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# An interview with Richard Gunstone: Emeritus Professor of Science and Technology Education, Monash University, Australia

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The conversation between Richard (Dick) Gunstone and me took place at Monash University on June 19, 2009. The purpose of the interview was to record some of the rich and varied history of this well-known teacher, researcher, and advocate for quality science education in schools. In the course of the interview, Dick describes how circumstances conspired to lead him to science teaching, his fascination with research, and how educational thinkers and researchers influenced his own and others thinking at important times. He offers a perspective on where to from here and concludes by saying "how lucky can you be".

*Keywords*: Science Education, Teacher Education, Constructivism, Science Teaching and Learning, Curriculum and Pedagogy

## INTRODUCTION

It was a great pleasure to be given this opportunity to interview a longstanding friend and mentor who has made such an outstanding contribution to science education and education more generally. I first met Dick during my Diploma of Education year at Monash University in 1972. He was part of a team of enthusiastic science educators whose passion and concern for quality learning modeled what it was to be a great teacher. One of the most important lessons I learnt from Dick as a beginning teacher was about the nature of learning. Of course we had been exposed to Piaget but it wasn't until Dick asked us to consider the meaning of sentences such as, 'The notes were sour because the seams were split', that I really understood the role of activity and experience in meaning making.

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Some years later, my interest in the role of metacognition in mathematical problem solving lead me back to Monash and to Dick. Many rich and insightful discussions followed, and I, like many others, are eternally grateful to him for the support and encouragement he provided as the senior supervisor of our Ph.D studies. Dick is a great teacher, scholar and advocate for experiential learning. Many have been touched by his passion, extensive knowledge, and abiding commitment to the profession. I hope you enjoy this interview with one of our national treasures.

## PROFESSOR GUNSTONE'S VITA

Richard (Dick) Gunstone is Emeritus Professor of Science and Technology Education at Monash University. Dick has a Trained Secondary Teacher's Certificate (from the Secondary Teachers' College Melbourne, 1960), B.Sc. (University of Melbourne, 1963), a postgraduate B.Ed. (Monash University, 1974), and Ph.D. (Monash University, 1981 – thesis title Structural Outcomes of Physics Instruction). He is a Fellow of the Academy of the Social Sciences in Australia (one of only 4 science education researchers to have been awarded this honour), and a Life Member of


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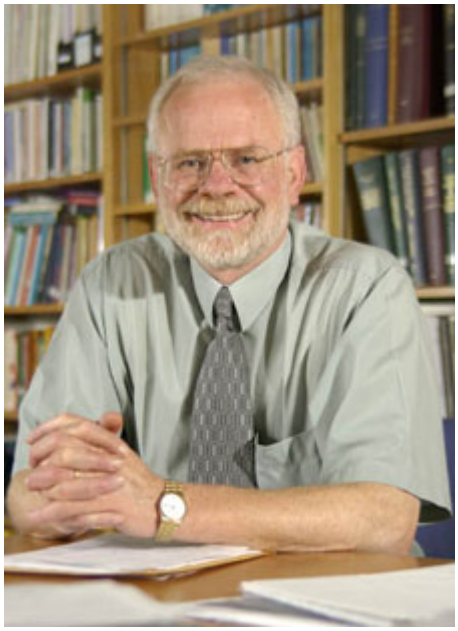

**Figure1. Dick Gunstone**

the Science Teachers' Association of Victoria (one of only 14 created in the 66 year life of this body).

Dick's first career was as a teacher of physics, science, and mathematics. He taught in a number of high schools in Victoria from 1962 until the end of 1973 (Lake Bolac High School, University High School, Upwey High School, Dandenong High School). In this time he became heavily involved with the Science Teachers' Association of Victoria, including being for different periods their first "Executive Officer", editor of their journal (Lab Talk), Director of their "Science Talent Search" for school students, and a number of administrative positions such as Treasurer etc. He was also seconded one day a week to University of Melbourne to teach pre-service methods programs 1968-70, and half time to Monash University to teach methods programs 1971-73. He has been at Monash University since 1974. He nominally retired at the end of 2005; after his wife died early in 2008 following a long illness he has become active again in research and development and teaching and, particularly, mentoring younger science education academics.

During his long time at Monash, Dick has had sabbaticals at the Learning Research and Development Center, University of Pittsburgh (1980-81), University of Leeds (1988) and University of British Colombia (1994). He has also spent shorter periods teaching and/or collaborating on research and development projects at the Regional Centre for Science and Mathematics Education, Penang, Malaysia (1985), University of the Philippines, Manila (1986, 1989, 1991, 1992), University of Gothenburg (1988), Seoul National University (1995, 1997), Faculty of Engineering University of Cape Town (1998, 2008), Hiroshima University (1998), King's College, London (2000, 2003, 2006), University of Waikato (2003, 2008). He has been a keynote speaker at international conferences in Korea, Spain, Germany, England, USA, Israel, Netherlands, Australia and at regional or national conferences in Singapore, New Zealand, Mexico, Japan, Australia, Bahrain, Namibia, Papua New Guinea, USA, and has conducted professional development workshops for science education academics and/or science teachers in a number of locations in Africa, North America, Europe, Asia, and in many Australian states. In 1985 he was the first science education researcher to win funding from the major Australian government research funding body (then called the Australian Research Grants Committee, now the Australian Research Council), and had a succession of large grants from this body 1985-2005. With his colleagues John Baird, Peter Fensham and Richard White he won the JRST award in 1992, for the paper "The importance of reflection in improving science teaching and learning". He is currently a member of the editorial boards of the ISI-listed International Journal of Science Education and Research in Science Education, and has previously been a member of the editorial board of Journal of Research in Science Teaching and a co-editor of the Learning section of Science Education.

His teaching in the Education Faculty at Monash has involved the spectrum of science education, at undergraduate and post graduate levels, and also more broadly issues of curriculum, assessment, learning and metacognition, and evaluation. He ahs also taught intermittently at both undergraduate and post graduate levels in the Faculty of Medicine and written materials for distance teaching of a master's degree in Family Medicine, and at undergraduate level in the Faculty of Engineering. His research student supervision has been a major part of his teaching. He has, in the "British" mode of single supervisor, supervised 35 Ph.D. theses to completion. His former students include people who now hold Chairs in Science Education, Mathematics Education and Public Health. (In 1995 and 1997 two of his PhD students separately won the "Outstanding Dissertation Award" for research on Teaching and Teacher Education given by the American Educational Research Association; these were the first two times this award had been made to theses awarded by universities outside North America.).

He has also had a wide range of involvements with science education in much broader contexts. For example, he with two Monash colleagues (Professor Richard White Education and Professor Bill Rachinger Physics) created Melbourne's first (and Australia's second) interactive science centre ("experilearn", opened Sept. 1983 within the Melbourne Museum, and closed early in 1989; this was the predecessor of the current "ScienceWorks" that is part of the Museum of Victoria organization). He was for a number of years Chair of

the Management Committee of the Family Science Project of Australia, he spent a decade as Examiner of senior high school physics in Victoria, he was for several years a member of the Education sub-committee of the Committee for the Scientific Investigation of Claims of the Paranormal (USA). He has been closely involved from its begins in 2001 in the development of a high school specifically for senior students with high science interests that is being built on the campus of Monash University; the school, the John Monash Science School, takes its first students in 2010.

## THE CONVERSATION

DS: Dick you have been at the forefront of science teaching and science education for many years. Three questions: What prompted your interest in science in the first place? How did you get involved with science education and thirdly what lead you to science education research?

Dick: Ok. I need a more complicated answer, in a way. The thing that attracted me to science … actually, I want to ask another question first. How come I stayed at school? Because, that is, actually quite significant. I come from rural Australia. No member of my broader family had ever stayed at school past the compulsory leaving age, which at that time for me was 14. I had a mother who was raising me as a single parent, who was desperately anxious that I should stay at school and four uncles who all told me that "people like us" didn't do what I was doing [continuing with an education]. And so the real battle for me was not what I studied at school but staying at school. And my mother and a profoundly wonderful teacher of English at this rural high school, helped me remain in schooling, which, of course, I am very grateful for. Apart from that I would have left school at 14 and have been a manual labourer all my life. That I did science, then initially, is just a reflection of the 1950's.

At that time, the assumption in [Australian] schools was absolutely that people who were seen to be bright automatically did maths and science. I have no regrets about having done that. Had I had a completely open choice at the time, without my own feelings of peer pressure and concern where my friends were going, I would probably have studied history and politics. But I have done that [history and politics] anyway, as a "side line", anyhow and probably have got more from it than from being formally taught it. So science didn't become a real passion for me until I started teaching it. I was pretty disengaged from science [at school and university]. Yes, I did it and I mostly passed exams, but not always when an undergraduate. And I had a lot of other interests then.

DS: Did you know you were going to be a teacher during University?

Dick: Yes. That also was a matter of circumstance, which was very fortunate because I found I was actually quite good at teaching and I enjoyed it enormously and I had great passion for it. But that was accidental. I had two scholarships to choose from at the end of my high school and I needed one of those to get to University because I had to be completely financially independent. One of them was a teaching studentship which paid me quite a reasonable living allowance and provided me with subsidised accommodation, so it was financially very good. The other was a scholarship given by the Commonwealth Government of Australia. Because I did not know I could work part time as a University student I assumed I could not survive on the Commonwealth scholarship so I took the teaching scholarship. Absolutely an ignorant decision and a very fortunate one, because I love teaching. So, I didn't think about teaching essentially until I began it. My first school position was in 1962 and suddenly I found teaching was fabulous stuff, I really loved it, I loved being engaged with the community I was in and all those sorts of things. So there were two really happy accidents that led me to into a wonderful career of science education.

DS: So why research?

Dick: The accidents continued to be fortunate for me. My first school was a little school in the country. When I got married I came to the city so my wife did not have to change jobs, and, quite by accident, landed in a wonderful school very well known in Victoria, University High School, where I taught with a person very heavily involved with the Science Teachers Association [of Victoria[. So, I became heavily involved with the Science Teachers Association too. I was already thinking in fairly ignorant ways about why was it with all my 'wonderful' physics teaching, people didn't get what I was saying. I then started to think a lot about professional development of teachers through my work in the Science Teachers Association. Because I was involved with them and became a reasonably prominent figure (I am very proud to, say I am one of a small number of life members of this professional body), this led Melbourne University to ask me to work part time there, teaching physics and science methods subjects in pre service teacher education - only because of the linkages that had been some what accidental did I get this opportunity. And then Monash University wanted someone to come here half time to teach physics and science methods and they poached me from Melbourne. I came here [to Monash], and really enjoyed it. A fulltime job was then advertised, which was for 3 years and to be only 3 years, to work in preservice teacher education. I applied for it because I wanted to see what it was like and I was having some difficulties with working half time at schools and half time in Monash.

Then I started a PhD and became addicted to research. There is a whole set of accidents in all of this.

DS: Very serendipitous.

Dick: Absolutely

DS: Excellent. So, we will come back to looking at science education research more specifically, but let's look back a bit earlier. How would you describe the history of science education research in Australia?

Dick: Early and strong. The serious beginning point is probably the appointment of the first professor of science education in Australia who was my wonderful friend and colleague Peter Fensham who was the first Professor of Science at Monash and the first in the country. And as far as we can tell, probably, I feel reasonable confident, the first professor of science education anywhere outside of the United States. So there was a commitment fairly early on at Monash to pursue issues of science education research. Its origins were very much as they were in the United States. The motivations were to do with curriculum concerns, curriculum change, the need to try and understand what the consequences of curriculum change were. Very early forms of evaluation. That led to the very first time, it didn't happen in America till the 1960's, for the first time there were people who called themselves science educators rather than evaluators or educational psychologists or people who were concerned about the teaching and learning and curriculum of science. And the motivation and origins were pretty much the same here.

That all coincided with the then Dean of Education at Monash convincing the Federal Government, who were responsible for these things in Australia, to allow the Faculty of Education at Monash to get heavily into post graduate work. This was very unusual; in fact until then the faculties of education trained high school teachers and just had very occasional research students. So Monash Education, in fact, got heavily into education research. Peter Fensham was an outstanding researcher in his own right, including in Chemistry. He was a senior academic of chemistry before he came here, with one of his two PhDs being in Chemistry. So he became centrally involved in the development of the research culture in this faculty, central for the development of research student numbers and research student practice. And so that led Peter into things like establishing what is now the Australasian Science Education Research Association, ASERA, which is the second oldest such body in the world, behind the US one [NARST]. So, there is this whole set of, again, interesting circumstances which Peter, a remarkable individual, ran with and used to develop a really strong culture of research in science education in Australia. I don't think there is much question Australia is over represented in the science education research forums around the world. We also had from very early on an advantage, which a lot of education research in Australia has shared - we understood that there was work going on in both North America and in Europe and we were aware of both. On the other hand the North Americans and the Europeans tended to be blissfully ignorant of each other, and even to reject each other almost, through the 60's and 70's.

DS: What major turning points do you think there were, looking back?

Dick: There was an enormous stimulus given by the very first Federal Government intervention into school curriculum in this country, which was a science curriculum project called the" Australian Science Education Project." That gave a real boost to science education research because for the very first time the Federal government was putting money into these things rather than the State government being totally responsible. That coincided with the early days of ASERA. So ASERA grew rapidly and had lots of original research to publish. My own prejudice and I am not sure I have much data for this, my own prejudice is to believe the nature of the organisation that Peter Fensham established in ASERA was really crucial to the very rapid growth of research in this country. ASERA is still a conference that has never had an invited [or keynote] speaker. It is a conference that still treats all presenters equally. Every one gets the same length of time. We still hold to a structure where it is 40 mins for every paper session and that will be 20mins presentation and 20 mins discussion, even though we are now running 6 or 7 or 8 parallel sessions. So there are a whole set of issues about ASERA which have made it a place which has fostered young researchers. For a long time the only financial assistance we gave to researchers was for people giving their first ever academic paper. But never to people who were "self proclaimed gurus", who might come and give an invited talk and so on it goes. Now that's not a turning point , but it has been central to an ethos of collaboration and sharing which has been central to the slow development of the strength of science education research in Australia.

Science educators were amongst the very early people to seriously engage with education research conferences in North America. So, science educators … I am not suggesting that this is a turning point, it is part of the same gradual evolution. A former colleague of mine, Leo West, and I began a special interest group at AREA at the US in the early 80's, which became the place where all the significant AREA constructivist presentations were made as they occurred through the 80's and to the mid 90's. It was not surprising that Australians initiated that SIG. Australians a decade before, including science educators, had been amongst the very early people to regularly go to AREA and publish in American journals and those sorts of things. This all contributed [to the growth of science education

research in Australia]. The only specific turning point, I think, was the appointment of Peter Fensham, thereafter it has been a much more gradual growth and consolidation. Which is one of its strengths.

DS: And obviously this has spread through out of Australia. But what do you think the impact of this, the Australian effort has had locally, perhaps in Asia? Has there been any influence there?

Dick: Oh yes. We now have significant cohorts attending ASERA each year from Korea and Taiwan, and smaller numbers from other Asian countries. The Monash and ASERA linkage has been very strong in Korea where we worked with Seoul National University, the major public university, through the 90's to establish a doctoral program in Physics Ed and more generally science education as well. So, there have been some quite direct linkages. I have been involved in a number of collaborative research projects with Japanese science education academics. In the early days, a Monash person, Dick White, was on the board of management of RECSAM, the Regional Centre for Science and Mathematics Education in Penang - and you will recall that you and I were once in Penang at the same time teaching there. Peter Fensham, as we keep joking, but a factually based joke - Peter Fensham has been everywhere and very often. So there have been some really strong personal linkages many of us have developed.

DS: Into Asia

Dick: Into Asia.

DS: Not just Europe and America?

Dick: Yes. And they have been for the best of reasons. There has been nothing colonial about them.

DS: That's very good.

What paradigms do you think have influenced science education research?

Dick: When I first came into science education research we were still running very strongly on what I want to call, for very good reasons not belittling reasons, the agricultural paradigm. And that is an appropriate descriptor for experimental methodology such as 'brand A versus brand B'. These things were driving what I would argue were stupid research questions, like "does lab work assist student learning" – and failing to understand that student learning is a multi-faceted beast and it can be defined in many ways, so what form of learning do we focus on in such a question. And lab work is a multi-faceted beast and yada yada. And I call it agricultural because of all the statistics we used, and still use, were developed in the agricultural context. The Campbell and Stanley perspectives on experimental design were the absolutely dominant paradigm. This was experimental research in the traditional sense. This is quasi bench-top chemistry, seeing students as subjects, or teachers as subjects, as people on whom research was 'done'.

That dominant paradigm didn't advance us a lot because it led us into asking two-variable questions and that was a big weakness. Because when you try and conceptualise complex educational issues in terms of how is A relating to B this is always going to give you some difficulties. As an example, when I was editing the research section of the Australian Science Teachers Journal, I guess was probably middish to late 70's, I'm not sure, it used to have a research section. It is the major professional journal for the Australian Science Teachers' Association. I received a paper that was a teacher-audience version of something that had won a major award in a major overseas educational research journal. This was a profoundly strong study of all sorts of things to do with learning biology. Multi variant and all sorts of good stuff. The trouble was, this exploration of maybe eight or nine factors impacting on biological learning with quite sophisticated statistical approaches and really tight experimental design, had managed to arrive at an explanation for about one and a half percent of the variance in student learning. So I, of course, refused to publish the paper on the grounds that it had no relevance to teachers. Now that might have been cheeky of me, but I think it is also a really nice illustration of where we were at with research when I first came into it. This [rejected paper] was a fated and lauded study which was technically wonderful but educationally quite useless. What does 1.5% matter, when we could manage more than that by giving them all decent breakfast in the morning? And we know that.

One of the other harsh characterisations of experimental research, harsh but I would argue fair, is that individual difference was in the error column in the analysis of variance. And it is that central issue that led us off into very different directions, I believe. Some Monash people, me and Peter Fensham and Dick White, have been sufficiently self indulgent as to write a piece in the mid 80's about the ways our research approaches to the learning of science had evolved (*Gunstone, White, & Fensham, 1988*). All this was all laid out in that paper including the things which led us to go from multi-variant statistical approaches into much more intensive studies of individuals and then to oscillate backwards and forwards between the two. The experimental approach of the 1960s was based on many things, including a simple assumption – that in educational research we could use a form of science approach and operate with a simplification which said "lets pretend the world is of the simple form 'A causes B' and see what happens when we explore that". That's profoundly valuable in physics and leads to generalisations which you can't see but which are really significant. But it doesn't work in education. So the big transformations were to move to paradigms which recognised the individual as central [individual differences], which recognized the crucial importance of

complexity, which saw matters such as context as major variables rather than a nuisance, and so on.

DS: And at the same time, the work of Novak?

Dick: Yes, and many others. Joe Novak and his appropriate commitment to David Ausubel's views of learning, one of life's very under recognised people, I think. David Ausubel – who died early this year, after being a recluse for a long time. Joe's commitment to those things and to meta cognition had a very different perspective in some ways but mapped strongly onto the commitments that were being worked through at Monash to understanding learning in terms of individual students, commitment to the nature of understanding and how to foster metacognition and its role, all those sorts of things. That is a nice example of how the world is pluralist and multiple perspectives will always help us understand it better. I have never been committed to a single theoretical position. Rightly or wrongly I have always been a user rather than a generator of theory because my motivations have been, at one level, pretty unchanged since the day I walked in the door.

DS: That sounds like constructivism, which has informed many educational research endeavours. What are the similarities and differences do you think across the various fields of educational research in the use of constructivism?

Dick: Quite profound. I think it is very illuminating that constructivism hit science education early and hard. And it arose from researchers actually trying to ask kids what they thought - and listening to the substance of the explanations kids had for phenomena, explanations they gave for what might happen and why. One of the overwhelmingly important messages of this huge quantity of constructivist research in science education, which must be more than in every other [curriculum] area put together I would guess. I mean one of the most well known bibliographies is up to about six and a half thousand – seven thousand entries by way of research studies. It is just huge. The single most obvious thing, for me, the message, the most significant message is, it matters what one is learning. And we tend to forget that when we look across disciplines. So, I find it very difficult to see how, for example, the learning of mathematics can be helpfully informed by the research on the learning of science and vice versa. Because the nature and knowledge that is what we call science, the way of knowing we call science, is so different from the way of knowing we call mathematics.

That raises an example for me as to why some particular variants on constructivism have arisen in one [curriculum] area but not the other. That is why, to use an example I am fond of using and I have written briefly about, that is why the notion of what is commonly known as "radical constructivism", it seems clear to me that that emerged in mathematics. This has to do with the nature of knowing that is mathematics. That it did not emerge within science, that "radical constructivists" in science have von Glasersfeld to cite rather than their own guru, is to do, for me, with the nature of knowing that is science. There are huge differences [with mathematics]. It also is no accident that science is the area in which constructivism has been most influential, most prominent, most widely practised and in some ways most abused.

DS: What, now very strongly do you associate with cultural theories, perspectives on constructivism? Has that impacted on science education research?

Dick: Yes. And indeed in other circumstances, I would have been able to say my last major funded research project was on socio cultural perspectives and science learning in the informal context of early childhood. It was that that Marilyn Freer and I had an Australian Research Council grant for. It was awarded about a month before my wife was diagnosed so Marilyn ran the project herself. And so I was little engaged with it, but Marilyn Freer, Professor of Early Childhood at Monash, is a nice example of some one who sits very clearly across both fields. Her research has been largely on early childhood learning, has been largely embedded in the context of science of learning and technology for the whole of her professional life. She is a very strong adherent to the development of and practice of socio cultural theory. This is how she seeks to understand the learning of science. Yes. It's been quite dramatic growth in the last decade.

DS: So is that moving away from individuals to perhaps a concept that scientific conceptions perhaps have been formed by groups or by students interacting in groups?

Dick: I think it is both. And I am quite happy to have someone be really in disagreement with this. Its not something I think is in the way of the "truth", but it is my interpretation of what has happened. I think the really strong commitment for a long time to individual construction within science education research led us to the point where we had a really deep understanding of what kids were almost certainly were going to be thinking, in most of the contexts you could imagine. We were still struggling with trying to understand more than logical inference for why they might be thinking that. Trying to understand the socio cultural dimensions of the evolving ideas then helps us to get a better sense of why the ideas are the way they are, how we might seek to intervene a little earlier. So the most - what will be, if I can get my head around the outrageous comments of a really strange reviewer - what will be my most recent publication within the next week, once I sort this out, with a Korean colleague who had a post doc here a little while ago. Yong Jae's work has involved the really interesting notion of "typically perceived situations", what are the situations where, in which children are

more likely to apply their naïve conceptions of what ever it might be, force or energy. What we were doing was to try and understand a little of how these were culturally different. Which of course, they are. One of the things that has been a problem for science in all of this is the tendency to maintain the mythology that science is a culturally free discipline. And other lies we have lived with.

DS: Do you think there is going to be a need, or is there a need, for some sort of new paradigm, to help take the field forward?

Dick: Yes. But it won't be singular. I have a really strong commitment to the view that in any area, whether it is laboratory science, educational research, political enquiry, in any area, the most significant hallmark of good quality research is that it lets you ask better questions. Research is not something which should always lead to answers. Research should always lead to better questions. Along the way we have a better understanding of whatever the phenomenon is, but we will always be moving to new ways of conceptualising research and that will lead us to new paradigms. I think the most obvious shift over my time in research is that much more fundamental beginning acceptance of the significance of complexity. When I began research, when we were in the agricultural paradigm, the conception of significant issues as "A causes B", now seems to be really strange. Really odd. And so, the movement to recognising and embracing complexity, which is taking us forwards, the failure to address the complexity [in the past] meant we kept getting further away from what we wanted to understand. That move brings a whole raft of new paradigms that may potentially, may have positive impact, And the most obvious in that, the most obvious new paradigm is, if that is the right word, is that there a whole set of new issues contained in the perspectives of what is known as Complexity theory, which I don't really understand yet, but I will poke around a little in my retired state. But complexity theory is, at its beginning point, is a position which says, we need to understand complexity. This is a huge paradigm, shift.

DS: Looking back then, over your long years in science teaching and science education research, what do you think your major accomplishments were during that time?

Dick: I find that a really difficult question. But, don't misinterpret this, but I think my major accomplishment has been being able to work with a lot of people and develop a lot of other people in their research capabilities. And that's "with", not "on". It is working with many PhD students, learning from them and helping them learn, with research colleagues and mentoring people - and all of that doesn't answer the question, in one sense, because it doesn't answer what is it that we were researching, that is, what I see as my most significant achievement. I guess these are research outcome things that are probably to do with, a much better understanding of the complexity of physics learning, somewhat better understandings of the nature and significance of better cognition, particularly meta cognition in a classroom context, in undergraduate or school classrooms. And I have helped a little bit along the way with better understanding of teacher development - pre service and in service. So that is probably three major issues in order of whatever significance they might have.

DS: Anything that you think you might have you feel passionate about that is left undone that still needs to be done?

Dick: Oh Yes. In the last ten years I have become increasingly interested in and concerned for the intended curriculum. And, I am about to use something that is a little bit glib and simplistic in order to make a fairly fundamental point, When I was working at the University of British Columbia, so it would have been 1994, and Jim Gaskell, who was a science educator, curriculum person from the University of British Columbia for a long time, he is now retired from academia. Jim and I were playing around with some metaphorical thinking, which we didn't publish. The summary of it all was, at the beginning of the 20th century both the teaching of English literature and the teaching of science involved learning the great texts, and assessment of that learning involved reproducing the great texts, perhaps with a little bit of teacher help on some commentary to link them. By the beginning of the 21st century, literature teaching had changed. So there is a sense in which Joe Schwarb's wonderful description of science curriculum in the 1950's as a "rhetoric of conclusions" still dominates what happens in school and under graduate science education. And I have increasing passion for the need to change that, both because I feel a bit sad that so many people don't understand the extraordinarily wonderful things that there are to be understood about this way of knowing and because the world can't afford to keep producing people who are anti-science in the ways that we do. Some of that is the responsibility of our outrageously, fact-ridden, nonsensical and absurd school and university curriculum. Now my passion for that is stronger than it was 20 years ago because I have come to see that as much more significant than I did 20 years ago. In the unlikely event that I am ever an educational dictator, my first step will be to make all exams open book and that is just the beginnings to try and break this appalling focus on facts which continues to plague both science and, dare I say it, maths, education in ways in which other [curriculum areas] have grown up from. And I say grown up rather than grown away very deliberately.

DS: Sounds like a very big task indeed.

Dick: I don't have fantasies that I will achieve that. But that is where my passion is now.

DS: That links nicely to the next question. The relationship between research and practice is a perennial topic of debate in most fields of educational research. How do you see this relationship in the case of science education research?

Dick: Much healthier than it was forty years ago. As a beginning point, I'm speaking very specifically in the context in which I link with practice. It seems to me a necessary consequence of that really important question that you can't generalise, because practice in the Australian State of Victoria is not the same as practice in, well no I won't name a country, but its clearly going to be very different. I mean some countries I have worked in, the whole set of issues associated with the funding of education, the lack of education of teachers, the nature of the curriculum that teachers have to teach, mean that the practice has no relationship. The teachers in those places could not teach in Victoria and the teachers in Victoria could not teach in those places, full stop. So, I can only talk about it where I understand and have lived the practice.

It's much healthier than it used to be because it is much less hierarchical. Where it is not healthy, it is because it is still hierarchical - as a gross generalisation. It has been a very, very, very long time since people had any significant impact on school science teaching in this State through asserting what needed to be done. So that is tied up in a whole raft of things to do with the interactions that science educators have had, and others too, I know, with teacher research. They, the extent to which research is now done with teachers in real contexts, so in part it is tied up with research moving away from experimental research into the recognition of complexity. Tied up in ways in which pre service teacher education has shifted, in which professional development has shifted, most fundamentally it is tied up with changes in attitudes of the researchers, I would argue. Researchers in science education [at Monash], generally, not universally, but generally a long time ago, stopped seeing themselves as experts who told. There are some parts of the western world where that shift hasn't yet always happened, and I think the relationship between research and practice in those areas are much less healthy. The relationship is still not as good as I want and the ways in which research impacts on practice are slower than I want but I console myself by looking outside education and the ways research and practice interact elsewhere and then I am a little more sanguine about things. We tend to forget that the same practices operate in all professional areas, the same difficulties.

DS: You sort of have answered the next question, which is about the relationships between research and practice and how similar or different they are to the relationships in other professional fields?

Dick: I think it is really important to think about the similarities. We focus much too much on how we are different and not enough on how we are similar, I would argue. And the same is true of the education of professionals. I think we have a lot to learn. This is an idea so powerful that I wrote about it ten years ago and no one took any notice. I think we have a lot to learn about the commonness across professional education and the commonness across research-practice interfaces. As an anecdotal beginning point, I've off and on been doing bits and pieces of research and development in other faculties in Monash, Engineering and IT and Medicine and Science. In one of my incursions into Engineering, some years ago, I had an engineering researcher bemoaning the appalling state of events that, in his view, maybe one in 50 of the significant intellectual advances he had made in the particular area of materials engineering that was his research field impacted on practice. So I asked "what happens to the rest?" And you know, it was just like listening to someone in the Education Faculty. It was quite a singular moment for me. It was what first started me thinking about this. So, I think it is a reasonable assertion, if data free, that if we had never had drug salesmen there may still be a general practitioner practicing medicine in Australia who hadn't quite got his/her head around penicillin. Medicine tends to be the lived experience of research-practice interactions for most of us and there are change agents in medicine. These agents are driven by money, and do a lot to move some things. In other areas, like social work, like engineering, like IT, commercial structures that have set practices that are functioning well are hard to shift. Surprise, surprise. People who have learned to do things in particular ways are hard to shift. Surprise, surprise. All of these things are very familiar. The significance of that for me, is if we recognise that this is more the norm than the exception, then perhaps we will stop wailing and wringing our hands and blaming people for this and recognise that we need to be a bit more positive and function a bit more directly and look at the drivers a bit more directly. That's why I regard, quite seriously, a requirement to have all exams open book as being the single most significant educational reform we could undertake. Because assessment and the pursuit of grades is always going to be a really strong driver that is going to change both teaching practice and much more importantly, the learning approaches of kids. So let's stop sitting here, blaming teachers because 'they won't change', and accept that change is always problematic and difficult and see what can drive it. Assessment is always going to be one of the major drivers, so let's play with that.

DS: So, what do you think is the role of professional development?

Dick: Profound and deep and will only get near to recognising its really fundamental potential in the sense that any professional I want to have as my doctor, or teacher of my kids or my counsellor when I am having difficulties, is one who regards themselves as always learning. That is self evident, I think. One who regards themselves on a journey and their only commitment is that they are always moving forwards and uphill and don't expect to reach the top of the mountain. We need to find ways to value it [professional development] much more and that is both in terms of making it easier to participate in and in terms of rewarding the consequences. I haven't given huge amounts of thought as to the way we need to restructure the teaching profession, and I don't want to be committed to all of this. I don't have anything I want to say, like this is what we should do, but finding ways to reward the consequence of what is rather trendily called "life long learning" is fairly central, as they are for academics as well, I must say. So, but academics are harder than teachers. They just don't like to be reminded of that fact. But they are. I think the evidence is quite clear, across research fields again, it is not an issue just for education academics, and the history of science is littered with the inevitable consequences of reactions of senior people who have spent forty years researching a particular perspective and along comes some one who is 25 and says you are all wrong. Well of course, they don't get a favourable reaction. Researchers tend to be even more passionately committed to their world views. They are even harder to change than teachers, indeed.

DS: What do you think can be done about all of the current pleas for bringing creativity, innovation for ensuring our students have those capacities? I don't know if you heard Ken Robinson the other night? But what, how does that impact someone's education in schools? How might it impact on the sort of research that we do?

Dick: It impacts on the research we do by, well one of the shifts that we really need is this issue of complexity, which is almost an intersection of the sets of individual constructivism and the significance of complexity. We are well past more studies of how kids understand force. We need to recognise the complexity that has to be central to learning in science in the 21st Century. So, this is both terrible obvious but still not something we are pursuing enough. I think we will have made real progress with the sort of issues you are raising in Australia - all of these things are contextually culturally imbedded - when soil salination is a central part of the science curriculum. I despair when it continues to not be. There hasn't been the beginning of an attempt to understand how people's ideas about that complexity, that multi-variant thing that is soil salination evolves. So it is a nice example of how our research needs to better embrace the complexity that learning in the 21st Century must be. That also needs to take us away from factually based assessment and then curricula. It probably means playing around with another variation of the century old approach of problem based learning. I want to be careful about that because it tends to get seen as some great Nirvana which will transform the world and wasn't when it was first advocated at the beginnings of the 20th Century in undergraduate engineering and medicine. That sort of perspective is where we need to get to.

DS: And that, of course, puts very different demands on the type of science teachers we have in schools.

Dick: Absolutely.

DS: And the nature of our pre service courses, then

Dick: No. The nature of the undergraduate science those people are studying. That's where the problem is. The pre service teacher education courses, at least in this country, are at least OK. In general the sort of thing you are talking about, it is the science we teach and who teaches it and how it is valued. That's where the real changes needed. That's been true for a long time. I've had more passionate conversations than you would care to know about with people in science faculties who make the terrible mistake of telling me that teachers don't understand the science they teach very well. Because they get reminded by me very strongly and very harshly and very directly of where the teachers learnt their science. And it is from the very people that are complaining. And that is a universal phenomenon. I have had that argument with the vice chancellor of the University of Leeds; I have had it at an institution in America. Anyhow that is another story.

DS: Any conclusions or things that you feel you would like to shed some light on, in your long and lustrous career?

Dick: I have been desperately fortunate. My professional life has been a set of desperately fortunate circumstances. It's not surprising that in my nominal retired state I am working 3 or 4 days a week. Because it is not work at all. How lucky can you be.

DS: Exactly. Thank you very much Dick. That has been a good place to finish.

Dick: Thank you.

## DICK GUNSTONE'S SELECTED PUBLICATIONS

Dick has published: 12 books (8 authored & 4 edited; 8 'academic' & 4 school or teacher texts; 2 more research books currently in preparation), 45 book chapters, 161 research papers (journal & conference), and many research reports, and considerable curriculum and text materials (for school and university levels, including science and medicine students). These publications include the following notable scholarly contributions.

Gunstone, R.F., & White, R.T. (1981). Understanding of gravity. *Science Education, 65*, 291-299.

Champagne, A.B., Klopfer, L.E., & Gunstone, R.F. (1982). Cognitive research and the design of science instruction. *Educational Psychologist, 17*, 31-53.

Northfield, J.R., & Gunstone, R.F. (1985). Understanding learning at the classroom level. *Research in Science Education, 15*, 18-27.

Champagne, A.B., Gunstone, R.F., & Klopfer, L.E. (1985). Effecting changes in cognitive structures among physics students. In L.H.T. West & A.L. Pines (Eds.), *Cognitive structure and conceptual change*. New York: Academic Press, 163-187.

Champagne, A.B., Gunstone, R.F., & Klopfer, L.E. (1985). Instructional consequences of adolescents' knowledge of physical phenomena. In L.H.T. West & A.L. Pines (Eds.), *Cognitive structure and conceptual change*. New York: Academic Press, 61-90.

Gunstone, R.F., & Watts, D.M. (1985). Children's ideas about force and motion. In R. Driver, E. Guesne, & A. Tiberghien (Eds.), *Children's ideas about some scientific phenomena*. Milton Keynes: Open University Press, 85-104.

Rice, P., & Gunstone, R.F. (1986). Health and sickness causation and the influence of Thai culture among Thai school children. *Research in Science Education, 16*, 63-72.

Ameh, C.O., & Gunstone, R.F. (1986). Science teachers' concepts in Nigeria and Australia. *Research in Science Education, 16*, 73-81.

Gunstone, R.F., & Northfield, J.R. (1987). Learners-teachers-researchers: Consistency in implementing conceptual change. *Tijdschrift voor Didactic der Beta – Wetenschappen*, *5*, 60-74.

Gunstone, R.F. (1987). Student understanding in mechanics: A large population survey. *American Journal of Physics, 55*, 691-696.

Gunstone, R.F., & Baird, J.R. (1988). An integrative perspective on metacognition. *Australian Journal of Reading, 11*, 238-245.

Gunstone, R.F. (1988). Learners in science education. In P.J. Fensham (Ed.) *Development and dilemmas in science education*. London: Falmer Press, 73-95.

Gunstone, R.F., White, R.T., & Fensham, P.J. (1988). Developments in style and purpose of research on the learning of science. *Journal of Research in Science Teaching, 25,* 513-529.

White, R.T., & Gunstone, R.F. (1989). Metalearning and conceptual change. *International Journal of Science Education, 11*, 577-586.

Leder, G.C., & Gunstone, R.F. (1990). Perspectives on mathematics learning. *International Journal of Educational Research, 14,* 105-120.

Gunstone, R.F., & Champagne, A.B. (1990). Promoting conceptual change in the laboratory. In E. Hegarty-Hazel (Ed.), *The science curriculum and the student laboratory*. London: Croom Helm, 159-182.

Gunstone, R.F. (1990). Reconstructing theory from practical experience. In B. Woolnough (Ed.), *Practical Science*. Milton Keynes: Open University Press, 67-77.

Gunstone, R.F. (1991). Constructivism and metacognition: Theoretical issues and classroom studies. In Duit, R., Goldberg, F. & Neidderer, H. (Eds.), *Research in Physics learning -Theoretical issues and empirical studies*. Keil, Germany: IPN, 129-140.

Baird, J.R., Fensham, P.J., Gunstone, R.F., & White, R.T. (1991). The importance of reflection in improving science teaching and learning. *Journal of Research in Science Teaching, 28*, 163-182.

Gunstone, R.F. & Leder, G.C. (1992). *Qualitative methods in education research: A case study*. Geelong: Deakin University Press. (viii + 43pp.)

White, R.T., & Gunstone, R.F. (1992). *Probing understanding*. London: Falmer Press. (X + 196pp.) (Japanese language edition The English Agency (Japan), 1995; Chinese language edition in preparation)

Gunstone, R.F., Gray, C.M.R., & Searle, P. (1992). Some long term effects of uninformed conceptual change. *Science Education, 76*, 175-197.

Brew, C.R. & Gunstone, R.F. (1992). Students' perceptions of a university biology practical. *Research in Science Education, 22*, 55-62.

Gunstone, R.F., Slattery, M., Baird, J.R. & Northfield, J.R. (1993). A case study exploration of development in pre-service science teachers. *Science Education, 77*, 47-73.

Gunstone, R.F. & Northfield, J.R. (1994). Metacognition and learning to teach. *International Journal of Science Education, 16*, 523-537.

Fensham, P.J., Gunstone, R.F. & White, R.T. (Eds). (1994). *The content of science: A constructivist approach to its teaching and learning*. London: Falmer Press. (xii + 278 pp.)

Gunstone, R.F. (1994). Technology education and science education: Engineering as a case study of relationships. *Research in Science Education, 24*, 129-136.

Northfield, J.R., Gunstone, R.F. & Erickson, G.L. (1995). Constructing an approach to science teacher education. In D.F. Treagust, R. Duit & B.J. Fraser (Eds.) *Improving teaching and learning in Science and Mathematics*. New York: Teachers College Press, 201-211.

White, R., Gunstone, R., Eltermann, E., Macdonald, I., McKittrick, B., Mills, D. & Mulhall, P. (1995). Students' perceptions of teaching and learning in first year physics. *Research in Science Education, 25*, 465-478.

Gunstone, R.F. (1996). International developments in improving the science and mathematics curriculum - Understanding and supporting changes in the classroom. In C. Stoll, L. de Feiter, H. Vonk & J. van den Akker (Eds.) *Improving science and mathematics teaching in Southern Africa: Effectiveness of interventions*. Amsterdam: VU University Press, 60-68.

Gunstone, R.F. & Mitchell, I.J. (1997). Metacognition and conceptual change. In J.J. Mintzes, J.H. Wandersee & J.D. Novak (Eds.) *Teaching science for understanding*. San Diego: Academic Press, 133-163.

Loughran, J. & Gunstone, R. (1997). Professional development in residence: Developing reflection on science teaching and learning. *Journal of Education for Teaching, 23*(2), 159-178.

White, R. & Gunstone, R. (1999). Alternativen zur erfassung von verstehensprozessen. *Unterrichtswissenschaft, 27,* 128-134.

Tao, P-K. & Gunstone, R.F. (1999) Conceptual change in science through collaborative learning at the computer. *International Journal of Science Education, 21*, 39-57.

Tao, P-K. & Gunstone, R.F. (1999) The process of conceptual change in 'force and motion' during computer-supported instruction. *Journal of Research in Science Teaching, 36*, 859-882.

Hart, C., Mulhall, P., Berry, M., Loughran, J. & Gunstone, R. (2000). What is the purpose of *this* prac? Or Can students learn *something* from doing experiments? *Journal of Research in Science Teaching 37*, 655-675.

Gunstone, R.F. & White, R.T. (2000). Goals, methods and achievements of research in science education. In R. Millar, J. Leach & J. Osborne (eds.) *Improving science education: The contributions of research*. Milton Keynes: Open University Press, 293-307.

Gunstone, R.F. (2000). Constructivism in the classroom. In D.C. Philips (ed) *Constructivism in education: Opinions and second opinions on controversial issues* (Ninety-ninth Yearbook of the National Society for the Study of Education Part 1). Chicago: University of Chicago Press, 254-280.

Berry, A., Gunstone, R., Loughran, J. & Mulhall, P. (2001) Using laboratory work to teach about the practice of Science. In R Duit (ed.) *Research in science education: Past, Present, and Future*. Dordrecht: Kluwer, 313-318.

Gunstone, R. (2001). The education of physics teachers: Content plus pedagogy plus reflective practice. In R. Pinto & S. Surinach (eds.) *Physics teacher education beyond 2000*. Paris: Elsevier, 27-33.

Mulhall, P., McKittrick, B. & Gunstone, R. Confusions in the teaching of electricity. (2001). *Research in Science Education, 31*, 575-587.

Loughran, J., Milroy, P., Berry, A., Gunstone, R. & Mulhall, P. (2001). Science cases in action: Documenting science teachers' pedagogical content knowledge. *Research in Science Education, 31*, 289-307.

Case, J. & Gunstone, R. (2002). Metacognitive development as a shift in approach to learning: an in-depth study. *Studies in Higher Education, 27,* 459 – 470.

Ng, W. & Gunstone, R. (2002). Students' perceptions of the effectiveness of the World Wide Web as a research and teaching tool in science learning. *Research in Science Edcuation, 32*, 489-510.

Case, J. & Gunstone, R. (2003). Approaches to learning in a second year chemical engineering course. *International Journal of Science Education, 25*, 801-819.

Case, J. & Gunstone, R. (2003). Going deeper than deep and surface approaches: A study of students' perceptions of time. *Teaching in Higher Education, 8*, 55-69.

Brass, C., Gunstone, R. & Fensham, P. (2003). Quality learning of physics: Conceptions held by high school and university teachers. *Research in Science Education, 33*, 245-271.

Conner, L. & Gunstone, R. (2004). Conscious knowledge of learning: accessing learning strategies in a final year high school biology class. *International Journal of Science Education, 26*, 1427-1443.

Gunstone, R. (2004) Physics education past, present, and future: An interpretation through cultural contexts. In Y. Park (ed.) *Teaching and Learning of Physics in Cultural Contexts*. Singapore: World Scientific Publishing Company, 25-45.

Gunstone, R., McKittrick, B. & Mulhall, P. (2005). Textbooks and their authors: another perspective on the difficulties of teaching and learning electricity. In K. Boersma, M. Goedhart, O. de Jong & H. Eijkelhof (eds.) *Research and the quality of science education*. Dordrecht: Springer, 435-445.

Bishop, A., Clarke, B., Corrigan, D. & Gunstone, R. (2006). Values in mathematics and science education: researchers' and teachers' views on the similarities and differences. *For the learning of mathematics, 26*(1), 7-11.

Case, J. & Gunstone, R. (2006). Metacognitive development: A view beyond cognition. *Research in Science Education, 36*, 51-67

Corrigan, D., Dillon, J. & Gunstone, R. (Eds). (2007) *The re-emergence of values in science education*. Rotterdam: Sense Publishers. (viii + 280 pp.)

Thong, W. M. & Gunstone, R. (2008). Some student conceptions of electromagnetic induction. *Research in Science Education, 38*, 31-44.

Mulhall, P. & Gunstone, R. (2008). Views of physics held by physics teachers with differing views of the nature of physics learning. *Research in Science Education, 38*, 435-462.

White, R. & Gunstone, R. (2008). The Conceptual Change Approach and the Teaching of Science. In S. Vosniadou (Ed.) *Handbook of Research on Conceptual Change*. New York: Routledge, 619-628.

Smith, D.V. & Gunstone, R.F. (2009). Science Curriculum and the Market Liberal Society of the 21st Century: 'Re-visioning' the idea of Science for All. *Research in Science Education*, *39*, 1-16

Gunstone, R. (2009). Key Figures: Peter Fensham - Head, heart and hands (on) in the service of science education and social equity and justice. *Cultural Studies in Science Education, 4*, 303–314.

Gunstone, R. & Treagust, D. (in press) Conceptual change in Science – Research at the forefront over the past three decades. In S. Ritchie (ed.) *The world of science education: Handbook of research in Australasia*. Rotterdam: Sense Publishers

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The audio recording of this conversation/interview is available from the journal web site.