthermore, she argued against the dominance of the Piagetian stage theory of development. Together with Easley [her supervisor], she proposed that children's cognitive development may be more like a series of Kuhnian paradigm shifts, with new ideas about a phenomenon replacing older ones. She argued that children's learning was dependent upon their existing ideas about phenomena, rather than limited by their developmental stage. Through this work, Rosalind Driver became one of the main progenitors of the constructivist movement that was to dominate science education throughout the 1980s and into the 1990s." (Osborne *et al.*, 1997)

Professor Jim Ryder
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"I worked with Ros whilst she was at Leeds and I had just started – so for a few years. She then moved on to Kings. Since then my research focus moved more towards curriculum and education policy rather than teaching/learning in the classroom. I think the best area I can comment on is how she was to work with as an early career researcher – as I was just starting my academic career when Ros was at Leeds. So, I've drafted a few lines on this below. I hope these are of some help – feel free to use or not.
I worked with Rosalind Driver during my first few years as an education researcher. She was an inspiring person to work with. She set high standards of intellectual activity but could also give clear guidance on achievable steps that an early career researcher should take to develop. I particularly recall her emphasis an engaging with original research texts by seminal education researchers (rather than relying on accounts given by others). Despite a busy schedule she was willing to spend time discussing fundamental concepts of the discipline with an early career researcher. She was also a great leader within a team – organised, demanding, informed, thoughtful, respected, a good listener and a great teacher."

Rosalind Driver's legacy in science education

John Leach, Leeds Trinity University, UK
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"It is now a quarter of a century since Rosalind Driver's death, yet the impact of her research and curriculum development lives on. This is evident from the continued citation in contemporary academic articles of her key publications, showing that they are judged as seminal rather than out-of-date. For most of us, this will not be the case.
I have been asked to reflect briefly on Ros Driver's legacy, and offer the following 3 points:
1. Although there are differing views on how, it is now generally accepted that student is active in learning and that teaching needs to take account of this. It is also generally taken for granted that some scientific content is hard to learn due to students' previous exposure to the behaviour of, and common explanations for, the behaviour of the material world. Teaching therefore needs to take account of this prior knowledge (variously labelled – quite imprecisely – as 'misconceptions'/'prior conceptions'/ 'students' conceptions'/ 'pre-instructional knowledge'). Although there were a few other pioneers at the time, Rosalind Driver is generally known in the English-speaking world as the person who moved

understanding of science learning away from age-related ideas (often attributed to Piaget) to subject-specific ideas: the challenges of learning Newtonian mechanics are not the same as the challenges in learning evolutionary theory. Ros and her co-workers undertook several empirical studies of how learners explained phenomena and events in the material world in their own terms, before or after teaching, along with a growing number of researchers around the world.

2. A few teaching activities now feature in schemes of work around the world that were developed to address learners' previously unknown difficulties by Ros, her research group, and science teachers in the Leeds area (including me in a former life). These are not generally attributed, which is the true measure of their impact on science education.

3. In the later stages of her career, Ros moved her attention onto the curriculum, addressing the question 'Why teach science to all pupils to the age of 16?'. With Robin Millar she obtained funding to host a seminar series bringing together academics, teachers, school inspectors, and the government agency responsible for the school curriculum, to address this question. The products of the seminar series were published after her death in the seminal report 'Beyond 2000: science education for the future'. (Millar & Osborne, 1999) It argued that school science should reflect the future needs of pupils as citizens, as well as providing a firm foundation for the much smaller number who would carry on with their studies of science. This, in turn, led to curriculum development in England and elsewhere that still has echoes in the inclusion of content about how science works and socio-scientific issues in the curriculum.

I had the privilege of working for and with Ros during my early career in academia. After all these years I still hear her voice asking challenging questions about my work (more in management rather than research these days). I suspect that I am not alone in being gifted this personal legacy amongst those who knew her well.
"

Conclusion: Rosalind Driver's legacy

Rosalind Driver's work is still frequently cited in books and articles on science education, which is an indication of its lasting importance, especially in the areas of constructivism and alternative conceptions. Peter Fensham gave the Rosalind Driver Memorial Lecture to the 2nd ESERA conference in Kiel in 1999 (Fensham, 2000). In a later comment Fensham said:

"Driver's work established a new field of educational research that has been important since its inception, influencing both traditional educational researchers and scientists-cum-discipline-based science education researchers." (Fensham, 2004).

In 2007 King's College, London, the last place that she worked, announced the setting up of a £1 million endowment fund by her husband Geoff Driver, The Rosalind Driver Memorial Fund, to support advanced research in science education. This fund is still in operation and to date 23 scholars have benefited from its support. (Scholarships in CRESTEM | School of Education, Communication & Society | King's College London (kcl.ac.uk).)

A recent article by David Gooblar (Gooblar, 2018) on 'The benefits of doing it wrong' gave a lot of credit to Rosalind's work.

"In the early 1970s, Rosalind Driver, then a graduate student in education at the University of Illinois, had a peculiar notion. To understand how children learn important scientific concepts, she argued, we first need to grasp how they see the world before they start school. Children do not come into their first science classrooms as blank slates, with no sense of the natural world or of the way objects move in space. Talking with children, Driver showed, often revealed that they had quite fully developed (if incorrect) ideas about scientific phenomena.

Her crucial — and radical — insight was that learning is dependent on preconceptions. We learn by revising our understanding of things."

….

"By patiently interviewing students about the way they saw the world, Driver provided the first detailed information not just about where students tended to go "wrong" but how. She established a new area of research in science education, laying the groundwork for a great many studies of how students understand important concepts. Reflecting in 1989 on the progress of such studies, Driver, who died in 1997, noted that they illuminated "problems of communication and understanding that exist at the heart of the job of teaching."

Rosalind Driver was active to the end and was involved in initiating the influential report *'Beyond 2000'* from the Nuffield Foundation. *"The original proposal and initiative for the report came from the late Professor Rosalind Driver and Dr Jonathan Osborne of King's College London. Rosalind Driver had a passion for science and science education, and an abiding concern for improving the nature and quality of the science education that we offer our young people. It is to be hoped that this report is a fitting contribution to that vision, energy and commitment which was the hallmark of her work."* (Millar & Osborne, 1998)

Perhaps her main contribution to science education was the recognition that it is important to listen to students in order to find out what they believe about science and how they think about natural phenomena. Questioning and discussion are essential for finding out students' alternative conceptions and helping them to adopt scientific explanations. Such research is personal, descriptive and qualitative but it opened up profitable areas of work, which are still active today.

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A helpful summary of Driver's ideas in *The pupil as scientist* can be found at Students' views about science theory and practice.pdf (curee.co.uk)

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