Turning teaching development into research outcomes

Richard Gunstone, Faculty of Education, Monash University
dick.gunstone@education.monash.edu.au

Introduction

All research has common features, but research in different fields also has fundamental differences. Significant differences are in the ranges of research methodologies appropriate to be used, and in the nature of appropriate knowledge claims each field seeks to establish. Both of these differences essentially derive from the nature of the questions it is appropriate for the field to seek to answer.

The focus of this paper is on, firstly, the nature of research in education and the ways in which it is similar to and different from research in the scientific disciplines, and, secondly, issues important in conducting educational research in ones' own classroom. An appropriate subtitle would be 'Conducting research of value in the teaching contexts in which you work'.

A brief comment on research

All research involves systematic inquiry, critical investigation. This inquiry is focussed by questions reflecting the motivation for the research. All research aims to develop new understandings/ explanations/relationships, either through the generation of new knowledge or through the reconsideration and collation, and often reinterpretation, of existing knowledge. Research is usually guided by theoretical position(s); research which is atheoretical is almost always fundamentally flawed.

As well as seeking to understand/explain particular phenomena, preferably through some form of causal explanation, research seeks to predict to other situations involving the same phenomena. It is in this predicting that the significance of guiding theor(ies) is most obvious.

Research in education

While all research shares the broad characteristics outlined above, there are clear, systematic and appropriate differences in research conducted in different discipline areas. For example, while much of the systematic inquiry in the sciences has parsimony and universality as fundamental needs, some areas of engineering inquiry are focussed on the development of a contextually specific solution to a specific problem.

There are crucial and necessary differences between research in the sciences and research in education, and particularly educational research concerned with understanding classrooms, teaching and learning. The fundamentally important difference is in the nature of the knowledge claims it is appropriate to seek in these two areas of inquiry. Educational research cannot seek the same forms and levels of parsimony and universality that are so correctly the focus of science; education cannot seek to generate valid knowledge claims that are universal across place and time in the way science seeks to do; education cannot seek to generate mathematically precise relationships in the way that much (but not all) of science seeks to do.

> *At the heart of the inability of educational research to generate universal and precise relationships is the nature of causality*. Conceptions of cause that pervade science and much … teaching and learning of science are often monistic (focus on unity) and absolutist

> (invariant). That is, there is striving to discover the *one* correct explanation of a particular scientific phenomenon, the *one* most elegant procedure for testing an hypothesis, and so on. The veracity and applicability of such explanations or procedures are taken to transcend time, context, and, for some 'universal laws', content. Unlike science itself, however, cause in teaching and learning is unlikely to be unitary and invariant. It is much more likely to be multiple (pluralistic) and content-, context-, and time-dependant (relativistic). For example, most teachers would acknowledge that the success of a particular lesson is influenced by the nature of the content *and* the time of day, *and* the ambient temperature, and so on.
>
> (Baird et al., 1991, p.181; emphasis added)

The essential point here is that although it is sadly not uncommon for educational research to seek singular and universal causality (see examples below), this cannot be done. Causality in educational matters is always multiple and relative. One central reason for this (and *not* the only reason) is that context is a determining variable in situations/phenomena we seek to understand.

Context, rightly, is seen in much scientific research as 'noise', and methodologies are used which seek to eliminate the effects of this 'noise'; in simple terms, 'noise' is a nuisance. This is clearly appropriate for the seeking of knowledge claims that are singular, universal and absolute, and therefore not partially determined by context.

Context, on the other hand, is so central in educational research, and particularly in research concerned with understanding classrooms/teaching/learning, that it needs to be seen in terms of a number of determining variables of central significance to an understanding of the phenomenon being investigated. And one fundamental and inevitable consequence of this is that the notion of 'generalisability' must be seen differently in educational research than it is in scientific research. I return to this issue below.

Context, in the ways it is being used here and when referring to research on classrooms/teaching/learning, clearly embraces a range of matters relating both to individuals and to groups in classrooms. Examples include:

- the motivations of the students and the nature of any 'distracting' possibilities (such as an Olympic Games) that may exist;
- the physical environment and resources being used;
- the extent to which one teacher understands and accommodates/uses the other experiences her/his students are concurrently involved with; and so on.

I see four issues that are part of this broad context that have particular importance for research in science/engineering/technology classrooms at both school and post-school levels:

- the ideas and beliefs students and teachers bring to the teaching/learning of a given topic;
- the content that is to be taught/learned;
- the ways in which the intentions (aims) of a teaching program, approaches to teaching, and assessment are coherent or not coherent; and
- time.

By 'time' I mean that what is understood at one point of time may well not be as valid an interpretation of a situation/phenomenon at a later time. This is not at all specific to science-related classroom contexts. For example, conclusions from research on the ways Australian school students undertook homework in 1955 (pre television) clearly could not be translated unchanged into the totally different broad social situation of 1995. (See also Example B below, in which 'time' is a contextual variable of central significance via a form of feedback mechanism).

There is an extensive literature concerned with parts of the other three aspects of context argued here to be particularly significant for science-related learning and teaching at undergraduate levels (see dot points above):

- the nature of the science concepts held by students when they begin a program, often termed 'alternative conceptions' or sometimes 'misconceptions' (there are many, many studies and reviews here, although the substantial majority are concerned with school rather than undergraduate student understanding; see for example the chapter by Wandersee et al. in Gabel, 1994);
- the nature of ideas and beliefs about learning and teaching brought by undergraduate students to a program, the learning approaches they use and their perceptions of their experiences, both generally (for example the very widely used dichotomy of 'surface' and 'deep' learning and more subtle ways of understanding these approaches; e.g. Biggs, 1993; Marton and Booth, 1997) and in specific science or engineering contexts (e.g. Bliss and Ogborn, 1977; Prosser, Walker and Millar, 1996; Tobias, 1990); and
- the huge impact of assessment on the 'what' and 'how' of student learning (e.g. Ramsden, 1988).

The nature of the content to be learned is certainly recognised as significant context (for example, mechanics and electricity are both very similar – each involves highly abstract concepts and relatively simple mathematical relationships between these concepts – and very different – in the area of mechanics direct observation of phenomena, etc. is clearly possible while in electricity all observation must be indirect via forms of instrumentation). This content variable on learning is less researched as yet. There is also very little yet known about the ideas and beliefs university teachers bring to the teaching/learning of a given topic. Both logic and our own teaching experiences strongly suggest this to be an important variable, both for ideas and beliefs about teaching/learning/roles appropriate for teachers and learners and for ideas and beliefs about content. It needs investigation.

Two examples of failure to recognise context as a variable of significance

Much educational research, both in the past and still some today, is fundamentally flawed because of a failure to recognise the nature of knowledge claims it is appropriate to seek. I now give two examples. Both are flawed because of the consequences of failing to recognise the impact of context as a variable of significance, a failure derived from the vain search for 'precise universality' in educational research.

Example A

Research on laboratory work in science: In the late 1950s-1960s, in school science education, there was a period of quite massive curriculum development (PSSC Physics, CHEM study, BSCS Biology, Web of Life, Harvard Project physics, many Nuffield science programs, etc., etc.). These all gave greater and more integrated emphasis to laboratory work than had previously been the case. Therefore there was a great surge in interest in laboratory work. This included much increased research interest in the impact of laboratory work on school science, particularly the learning of science.

Commonly this research interest was manifested in the pursuit of an answer to the question 'Does laboratory work help the learning of science?'. The methodology then used was, again commonly, to recruit a large number of school science classes where laboratory work had a central place, and a separate large group of classes where laboratory work was of marginal importance or not even used. The same test(s) of science learning were then given to both groups of classes, the results compared by statistical analyses of the two groups as whole entities, and educational judgements then made on the basis of statistical significance (or otherwise) of differences between the two groups.

There is a superficially appealing logic to this methodology, particularly for those of us whose original 'discipline home' is science related. But consider, for example, the two following questions:

- how do we decide what 'learning science' is, and how do we measure this? (How do we decide what is to be the form and the detail of the test(s) of learning? If, for example, we decide to include on the test(s) a probe of ability to use a burette it is clear that those who have used a burette, i.e. have done laboratory work, will do better. However, if we decide to include questions requiring rote recall of definitions then those who have spent more time on this, by spending less time on laboratory work, will do better. The essential problem here is that decisions about what mode(s) of learning science are to be assessed is a *value judgement*, and must be so.)
- how do we determine whether or not all the classes in one group are sufficiently similar as to allow one to say they are common in terms of laboratory work or no laboratory work? (Laboratory work is used in a very wide range of ways – the variation within the group of laboratory work classes in such studies was often greater than the variation between the mean form of practice in each group. We also know that the class teacher is the strongest determinant of the 'what' and 'how' of any classroom, yet this methodology assumes the teacher is not a variable of significance. There was even reason in some cases to ask how we decide what laboratory work is, which group a particular class belongs to? For example, if a teacher takes an experiment and has the class work through this, step by step all together, under her/his direction, then would we call this laboratory work?)

The point I am trying to make is I imagine clear. This methodology does not permit a valid answer to the question to be obtained. The initial question, 'Does laboratory work help the learning of science?', seeks to establish a knowledge claim that cannot be made. Issues that are context for this initiating question are causal determining variables for the question, even though the 1960s investigations of this question did not recognise this. (It is significant that this methodology in educational research, which might well be pejoratively described as 'Brand A versus Brand B', is directly taken from agricultural research such as comparisons of crop yields with and without a given fertiliser. In that context neither the criterion measure nor the determination of the groups A and B were at all problematic. This taking from agriculture includes the direct use of statistics used to generate considerations of levels of statistical significance of any differences.)

It is true that, given adequate responses to the difficulties of what to include on criterion tests and how to form valid and cohesive groups, this research would have some purpose for education systems such as DETYA or State Education Departments in terms of allowing them to consider if the money being spent on laboratories was worthwhile. However even for this 'non-classroom' use of the research a much better approach would be to ask a different question – 'what sorts of learning result from particular uses of laboratory work?' – and to then consider the data in terms of what learning was to be valued by the system. For understanding of classrooms, teaching and learning there is nothing of value to be found here. (For an account by one research group of the ways changes came in research on learning science from the days of 'Brand A versus Brand B' to the mid 1980s, and why, see Gunstone et al., 1988.)

Example B

Selection into university: This is a conjectural example, perhaps even a somewhat puerile one. There is much thought and energy devoted to selection into first year university courses. People are concerned about the quality of that selection, where quality is usually taken to have a very specific meaning – selection will be seen as of higher quality if performance at first year (or in terms of degree completion) is better. Frequently the adequacy of selection is considered in terms of the correlation between year 12 (selection) performance and performance at first year (or over the undergraduate experience). Real problems arise when one goes to what seems the logical next step – to see the goal of the selection process as having the correlation as near to one as possible. Imagine that this was achieved in year X at your institution, that the relationship between year 12 performance and first year performance was a precise linear one, as shown in Figure 1 (with the indication of year 12 performance as the independent variable being deliberate).

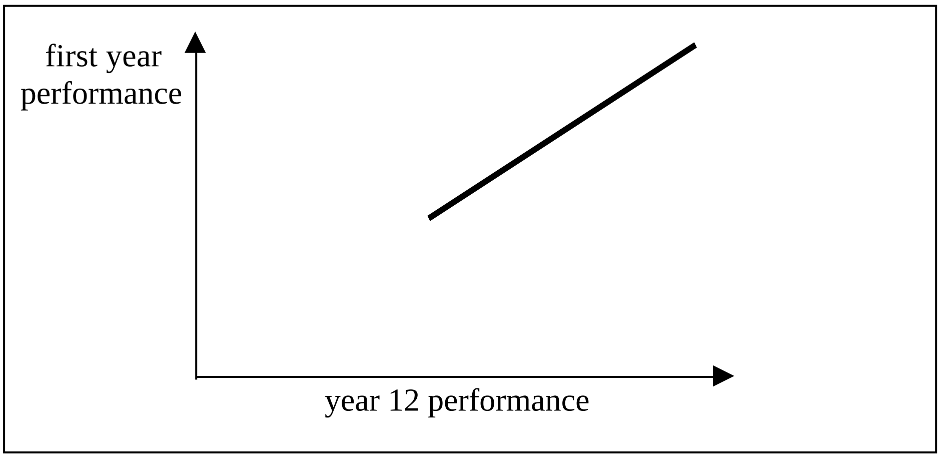

Figure 1. Relationship between year 12 and first year performance desired by many selection processes

And now consider what happens in year X+1, when the next batch of first year students know about the correlation of 1 in year X. Obviously this knowledge will have considerable impact on the ways a proportion of first year undergraduates approach their studies. Some will decide that their performance at year 12 has some predetermining effect on their first year performance and will not approach first year as they would have in other circumstances. Thus the correlation of 1 will evaporate. If it was ever possible to achieve such a correlation, the existence of this relationship in year X would become such a powerful feedback loop into year X+1 that the relationship would no longer exist.

A brief summary of these comments on educational research

Research in education should not attempt to establish causal knowledge claims that are validly independent of place and time – because it cannot do this. Issues that are rightly irrelevant context, 'noise', in scientific research are often relevant causal variables in educational research. And this is even more central in that subset of educational research that is concerned with classrooms/teaching/learning.

Two important consequences of this for those to whom this paper is addressed – academics seeking to turn teaching development into valid research in/of their own classrooms – are the nature of generalisability of knowledge claims and the nature of the questions it is appropriate to seek to generalise about. These are of course significant issues for any teacher at any level of education who seeks to understand aspects of their own classrooms by conducting valid research in these classrooms. There is a substantial recent history of this, widely and appropriately, described as 'teacher as researcher'.

At the heart of the notion of 'teacher as researcher' is an understanding of the nature of research on classrooms/learning/teaching that academic researchers such as me conduct. Academic researchers do (usually) have broader understandings of relevant existing research than a teacher researcher will have (because research is part of the 'core business' of the academic researcher in ways that are rarely the case for teacher researchers). However the academic researcher's understanding of the detailed context of classrooms they are investigating will be much less than the understanding of context held by a teacher researcher. In essence, the knowledge of the academic will be broader than that of the teacher researcher, but will suffer by not being as contextually rich.

Clearly the knowledge of the academic researcher and the teacher researcher are complementary in important ways. It is recognition of this complementarity that has led to the acceptance of teacher research as a legitimate genre of inquiry. And it is the same matter of the need to understand the detail of relevant context in classrooms that has resulted in some science education academics concerned with understanding school science classrooms/learning/teaching returning to school classrooms to explore the validity of their research findings (e.g. Loughran and Northfield, 1996; Northfield and Gunstone, 1985).

I now briefly consider this genre of research, its relevance to teacher researchers working in academic contexts, and address in that context the issues of the nature of questions it is appropriate to ask and the generalisability of knowledge claims that arise.

Teacher as researcher

The notion of 'teacher as researcher' has a substantial history and presence in Australia, including in Australian science education. (Two recent issues of the Australasian origin international science education research journal Research in Science Education have been exclusively devoted to teacher research, one in 1999 – Volume 29, Issue 1 – and one in 2000 – Volume 30, Issue 2. The latter issue was exclusively Australian research.) Teacher research became prominent here shortly after the English education academic Stenhouse (1975) first advanced it.

The descriptor 'teacher as researcher' denotes explorations by teachers of *their* concerns in the context of their own classrooms, and reflections by teachers on the value to them, as *teachers*, of systematic study of their own contexts. It is not intended to embrace teachers undertaking research degrees in education (where research concerns and approaches are often moderated or changed by the expectations and requirements of research being undertaken for certification).

The essence of what is accepted as 'teacher as researcher' inquiry is the combination of:

- the comment just made – 'explorations by teachers of *their* concerns in the context of their own classrooms, and reflections by teachers on the value to them, as *teachers*, of systematic study of their own contexts'; and
- the comment about research in general made at the start of this paper – 'all research involves systematic inquiry, critical investigation'.

That is, while the motivations for teacher researcher investigations are frequently quite different from the motivations of an academic researcher, the same demands exist on teacher research as on any other genre. There is fundamental need for data to be valid representations of the situation/phenomenon under investigation, and for the interpretations of the data to be independent of the interpreter.

The nature of research questions; the nature of generalisability

The nature of research questions I argue it is appropriate for teacher researchers to ask is clear from the immediately preceding comments. It *is* appropriate to ask questions that are quite contextually specific, to seek knowledge claims that are quite contextually specific. Other papers given at this workshop are good illustrations of this.

If one is seeking knowledge claims that are at the very least in part contextually specific then the notion of generalisability needs to be seen somewhat differently than in science research. There are two issues here.

The first is how to approach the issue of generalisability in the reporting of a study. This requires being clear and explicit about relevant context in this reporting so as to lead to two approaches: (a) you can also be clear and explicit about the extent to which the study is claimed to be representative of other situations, and (b) readers of the research report will be able to determine what of the research can validly be generalised to the reader's context.

There is also a wider issue of generalisability in educational research. There are some knowledge claims about classrooms/teaching/learning that I argue are independent of time and place and other aspects of context. These include assertions such as:

- students come to the study of science and technology with ideas and beliefs already formed;
- these ideas and beliefs can impede understanding;
- rote learning will be more prevalent in content areas with a higher proportion of unfamiliar words; and
- students' perceptions of the nature and demands of assessment are a strong determinant of what students learn and how they learn this.

None of these assertions is derived from a single study. Rather each is derived from a considerable number of studies, each of which has been motivated by questions that have been quite contextually specific. The generalisations listed above are, clearly, syntheses across studies.

Where to start and what to do?

The experiences we have had over 20+ years with 'teacher as researcher' in school contexts make clear one fundamental issue – support is crucial for the teacher researcher. This support can be from informed colleagues and/or academic education researchers, and is generally best if both forms of support are involved. In the absence of this support, it is extraordinarily difficult for the teacher researcher to maintain the level of systematic and critical inquiry that is necessary in any form of research. This is because two fundamental aspects of systematic inquiry are not part of the expectations of teachers – knowledge of relevant educational literature and knowledge of educational research methodologies.

Both of these also apply to tertiary teachers of course, and in some contexts are even more problematic. These are contexts where the potential teacher researcher has senior colleagues exerting pressure to not 'waste time' on investigations that are not 'real research'. (There are other aspects of difference in the tertiary context, by comparison with school contexts, that also impact on teacher researchers. These include the common extraordinary difficulty of knowing what experiences one's students are having outside the class in which one teaches them, even other subjects.)

By way of illustration of the need for collegial support for the tertiary teacher researcher, consider the following view from Ramsden (2000) of researching learning in a tertiary classroom.

	Know literature	Improve teaching	Improve own students' learning	Improve learning generally
Collect, read literature	A	B		
Investigate own teaching			C	
Relate discipline knowledge to T&L literature			D	
Communicate results				E

The labelled cells imply a logical sequence, beginning with concern for one's own teaching and leading to the publication of research. At each of the five points A-E support is very likely needed. For A, systematic knowledge of the literature will be clearly valuable (including, but not only, for the articulation of underpinning theory); for B, discussion of the implications of the literature crucial; for C, a colleague to be involved in data collection is often necessary; for D, the same needs as for A; and for E, as for any research report, reaction from an informed colleague will always lead to greater clarity and validity in arguments.

For a small number of tertiary teacher researchers it will be appropriate to seek this support through the formal approach of undertaking a higher degree with this focus (often in education, and with the involvement of colleague(s) from the discipline you teach). Beyond this, and as for school teacher researchers, the obvious sources of collegial support are colleagues in one's department and education academics. The extent to which these are available to you will be very variable of course. However, in general across Australia, both science education research and mathematics education research are, in international terms, very strong. There is a reasonable chance that in your institution there are academics in these areas who are both good researchers and willing collaborators.

The reporting of teacher research is also important to consider. I imagine each of you will be aware of a subset of your discipline professional body concerned with research on the teaching and learning of that discipline (e.g. AIP, RACI), and of other bodies concerned with undergraduate teaching (e.g. Australasian Society for Computers in Learning in Tertiary Education – ASCILITE). There are important possibilities beyond this. There are in this country strong and engaging professional bodies concerned with science education and mathematics education research. These are the Australasian Science Education Research Association – ASERA (http://www.fed.qut.edu.au/projects/asera/) and the Mathematics Education Research Group of Australasia – MERGA (http://www.merga.net.au/). Each runs an annual conference and publishes a journal of international standing. Details are on the Web sites. One of the substantial benefits of engaging with one of these bodies is the generation of a new set of networks to provide collegial support.

The question of 'what to do', in terms of issues to research, is one that will be strongly influenced by the issues of immediate concern to each of us. However there are a number of issues that seem to me to be crying out for investigation by tertiary teacher researchers.

- The notion of independence in undergraduate learning is little understood. There is a substantial literature on metacognition and its development that has yet to find a substantive place in tertiary teaching.
- While we all know the powerful impact on our students of assessment, there is as yet far too little known about the ways in which students perceive assessment tasks, and the ways they relate (or do not relate) these to course aims and teaching approaches, and the ways different discipline areas may have validly different assessment approaches.
- While the surface/deep learning dichotomy has been a powerful tool in focussing thought about learning and teaching, there is emerging evidence that the reality is more complex, and that this more complex reality can be in part discipline specific.
- And that which interests me most, and is clearly the most problematic to investigate – the ways in which <u>teachers'</u> views of learning, teaching, and assessment impact on curriculum and student learning in undergraduate contexts.

References

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

Biggs, J. (1993) What do inventories of students' learning processes really measure? A theoretical review and clarification. *British Journal of Educational Psychology*, **63**, 3-19.

Bliss, J. and Ogborn, J. (1977) *Students' reaction to undergraduate science*. London: Heinemann Educational Books.

Gabel, D. L. (ed.) (1994) *Handbook of research on science teaching and learning*. New York: Macmillan.

Gunstone, R. F., White, R. T. and 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.

Loughran, J. and Northfield, J. (1996) *Opening the classroom door: Teacher, researcher, learner*. London: Falmer.
Marton, F. and Booth, S. (1997) *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum.
Northfield, J. and Gunstone, R. (1985) Understanding learning at the classroom level. *Research in Science Education*, **15**, 18-27.
Prosser, M., Walker, P. and Millar, R. (1996) Differences in students' perceptions of learning physics. *Physics Education*, **31**(1), 43-48.
Ramsden, P. (1988) Studying learning: Improving teaching, in *Improving learning: new perspectives*, ed. P. Ramsden, 13-31. London: Kogan Page.
Ramsden, P. (2000, December) *Learning and assessment*. Presentation to the National Teaching Forum, Canberra. (Available at http://www.autc.gov.au/forum/papers.htm).
Stenhouse, L. (1975) *An introduction to curriculum research and development*. London: Heinemann.
Tobias, S. (1990) *They're not dumb, they're different: Stalking the second tier*. Tucson, AZ: Research Corporation.