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The Higher Education Academy STEM

Getting Started in Pedagogic Research within the STEM Disciplines

Edited by Michael Grove and Tina Overton

With contributions from: George Brown, Lou Comerford Boyes, Sarah Edmunds, Ross Galloway, Duncan Lawson, and Joe Kyle

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About this Document

In September 2011 the National HE STEM Programme commenced a series of activities aimed at supporting project leads with the evaluation of their educational enhancement activities. During the workshops and events that were offered it became clear there was great interest and enthusiasm amongst those within the UK higher education science, technology, engineering and mathematics (STEM) sector for these activities to be extended to provide support for those looking to undertake pedagogic research. In the 2012/13 academic year, the initial workshop series developed by the National HE STEM Programme was continued with support from the Higher Education Academy. This guide has been produced following the workshops and events that have been offered to date and complements the national network (@STEMPedR) that has been established.

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Introduction

Welcome to this guide that has been developed for those looking to begin pedagogic research within the science, technology, engineering and mathematics (STEM) disciplines. Its purpose is to provide an accessible introduction to pedagogic research along with a practical guide containing hints and tips on how to get started.

We have produced this guide following a series of national workshops and conferences that were started in 2011 by the National HE STEM Programme and continued in 2012 with the support of the Higher Education Academy. These events were aimed at supporting those looking to extend their educational enhancement activities by undertaking pedagogic research. We have distilled material from the presentations and interactive sessions at these events and have brought these together through contributions by those experienced in undertaking pedagogic research within higher education.

As with all forms of disciplinary research, the starting point for pedagogic research is defining your research question and this is discussed within Section 4. To answer their research question, a researcher will need to utilise a range of methods and tools. While those from the STEM disciplines will be familiar with quantitative approaches, qualitative methodologies will perhaps be less familiar. Quantitative research (Section 5) uses numbers and statistical methods to explore phenomena and test causal links and hypotheses, whereas qualitative research (Section 6) captures words and their meanings as data and provides descriptions of situations including the 'why' and 'how' of human behaviour. Within pedagogical research it is this emphasis upon understanding human behaviour that is particularly important.

Demonstrating the impact of an educational intervention requires the collection of baseline data against which changes can be measured; diagnostic tests are an important mechanism for doing this and are discussed within Section 7. Equally, ensuring the data that is captured is valid and reliable is vital if the research is to be credible (Section 8). Pedagogic research involves working with individuals and as such it is important that it is undertaken in an ethical manner (Section 9) that protects participants from harm, and the research from anything that might question its merit and worth.

A barrier often cited by individuals for not undertaking pedagogic research is a failure to secure funding. While funding is not essential, even a modest level of financial resource can greatly enhance pedagogic research activity. Strategies and approaches for securing funding are therefore discussed within Section 10, and this Section will also be relevant for anyone seeking funding for educational enhancement activities. In a similar manner, working as part of a community (Section 11) can also enhance pedagogical research and provide a supportive environment for individuals who may feel isolated within their own academic departments.

It is important to share the learning and findings from pedagogic research and not just when it has concluded. Dissemination is therefore vital throughout a research project, and disseminating effectively involves thinking carefully about your audiences and the messages you wish to convey (Section 11). Finally Section 12 concludes this guide by discussing how results and findings from pedagogic research might be shared through publication in a range of educational journals (Appendix 1).

Section 3 discusses what we mean by pedagogic research and scholarship and their role within higher education. Perhaps the most common reason cited by those within higher education for not undertaking pedagogic research is that it is not valued within their institutions. Pedagogic research is important for understanding more about effective approaches to aiding student learning, and with recent changes to higher education funding within England, there is a greater emphasis than ever before upon teaching and learning.

While reading this guide, Appendix 2 contains a template for you to develop your own action plan for undertaking pedagogic research. The higher education landscape and its culture is changing; now is the ideal time to begin your pedagogic research journey. Good luck!

Michael Grove & Tina Overton
December 2013

About the Authors

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Section 3: Pedagogic Research and Scholarship within the STEM Disciplines

Duncan Lawson, Newman University

What is pedagogy?

Dictionary definitions of pedagogy include "*the art, science or profession of teaching*"[1] and "*the study of the methods and activities of teaching*"[2]. Pedagogy may be thought of as a subset of education; pedagogy focuses on teaching – who and what is taught and how it is taught – whilst education is a broader term encompassing the institutions in which teaching takes place (such as schools and universities), policies governing how institutions operate and political and social aspects.

What is meant by pedagogic research and scholarship?

It is to be hoped that all who engage in teaching within higher education adopt a scholarly approach to their teaching – that is, as professionals they reflect on and seek to improve their practice. However, scholarship and research in pedagogy go further than this. The classification presented by Ashwin and Trigwell (2004, p122) is helpful in illustrating this (see Table 1).

A scholarly approach to pedagogy does not go beyond the individual who reflects on their own practice for their own information with their conclusions verified by themselves. The outcome is personal knowledge which (hopefully) is then used for the benefit of their students as it should result in improved practice.

Scholarship raises the level of enquiry taking it beyond the individual to a group level; but a group that has a shared context. The outcomes of the scholarship are verified by the group not by the individual who carried it out and results in shared knowledge within the group.

The purpose of pedagogic research is to inform a wider audience – those who are outside the immediate context of the work. Verification comes from those external to the context and the outcomes, in some sense, have widespread implications with the resulting knowledge being public not restricted.

Pedagogic research shares many characteristics with other forms of research. All pedagogic research should have connections with the appropriate literature. Researchers in STEM disciplines would never undertake a piece of research without first thoroughly exploring the relevant published work. However, it is remarkable how often these same researchers, when they turn their attention to pedagogic activity, fail to investigate work that others have previously carried out. As a consequence, much work either repeats what has previously been accomplished elsewhere or, in extremis, pursues avenues which are already known to be unproductive.

It is a sad reflection of what some thought to be pedagogic research that in preparation for the Research Assessment Exercise in 2008 the funding councils found it appropriate to make an explicit statement about what was not pedagogic research before describing what it is:

"Reports of studies providing descriptive and anecdotal accounts of teaching developments and evaluations do not constitute pedagogic research. Pedagogic research is firmly situated in its relevant literature, and high quality pedagogic research makes a substantial contribution to that literature." (HEFCE et al. 2006, paragraph 60).

Pedagogic research and STEM academics

Pedagogic research may be carried out by educational researchers (i.e. people who are educated in the

Level	Purpose	Verified by	Results in
Scholarly (reflective approach to practice)	To inform oneself	Self	Personal knowledge
Scholarship	To inform a group within a shared context	Those within the same group	Local knowledge
Research	To inform a wider audience	Those outside the context	Public knowledge

Table 1: Classification of pedagogic enquiry due to Ashwin and Trigwell (2004, p122) quoted in Morón-García et al. (2009, p4).

1 www.merriam-webster.com/dictionary

2 http://dictionary.cambridge.org/dictionary/british

discipline of education). However, experience shows that practising STEM academics can often be reluctant to accept findings from such researchers, claiming that because they do not come from within their own discipline they do not understand the peculiarities of the discipline. Pedagogic research carried out by practitioners from within the same field tends to be more convincing, not because the work is of any higher quality, but simply because those who might be influenced to change their teaching practice have greater respect for those from within their own discipline.

However, if STEM academics are to engage in pedagogic research then it usually requires them to expand their skill set and to use research methods that are new to them. Pedagogic research uses the methods of social sciences and psychology. You cannot carry out pedagogic research without investigating people. This is very different from the normal experimental activities that STEM academics carry out in the laboratory. Whilst there is still a place for quantitative research methods, those engaging in pedagogic research will often need to use qualitative methods as well. STEM academics may have to learn new skills such as designing questionnaires, conducting interviews and focus groups, analysing transcripts and other textual data. Ethical considerations too are likely to be much more significant than in many (although by no means all) STEM research projects.

There may be a temptation to regard much of this as 'common sense', as something that any intelligent person can do. But this attitude should be resisted. The quality of research will be greatly improved if the researcher invests time in developing these skills before embarking on a piece of research.

Current context

Most STEM academics who engage in pedagogic research do so for the express purpose of improving the learning experience of their students. This may be a different motivation from those from an educational background where the application of the findings of a piece of research may be of less interest than the results themselves. With the recent changes to the funding of education in England resulting in students having to pay considerably higher fees, there is greater emphasis than ever before on learning and teaching. A few institutions may be able to rely on their reputations for research excellence to continue to make them highly attractive to potential students. However, many others are having to examine all aspects of the student experience, with the learning and teaching element particularly prominent. Consequently, high quality pedagogic research which leads to an improved learning experience for students is becoming increasingly valuable.

There is a growing community of staff from all disciplines who are undertaking pedagogic research from a disciplinary perspective. The Higher Education Academy through its Academic Practice teams is building on work previously done by its Subject Centres and additionally supporting doctoral pedagogic research[3]. Internationally too the importance of scholarship in teaching and learning is increasing. The International Society for the Scholarship of Teaching and Learning[4] has a very well-established annual conference that attracts hundreds of delegates from around the world.

Now is a good time to be involved in pedagogic research.

References

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3 See www.heacademy.ac.uk

4 http://www.issotl.org/

Section 4: Writing and Framing Research Questions

Ross Galloway, University of Edinburgh

When embarking on any piece of research, but particularly in pedagogic research, a key element is identifying a suitable research question (or questions).

What is a research question not?

Put simply, a research question is not just a general area of investigation, a vague notion or a topic of general research interest. These are of course the key starting points: without them, no research would ever commence. However, it is important not to immediately engage with the research process without first properly considering your research question. To see why, let us introduce just such a general topic of interest as an example:

"I'd like to know if the new maths activities in my course's small group tutorials are effective."

This is a legitimate line of research enquiry, but it is not yet a research question.

All right then, what is a research question?

First and foremost, it is literally a question, i.e. it should be answerable. The research process should allow you to answer that question. In this way, the research question defines the intent of the research. It also defines the scope of the research.

Immediately we can see why our example is not yet suitable as a research question since in its present form it is not answerable. What does "*effective*" mean in this context? How would we measure that? Are we interested in all students, or only particular demographics? Why are we interested anyway? Would the answer be relevant for anyone else?

First, let us tackle the issue of 'effectiveness' by reformulating our example:

"I'd like to know if the new maths activities in my course's small group tutorials bring the class up to the minimum baseline in algebra needed for next year."

We now have some statement of what we really mean by 'effective'. Of course, the "*minimum baseline*" has to be defined; we can define it as we see fit, but it can be done reasonably objectively. For example, we might identify a set of key algebraic techniques used in the next year's course, and decide that a minimum baseline might be students successfully undertaking 80% of these techniques.

How would we measure that?

In the case of our example, the most effective way of measuring student abilities is probably a diagnostic test of some kind. With luck, something suitable might already exist. If not, you might have to construct a bespoke test. If the latter, this is likely to form a substantial component of the research project.

In other contexts and with different research questions, other techniques may be more appropriate, for example surveys, interviews or focus groups. At this stage there is no need to be excessively prescriptive, or to map out precisely how the research will be done; inevitably there will be some element of uncertainty about methodology. This should come into clarity as the research proceeds. However, it is important to give it some thought: there is no point in engaging with a research project if its research question is going to be fundamentally unanswerable with the research methodologies available to you.

What about defining the scope?

Having established the intent of the research project, we shall now consider its scope. For example, we might wish to investigate if there are any demographic differences to be found:

"Do the new maths activities in my course's small group tutorials bring the class up to the minimum baseline in algebra needed for next year, and are there any differences due to gender or previous school experiences?"

If you are interested in issues such as these, it is crucial to consider them in advance of the commencement of the research. Demographic data which would be easy to obtain at the time can be extremely difficult to determine after the fact. For instance, if you distribute an anonymous questionnaire, it would be trivial to add a 'Gender' tick-box. If you only realised much later that you were interested in this aspect of the responses then it is essentially impossible to recover that data.

It is for reasons such as these that carefully framing research questions is so important in pedagogic research. In many areas of science, it is possible to get away with much looser and more organic research processes, where research questions can be 'back-fit' in order to bring structure to findings, and in general the hard sciences have less of a culture of formal research question framing than may typically be found in, say, the social sciences. However, failure to properly delineate the scope of a project within pedagogic research can be crippling if the necessary data are not

gathered: in many cases, it would be necessary to wait a full academic year for the next opportunity to gather further data, and in some cases (for example tracking a particular cohort) there may be no second chances.

Furthermore, controlling for confounders can be extremely challenging in pedagogic research: people are messy and complicated, and are rarely predictable and consistent experimental subjects. Whereas isolating a single variable is the gold standard in much of experimental science, this can at times be close to impossible in pedagogic research.

Looking again at our example research question, the issue of "*previous school experiences*" is potentially an intractable variable: at best we might hope to treat this in a broad-brush manner, for example dividing students into home and international students. Even then, the school environment can vary widely in different countries, and it might not be sensible to treat all international students as equivalent.

If this was crucial to our research interests then we would have to find a way to deal with it: a survey might be used to characterise student school experiences. However, we may decide that such considerations are peripheral to our central research interests, or that they lie beyond the practical scope of the present research. For instance, there may not be the time or resources to properly investigate them. Accordingly, we might de-scope our research question slightly:

"Do the new maths activities in my course's small group tutorials bring the class up to the minimum baseline in algebra needed for next year, and are there any differences due to gender?"

How do we evaluate the research question?

We now have a draft research question. Before going further, we should evaluate it in the light of certain relevant criteria:

- **Focus**: does the question identify the particular element of the wider research topic in which we are interested?
- **Intent**: does the research question outline what we actually mean to achieve?
- **Scope**: does the research question delineate (at least approximately) realistic boundaries for our research?
- **Decidability**: can the research question be objectively answered?
- **Transferability**: will the answers to this research question be relevant in other contexts?

Of these criteria, the first four are of direct relevance, with the most significant being *Decidability*, as the notion of answerability or measurability is in many respects the defining characteristic of a research question. *Transferability* is an attractive trait: general research findings that are of interest outwith our own institution or discipline can result in a research project of greater impact. However, it will often be the case that the topic to be investigated is intrinsically limited or local in scope.

We can see that our draft research question acceptably satisfies these criteria:

- **Focus**: the research project will study the small group tutorials in a particular course.
- **Intent**: the project will establish if they succeed in establishing baseline algebra competence prior to the subsequent year's course.
- **Scope**: the project will examine the cohort as a whole, and will also look for gender effects.
- **Decidability**: baseline competence can be objectively assessed using a standardised diagnostic test. A threshold for establishing success can be defined using this method.
- **Transferability**: the principal objective is to assess the immediate effectiveness of the local course. However, if the outcome is positive then the course design or implementation may then be of interest for wider adoption.

We now have a usable research question. That is not to say that it is perfect; various further refinements could certainly be envisaged. Furthermore, a research question is a dynamic entity: you can and should anticipate that it will evolve as the research project progresses. This is an entirely natural process: investigations which initially appeared straightforward may turn out to be intractable in practice, or serendipitous new avenues of interest may appear. You should modify your research question as appropriate to the current status of the project: the research question remains the benchmark for evaluating the decidability of your investigation.

Colleagues can be a valuable source of feedback and insight: share and discuss your research questions with them. A fresh pair of eyes will often spot potential pitfalls or alternatively identify possibilities that you had not considered. Furthermore, the act of outlining the project and identifying your goals to someone else will help to clarify the issues in your own mind: talking through a research question will force you to confront all aspects, even those which otherwise might have remained ill-defined.

In summary

A good research question provides the framework for your research project, and keeps it focussed. The research question allows you to keep track of what you

wish to find out, and whether that is actually achievable. The end point of the project should be to provide an objectively decidable answer to your research question.

Useful links

The Writing Centre at George Mason University: http://writingcenter.gmu.edu/?p=307 (accessed 11 November 2013). *A concise summary of the important characteristics of research questions.*

Perneger, T.V. and Hudelson, P.M. (2004) Writing a Research Article: Advice to Beginners. *International journal for Quality in Healthcare. Volume 16 (Issue 3): 191-192*. Available online: http://intqhc.oxfordjournals.org/content/16/3/191.full (accessed 11 November 2013). *A brief discussion of the relationship between research questions and research papers.*

Creswell, J. (2008) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 3rd Edition. Sage Publications Inc. California. Chapter on research questions available online: http://www.sagepub.com/upm-data/22782_Chapter_7.pdf (accessed 11 November 2013).

Section 5: Undertaking Pedagogic Research using Quantitative Methods

George Brown and Sarah Edmunds

Introduction

Quantitative research is familiar territory for most academics in STEM subjects but there are differences between the use of quantitative methods in STEM subjects and in pedagogical research. Both rely on numbers and their significance but pedagogical research involves dealing with human beings in different contexts and cultures so, even in laboratory studies of pedagogy, it is impossible to control all the variables but the experimental ones. For quantitative research in pedagogy, the numbers are often obtained from mapping words on to numbers, counting or measuring the results from experimental studies or surveys, testing these results for their statistical significance and considering whether the statistical significances of the results have any pedagogical significance.

To ensure that the conclusions drawn from quantitative research are fair and probably accurate, one has to ensure the research problem, research methods and statistical analyses are in alignment. For convenience this approach to 'good' quantitative research may be designated the MIDAS[1] approach:

Methods of
Investigation
Design
Analyses based on
Statistics

Methods of Investigation

Box 1 shows the main methods of investigation in pedagogy in STEM subjects. These methods can be used in different forms of research such as research based on specific hypotheses, explorations, pilot studies, and curriculum development or action research.

Box 1: Methods of Investigation

- Questionnaires
- Highly-structured interviews
- Psychometric Tests
  - For example: Personality, cognitive, aptitude, diagnostic
- Assessments
  - For example: A -level and degree results, coursework marks, projects
- Structured observations e.g. checklists, rating scales

The use of a particular form of psychometric test, the diagnostic test, is discussed in more detail in Section 7. Research based on formative and summative assessments including examination results can be very revealing but one needs to bear in mind that data from these sources may be of variable quality. Structured observations are neglected in STEM subjects but they can be a valuable method of assessing practical competence in a laboratory, a computer studio, or engineering workshop. Highly structured interviews and structured questionnaires have very similar formats. They can be useful in telephone interviews but they are less economical than questionnaires in other situations. Most questionnaires and structured interviews contain fixed responses to items that are readily converted into numbers and some also include a few open questions. The mixed bag of structured and open questions are often referred to as 'semi-structured questionnaires'. The response rate to the open ended questions in semi-structured questionnaires is usually very low but the responses can be very revealing.

Questionnaires

Questionnaires are the most widely used method in pedagogical research and probably the most ill-used. Contrary to popular belief, they require careful attention to design and detail. One can put together a questionnaire in an afternoon and use it the following morning. But you would be lucky if such an approach yielded worthwhile publishable results.

Boxes 2 and 3 provide some hints and caveats on questionnaire design, but Burgess (2001), Bryman (2012), and Oppenheim (1992) are also worth consulting.

1 The mnemonic MIDAS was deliberately chosen because of its connotations of transmuting base metal into precious metal.

Box 2: Designing your questionnaire

- State purpose persuasively.
- Assure confidentiality.
- Ask for biographical data.
- Do a pre-pilot/pilot to eliminate ambiguities
  - to check statistical analyses and to estimate completion time.
- Keep the questions simple and user friendly
  - (3 sides of A4 plus a cover).
- Use a good typographical design.
- Use a questionnaire package
  - but make sure your questionnaire fits its parameters.
- Target the right people - at the right time.
- Ask yourself:
  - Do I really need to ask this question?

Box 3: Pitfalls – How to avoid them!

- Don't use leading questions
  - Most engineering students are in favour of coursework. Do you agree?
- Don't use double negatives
  - It is not true that MCQ cannot test problem-solving skills
  - Agree/Disagree
- Don't use loaded words in questions
  - Do you believe in the value of intended learning outcomes in design engineering?
- Don't use double-barrelled questions
  - The Head of Chemistry is a good academic but not a good manager?
- Don't use long-winded questions
  - Do you agree or not agree with the statement that physicists are usually more inclined to favour quantitative methods than qualitative methods of research in pedagogical aspects of physics learning at university?
- Don't use questions which are difficult to answer accurately
  - How many individual students have you seen privately in the past semester?

These hints will help you to design the questionnaire but you also need to think about the design of the survey, (that is how, to whom and when will the questionnaires be distributed) so as to maximise response rates. In-class questionnaires are likely to yield the best response rates provided they are undertaken when most students attend class. If you are doing inter-departmental surveys of students (or colleagues) then persuade colleagues from other departments to do the in-class surveys in their classes. Anonymous electronic (online) questionnaires yield better response rates than e-mailed questionnaires. Try to avoid distributing questionnaires to students near assignment deadlines or examinations. Avoid Fridays if you are using in-class surveys. For colleagues, avoid holiday periods, marking seasons and school half terms. Precise sampling, so as to achieve accurate population estimates, is the ideal of empirical research. But in practice, one has to work with the people one has the opportunity to sample but do report their relevant characteristics in the research paper or article you hope to publish.

Quantitative Observation

Direct observation either *in vivo* or of video recordings is a powerful tool for understanding and measuring what people do in practical situations. The simplest approach is to look and note what the observee is doing. This qualitative approach is a useful preliminary to developing more quantitative methods. It is even more useful if supplemented with informal discussions with the observee(s) around questions such as "*Why do you do it that way?*" and "*What seems to be the hardest part?*"

From this modest beginning one can develop rating schedules, which enable the observer to rate the performance on the key components of the tasks. But beware of attempting to rate more than 7 dimensions in a single observation session. More dimensions can overload the working memory. If you need to rate more than 7 dimensions then you should use video-recordings.

The disadvantages of rating schedules are they are based on the observer's *opinions* of the observees' performance. So one needs to ensure that observers rate consistently. One observer's 5 might be another observer's 3. As an aside, we prefer even numbered scales so the observer is forced to choose above or below the midline of performance and one can collapse the categories for statistical analyses if one only has a small sample.

Checklists of what an observee does are useful for assessment, training and research purposes. Intra-observer and inter-observer reliability are usually higher for checklists than for rating schedules. They are closer than rating schedules to measuring what a person does but the checklist should be designed to follow the accepted sequence of the task. Of

course, there may be a few observees who perform the practical task differently from the sequence of the checklist. But, if several observees do not follow the sequence discard the checklist and start again.

Design of experiments and surveys

Box 4 summarises the main approaches to design in quantitative research.

Box 4: Some Common Designs

1. One-shot sample.
2. Experimental and control groups (Maybe 'control' from previous year).
3. Pre-test – intervention - post-test.
4. Pre-test – nil - post-test.
   Pre-test - intervention – post-test.

Surveys are usually one-shot samples although sometimes the questionnaires contain self assessment questions about past views and present views along the lines of:

"*Looking back to the time before you did this course, how would you rate your competence?*

1 2 3 4 5 6

How do you rate it now?

1 2 3 4 5 6"

But be warned; there are dangers in using self-assessment as a research tool. The experience of an intervention can change the perceptions of participants and lower their self-assessment. For example, students might assess fairly highly their competence at writing computer programmes, but after working with experienced programmers in a workplace their self-assessment might be lower even though their computer programming skills have improved.

The control group vs. experimental group can present ethical difficulties (See Section 8). Some members of ethics committees might argue, fallaciously, that a new (experimental) method of teaching will necessarily be disadvantageous to students. A way to address this apparent dilemma is to recast the research as 'curriculum development' and compare results from a previous year and the year when the newer method was introduced.

Another possibility is to use a counterbalancing technique so that Group 1 are exposed to intervention A, 'tested' and exposed to Intervention B and tested again. The reverse order of exposure is used for Group 2. The results are then analysed using analysis of variance (ANOVA) for differences between Groups 1 and 2 including order effects. You will need to consider whether this design matches your research problem.

A more sophisticated approach to design is point 4 in Box 4. This design enables comparisons of pre-test scores to check if the groups have a similar baseline, a comparison of final results of each group, and the changes within the control and experimental group. A disadvantage of the design is that there should be roughly equal and fairly large numbers of participants (30 or more preferably) in each subgroup otherwise the statistical assumptions are breached and a more complex statistical analysis required (Brown, 2011 and Coolican, 2009).

It would be wrong to leave this brief discussion of design without highlighting that textbooks on design and statistics provide the ideals to be aimed at. In practice, one has to design the best possible approach within the resources of time, space, finance, expertise and samples available. So one has to adopt a 'quasi-experimental approach'. Control as many variables as you can and state the limitations of your approach in any reports or publications. Do not make bold claims that you have identified precise causes but rather indicate you have identified influences, factors and impacts.

Analyses based on statistics

As indicated in the introduction, quantitative methods in pedagogy have one key difference from research on materials: mapping words on to numbers. The words may be expressions of opinions, attitudes, values or judgments. Once mapped, all the power of mathematics and statistics can be used to analyse the data and infer conclusions. Unfortunately it is very easy to become over-enthused about conclusions drawn from numerical analyses so one needs to check that the mapping of the words on to numbers has been robust[2]. This caveat applies to relatively simple matters such as attitudes towards peer assessment and to more telling matters such as the metrics of Research Excellence Frameworks.

Types of statistics

The three major types of statistics are:

- **Visual representations** - such as bar charts, graphs and pie charts.
- **Derived statistics** - such as frequency counts, the measures of central tendency (mean, median and mode) and dispersion (range, inter-quartile range, semi inter-quartile range, variance and standard deviation).

2 **Editorial Comment:** As Editors we note the different views on the numerical analysis of data collected through Likert Scales. While we have our own opinions we make no judgement on the practice here but ask readers ensure they fully consider the different perspectives of this debate.

- **Inferential statistics** - which enable conclusions to be inferred from the analyses of data.

Visual representations and derived statistics provide summaries of data. Reports of medians and inter-quartile range are becoming more popular in research articles but the mean and variance remain the cornerstones of inferential statistics and inferential statistics are themselves *the sine qua non* of well-grounded quantitative research.

Inferential statistics

Put very simply, inferential statistics have three functions. Firstly they estimate levels of probability so that the statistical significance of results can themselves be estimated. Secondly, they analyse similarities and differences between sets of data (see Box 5), and thirdly they measure the probable size of the effects of an intervention such as the influence of a new method of learning.

In standard significance testing a *p*-value (a number between 0 and 1) helps determine the significance of results. Ultimately all hypothesis tests use a *p*-value to provide a measure of the strength of evidence of what the data is telling you about a population. A $p < 0.05$ is conventionally considered significant, a $p < 0.01$ as highly significant, a $p < 0.1$ might be worth exploring further and a $p = 0.0$ is highly suspicious. Some journals now prefer exact levels of probability so the reader can decide what they think is statistically significant.

As well as levels of significance there is the issue of whether one should use one tailed or two tailed tests. Put simply, two tailed tests reveal if there is a significant difference between two or more groups or conditions whereas one-tailed tests supposedly also measure the direction of the difference. There are arguments about if and when to use one tailed tests. Our advice is, use the conventional two tailed tests otherwise you will become entangled in arguments about the role of null hypotheses in experimental research.

Box 5 provides a useful starting point for choosing appropriate statistical tests. Further details of statistical tests can be found in Coolican (2009). It is also advisable to consult an experienced researcher or practically minded statistician before commencing the process of collecting data.

The choice of parametric or non-parametric tests is rather complex. Strictly speaking, non-parametric statistics is used if you cannot assume the samples being studied are drawn from a normal distribution (or a close relation of that distribution). Parametric distributions are used if it can be assumed that the samples are drawn from a normal population. In practice, most researchers

Box 5: Which statistical test?

Are you interested in the *relationships* between 2 or more sets of data?	**Are you interested in examining *differences* between 2 or more sets of data?**
Non-parametric Use chi-squared for counting frequencies.	*Non-parametric* Use chi-squared for counting frequencies.
Non-parametric Spearman's Rank correlation for ordinal data.	*Non-parametric* Use Kruskal Wallis for multiple samples of rank order data and Friedman for a repeated measure of ordinal data. Use Mann-Whitney for comparing two samples and Wilcoxon for paired samples such as measuring changes in the same person.
Parametric Pearson's correlation for interval and ratio data (large samples).	*Parametric* Use Analyses of variance (ANOVA) for multiple samples. Several types including repeated measures (ANCOVAR). Uncorrelated t test based on two samples and correlated t test for repeated measures such as measuring changes in the same person.
Parametric Regression (goodness of fit) Different types – linear and curvilinear. Two variable linear most common. Related to correlation. Multiple linear regression models can be useful for predicting the effects of several variables on a predicted outcome.	*Parametric* Regression can also be used for showing differences between data sets.
Parametric Factor Analysis and Cluster Analysis.	*Parametric* Factor Analysis and Cluster Analysis

use parametric statistics for large samples and non-parametric statistics for small samples. But if you want to be more cautious then use the standard error as the basis of your decision. If the skew is more than twice the standard error or, if that measure is not available, the mean and median are more than half a standard error apart, then change to a non-parametric test or be prepared for some complex statistical manipulation.

Sizes of effects as well as levels of significance are important because levels of significance are determined in part by the size of sample. So one might get a statistical significant result based on a huge sample but its effect might be trivial. So as a rule of thumb, look for the amount of variance explained by the intervention as a measure of its effect. To do this one uses the attenuated Pearson correlation (0 = no effect, 1 = maximum effect), which is usually included in the printout of statistical packages. The customary guide is:

r= 0.10 (**small effect**: only 1% of variance explained).

r= 0.30 (**medium effect**: 9% of variance explained).

r= 0.50 (**large effect**: 25% of the variance explained).

Box 6 highlights the three statistical questions you must find answers to when designing your research study, not after you have collected the data.

Box 6: Three 'must ask' questions

1. Am I interested in whether the data sets are very similar or very different or both?
2. Should I use parametric or non-parametric statistics?
3. What is the size of the effect?

The Infamous Chi-squared Test

One of the most widely used and misunderstood non-parametric tests is the chi-squared test. It is a rather crude but useful way of measuring relationships and differences. It can be used to measure goodness of fit of a sample with a population but its main use is to test the association (sometimes referred to as contingency) between two or more independent variables. One can collapse the cells in a matrix if there are too few in any one cell. An example is given in Box 7[3].

Box 7: An example of results from a chi-squared test

Overall degree results

	1st	2nd Upper	2nd Lower	3rd	Pass	Fail
Placement	24	68	18	0	0	0
Non-Placement	6	30	25	2	3	7

Chi-square was not possible on the above data because several cells contained fewer than 5 individuals. So the table was collapsed as shown below:

	1st	2nd Upper	2nd Lower and below
Placement	24	68	18
Non-Placement	6	30	37

This table yielded a chi-square of 25.67 at 2df, $p< 0.001$

The results were very highly significant, so it can be concluded that in this sample, students who go on placements do obtain better degrees. But it cannot be concluded that the better degree results were caused by the students' experiences of work placements.

The most common form of chi-squared test is based on a 2x2 matrix such as Males vs. Females and High vs. Low scores. This test is very useful if you have only small samples but one needs to check the expected frequency in each cell is greater than five and apply Yates' correction for continuity. Fortunately, these results are now provided by most statistical packages.

Chi-squared is a popular test but interpretations of its output can be difficult or ambiguous. For example the result in Box 7 can be interpreted as either: there is a significant association between going on work placements and obtaining better degrees; or, there is a significant difference in degree performance between students who go on placement and those who do not.

Before, During or Beyond MIDAS?

MIDAS provides a protocol for doing quantitative research. But one also has to consider whether qualitative research would be a useful adjunct to one's quantitative research. Qualitative research can be a useful preliminary to quantitative research. It can provide pointers and clues of what to investigate. During quantitative research it can be useful for obtaining different perspectives of the same research problem.

3 Reprinted by courtesy of Ahmed (2009).

This 'mixed methods' approach is increasingly in favour in publications in pedagogy, social research and management. After a quantitative study, qualitative approaches can be useful for obtaining extra information from participants who gave unusual responses (known as outliers). Of course whether you use qualitative research as a complement to quantitative research depends partly on your values, the research problem under investigation and whether you are seeking understanding of the participants' abilities and perspectives or seeking to describe and explain them. A quotation often attributed to Albert Einstein is worth reflecting upon:

"Not everything that counts can be counted and not everything that can be counted counts."

Further reading

Brown, G. and Edmunds, S. (2011) *Doing Pedagogical Research in Engineering*, engCETL, Loughborough University. *This book provides a chapter on questionnaire design and on many other subjects concerned with quantitative and qualitative research including ethical considerations, philosophical issues and getting published.*

Bryman, A. (2012) Social Research Methods 4th Edition, Oxford: Oxford University Press. *This book provides a clear approach to questionnaires and interviews and the use of SPSS (Statistical Package for the Social Sciences) to analyse questionnaire data. It is a comprehensive text.*

Coolican, H. (2009) *Research Methods and Statistics in Psychology*. London: Hodder Education 5th Edition. *This substantial text contains a thorough, well-written and scholarly account of most aspects of quantitative and qualitative research methods in psychology. It is highly relevant to most research in STEM pedagogy.*

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Section 6: Undertaking Pedagogic Research using Qualitative Methods

Sarah Edmunds and George Brown

Introduction

A key difference between doing pedagogical research and other types of research in STEM subjects is that the objects of study are typically people (for example students, teachers, or practitioners) rather than components that can be taken off the shelf. These research 'participants' come with their own motivations, perceptions, ways of thinking and willingness to engage in research which qualitative research provides a method to explore. Often the method reveals insights and new perspectives into the topics which quantitative methods cannot reach.

Key concepts in qualitative research

Qualitative research is primarily concerned with words and their meanings in different contexts. It differs from quantitative research in that it does not aim to test preconceived hypotheses about relationships between factors or the impact of an intervention but rather seeks to explore a situation or experience in depth without making predictions about the expected outcome. Studies therefore typically begin with an open ended research question such as "*what do final year students feel they have learnt through doing their dissertation?*" or "*what are the experiences of students who drop out of their degree course during their first year of study?*"

Whereas quantitative research aims to study a representative sample from a population in order to make inferences about the wider population, qualitative research seeks to explore the experiences of a small number of individuals in detail. It is not concerned with generalising these findings to the wider population but rather at seeking new insights and deepening understandings.

Researchers who are familiar with quantitative research methods often perceive qualitative approaches as 'woolly' and lacking in scientific rigour. On the other hand qualitative researchers argue that quality is a key criterion of qualitative research. Differences in opinion reflect the different epistemological approaches of the two methodologies: positivist (quantitative) and relativist (qualitative). Put very simply positivists consider that there is a single, unequivocal social reality or truth which is entirely independent of the researcher, and relativists consider there are multiple perspectives of the world that are created and constructed in the research process. Although these two views may appear polarised and, indeed, people with beliefs at the extreme ends of this continuum are unlikely to agree, it is possible to take a more balanced 'realist' view. Realists consider it is possible to assess quantitative and qualitative research against common criteria of quality, particularly criteria of validity and relevance, although the means of assessment may be modified to take account of the distinctive goals of qualitative research (Mays & Pope, 2000). Some methods of checking validity that are used by qualitative researchers are given in Box 1.

Box 1: Qualitative methods of ensuring validity

Transparency: Thorough account of the methods of data collection and analysis so the study or at least its data coding could be replicated.

Triangulation: The search for patterns of convergent views either derived from different sub groups or from different methods of investigation. This is an extension of triangulation as used by quantitative sociologists and civil engineers.

Abduction: More popularly known as 'deviant case analysis' or 'attention to negative cases'. In this approach one identifies inconsistencies, paradoxes or contradictions in the data, seeks to explain them and thereby produce a more comprehensive (truer) account.

Reflexivity: There are two types of reflexivity: personal and epistemological. Personal reflexivity refers to the researchers' awareness of how their background, values and beliefs and relationships with the participants may have influenced the research. Epistemological reflexivity refers to the researcher's awareness of how the research has changed their conceptions of knowledge. Qualitative researchers argue that reports of reflexivity should be included in accounts of research so readers are aware of the perspective of the researchers.

Respondent Validation: This can be useful for improving the reliability of the data collection. In some circumstances, participants can be invited to check summaries of conversations or field notes to reduce misrepresentation or errors in understanding. We suggest 'summaries' since our experience is that full transcripts including the 'ums' and 'ers' are often rejected by the participants even though they are accurate records of the interviews!

Further, qualitative research in higher education pedagogy can be a useful way of increasing empathy with students' experiences of higher education, it has the potential to allow us to see the world through another's eyes and prevent the tendency to develop 'us and them' attitudes.

Qualitative research methods

The two methods which are most commonly used in qualitative pedagogical research are interviews and focus groups. These are described below followed by a brief discussion of the less commonly used, but valuable approach of qualitative observation.

Focus groups and interviews

Central to the process of running focus groups and interviews are the core skills of asking questions, listening and responding. These are familiar but complex behaviours, so it is worth considering how they can be used most effectively within qualitative research.

Asking questions

Questions can be categorised along four dimensions:

- Open-closed.
- Recall-thought.
- Encouraging-threatening.
- Clear-confused.

Open questions allow participants to express their opinions, describe their experiences and reveal knowledge, thus they are a staple component of interviewing/running focus groups. Closed questions (with fixed responses) are normally the province of quantitative research. Judgement about where a question sits on these dimensions is relative to the group being questioned, for example what is a thought question to first year students may be a recall question to third years, and a question which is perceived as threatening by one manager may be perceived as neutral by another. Where a question lies on the clear-confused dimension can be influenced by clarity of speech; some interviewers mumble their question, or ask multiple questions simultaneously leaving the participant unsure which to answer.

These dimensions can be used to check the quality of your questions with a few critical friends. While doing this you may be tempted to work out your intended questions word for word prior to the interview. However a drawback of this approach is that the questions can feel stilted and break the flow of the interview/focus group. It can be better to decide on the content of what you want to ask but allow the precise wording to emerge during the interview itself.

The aim of interviews and focus groups is to allow the participants views to emerge therefore leading questions should be avoided. "*Do you prefer course work to examinations?*" steers the participant to the answer a researcher might want. It is a leading question. Whereas, "*What are your views on coursework and examinations?*" is an open but guiding question.

Listening

Active listening requires attending to and remembering the content and context of what is said. It is generally best to avoid taking notes in interviews (as it can disrupt the flow of conversation) so one of the skills of facilitation is being able to remember the topics that have been covered so that you do not repeat discussions or miss out any areas you intended to cover. The context of what is said includes aspects such as body language, tone of voice and pace of speech. Be aware of your own body language and use it to show your participant that you are listening to what they are saying. For example nodding and eye contact can be used to show interest along with verbal acknowledgements. By showing the participant you are listening you will encourage them to expand on their answers and this approach often provides more depth to the interview. But be warned: you may be surprised to find how tiring it is to actively listen to a discussion lasting one hour or more.

Responding

Turn taking is required in an interview as it is in any conversation. However, in an interview you should aim for the participant to do the majority of the talking so keep your interjections relatively short and avoid the temptation to provide your own opinions or experiences in the topic being discussed. Try to make your responses non-judgemental, as this will encourage more honest responses from participants, tone of voice is important here as well as the content of what is said. Before you do a research interview or focus group, it is useful to do an audio-recording with a friend or colleagues and listen to how you ask questions and respond to answers.

When making responses bear in mind that what you attend to in a conversation depends on your own prior experiences. For example two people listening to the same conversation may focus on different cues. Be aware of how your responses direct the conversation along a particular route and keep your interview schedule in mind when deciding how to respond.

In summary, an important principle to keep in mind when collecting data using focus groups or interviews is: '**ask open questions and listen actively**'.

Running a focus group or interview

Once the core skills have been mastered within a research context the next step is to devise an interview

schedule which will be used to guide the discussion. Typically this will include an open question about each broad area which you wish the participants to discuss, and follow up prompting and probing questions which can be used if necessary to encourage participants to explore topics in more detail. A semi-structured interview style is recommended for most pedagogical research. This means that you have a list of topics that you want to cover during the session but the order in which you discuss them is flexible in order to allow the discussion to move naturally from topic to topic. However, as a general rule of thumb begin the session with open questions that the participant(s) are able to answer easily, then move on to more challenging questions once you have established a sense of trust. A list of example prompts and probes is given in Box 2.

Box 2: Examples of probing questions for use in interviews and focus groups

- Why did you do that?
- Do you still think that?
- Looking back, can you see any connections?
- Can you give me an example of that?
- So what made you change your mind?
- Could you provide more detail on that?
- You say it is an x, what kind of an x was it?
- Tell me a little more…
- So how do you see it now?
- So what seems to have stayed the same?
- So, what's different?
- What's so different now?
- What did you enjoy?
- What was difficult for you?
- Why did you feel that way?

Interviews and focus groups should be conducted in a quiet, private location where there will be no interruptions. They typically last between 30 minutes and an hour. Focus groups have on average about 6-8 participants, less than 4 becomes too few people to create a good discussion and with more than 10 each participant has little 'air time'.

Suggestions for structuring an interview or focus group are as follows:

- Be clear about the purposes of the session and ensure that the participants are also clear about its purpose.
- Conduct the session in a private, neutral and preferably quiet location.
- Put participants at ease at the start of the session; introduce yourself, and in a focus group get the participants to introduce themselves.
- Start with easy/non-threatening questions and move on to more challenging ones.
- Listen carefully and use prompts if necessary to deepen/extend discussion.
- In focus groups encourage participants to discuss the topic between themselves, encourage contributions from quieter members and manage more dominant characters.
- End with a summary of what has been discussed and allow time for any questions.
- Thank the participants.
- Avoid presenting your own opinion, teaching, counselling or moving between topic areas too quickly.

It is generally better to record the session rather take detailed notes during it. Note taking can be distracting and even threatening for participants. Use a digital recording device and test it in advance. It can be a good idea to use two recording devices simultaneously, if available, in case of technical problems. Write up your reflections and thoughts on the session immediately after it, these can be referred to during the analysis phase.

Participants

There is no equivalent to sample size calculations in qualitative research, the number of participants required will depend on the research question asked, the type of analysis that you intend to do and the time you have available. Data saturation, meaning that you have reached a point where you are finding no additional information from new samples, is often considered the best test of having reached a suitable sample size (Kvale, 1996).

Sampling will again depend on your research question. Purposive sampling is more common than random sampling in qualitative research. This means identifying the characteristics of who you want to interview and then identifying someone who meets those criteria. When recruiting for focus groups consider whether you want the groups to be homogenous, heterogenous or representative and select participants accordingly. It is generally better to avoid running focus groups with established groups.

Analysis

Analysis is the most time consuming part of qualitative research. There are a number of different methods of analysis, based on differing theoretical perspectives,

for example discourse analysis, conversation analysis, grounded theory, narrative analysis, interpretative phenomenological analysis, framework analysis, or content analysis. There is not space here to discuss each of these approaches and the various theories, of qualitative research. For these you are referred to Silverman (2013). Instead we focus here on a general method which underpins most qualitative analysis regardless of theoretical perspective: thematic analysis.

The starting point for thematic analysis is to read through a transcript of the interview, and also listen to the recording several times to familiarise yourself with the content. Listening is recommended as it provides additional information through tone of voice and pace of speech which is lost from the transcript, it is particularly helpful if you are analysing data which you did not personally collect. Note that transcribing a one hour interview can take 5-6 hours, so build time into your research plan for this. An alternative is to use a professional transcription agency, these will provide full transcripts of electronic recordings, usually within a few days, if you intend to use this approach then add the costs into your project budget.

Once you are familiar with the data, go through the transcript and note the micro themes which occur in the responses (first order coding). The next step is to group these micro themes in to sub-themes (second order coding) and then into main themes (third order coding). The themes that emerge from this process will not necessarily be the themes which you expected to come up when you developed the interview schedule. The unexpected can and does occur. Before doing the analysis consider your own opinions and biases regarding the subject being discussed and as much as you can avoid these from influencing your interpretation of the data.

Once you have coded your data it is good practice to have another person read through the transcripts and your analysis to see if they agree with your categories. A follow up discussion about the themes and categories where you disagree often leads to more insightful coding. The process helps to ensure transparency in the data analysis process, i.e. the person who reads your coding should be able to see the process by which each theme was arrived at.

It is possible to conduct a thematic analysis by hand, or alternatively you could use one of the computer programmes that are available to assist with qualitative analysis. NVivo is one of the most widely used of these programmes although a free alternative is available[1]. Such programmes can be helpful in terms of organisation of data, especially where you have a large number of interviews/focus groups to analyse.

1 http://www.pressure.to/qda

However, they cannot assist with the most crucial aspect of qualitative analysis which is the *interpretation* of what was said. Rabiee (2008) provides practical advice on analysing data from focus groups using a thematic approach and includes illustrative examples.

Writing up thematic analysis

There are a number of options at this stage (these are not mutually exclusive):

- List the main themes, and write a short explanation of each using quotations from the transcripts to illustrate the points you make. This explanation might include examples of contrasting opinions/experiences.
- List the themes and the number of times each theme is mentioned in the transcripts.
- Produce a diagram or table which shows the themes and subthemes. Diagrams sometimes include arrows showing the interactions between themes.

Qualitative observation

Qualitative observation is a way of exploring what people do. Applications in pedagogical research include: studying interactions in seminar groups; and students' performance in laboratory work. For example one could observe students' practical skills and compare the findings with the grades of their written laboratory reports (you may find the two are not highly correlated). Further uses are: analysing tasks; mapping routines; and matching claims to behaviour.

In qualitative observation the categories being observed emerge from the data and are reported and analysed linguistically rather than being predetermined and analysed statistically. The latter approach would be used in quantitative observation, where checklists, rating schedules etc. are typically used. Qualitative observations may be free flowing or semi-structured and may include the immediate thoughts, questions and feelings of the observer as well as what he or she observes. The categories in qualitative observation are loosely determined by the open or guided questions in the mind of the observer, his or her knowledge, what her or she observes and what the participants do and say.

Observation can be carried out covertly or overtly. Covert observation has ethical implications but it may reveal behaviour that would be modified in the presence of a known observer. Overt observation can be as a participant observer or a known non-participant observer.

Making observations

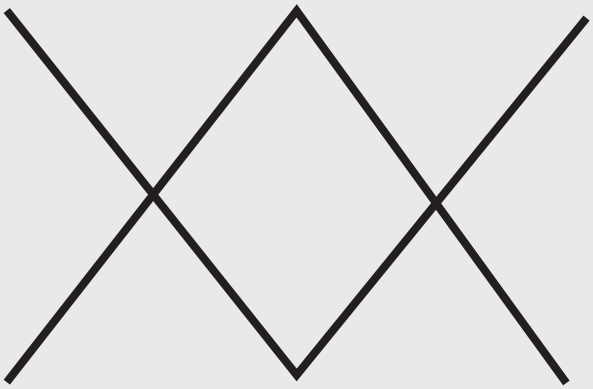
In observation, what you see is a function of:

- Your attitudes, values and beliefs.
- What is salient in your thinking at that moment.

- The purpose of your observation.
- Perhaps, the traditions of your subject.

It follows from this that two people can see the same thing in different ways. Box 3 provides an example to illustrate this point: spend a few seconds looking at the diagram and note down what you see – do this before reading the next paragraph!

Box 3: What do you see?



Mathematicians and some engineers often report seeing a Roman 20. Others report seeing two crosses, a diamond with two half diamonds, a diamond with whiskers, a mirror image of a M or W, two fishes kissing cheek to cheek, or just two sets of parallel lines. As you read these alternatives, you may be able to see them. The implications for qualitative observation is what you see is partly determined by what is in your working memory and salient in your long-term memory.

A study by Simons and Chabris (1999) asked participants to watch a video of people passing a basketball and count the number of passes, the astonishing result was that while performing this task about half the participants failed to notice a person dressed in a gorilla suit walk in and out of the scene thumping their chest![2] This effect is called 'inattentional blindness', focusing so hard on a certain thing that one becomes blind to the unexpected. Clearly, when conducting qualitative observation one wants to remain alert to unexpected and easy to miss details in the scene one is observing.

How many and how often?

The number of observations you do will be dependent on the research problem, feasibility and resources. If you are interested in changes in observable behaviour then obviously a minimum of two observations is required. At least two or three observation sessions are also useful for most observational studies as a sample of one may not be typical. If you are interested in consistency or standards of behaviour (competence) of participants the usual recommendation is 7-9 observation sessions (Norcini and Burch, 2007).

Rigorous qualitative observation can be challenging so we suggest you practise qualitative observation based on video recordings, preferably with a co-researcher and compare your observations. When you feel confident about doing qualitative observation, do at least two observations per sample, if that is possible. In your research report or paper, state the number of observations made, discuss the limitations of the study and be cautious in generalising the results.

Mixed methods

In recent years it has become increasingly popular to combine both quantitative and qualitative research methods within one study, this is known as a mixed methods research design. The different epistemological perspectives of these two approaches can make them challenging to combine. However, for the same reason the findings from these two types of research can mutually inform each other and create a fuller, more rounded understanding of object of study.

There are a number of ways in which the two methods can be combined. Qualitative research as a preliminary to quantitative research can provide more robust questionnaires and interview schedules. Qualitative research after quantitative research can provide greater insight and illumination of the results. Box 4 summarises some further approaches.

Leech and Onwuegbuzie (2009) have provided a conceptual framework for mixed methods research. They categorised mixed method studies along three dimensions: level of mixing; time orientation; and emphasis of approaches. Studies can be fully or partially mixed, an example of fully mixed study would be one which included a research objective of both exploration and prediction. Time orientation refers to whether the two types of research occur simultaneously or sequentially. Emphasis of approaches is about whether one approach is dominant or if each approach is given equal weighting in the analysis and results. Thinking about your research design in terms of these three dimensions may be useful when planning a mixed methods study.

2 You can try the experiment for yourself at www.livescience.com/6727-invisible-gorilla-test-shows-notice.html.

Box 4: Mixed method designs

Generation of hypotheses	Use qualitative research to identify issues and generate hypotheses.
Triangulation	Use quantitative research to cross check qualitative findings and vice versa.
Exploration	Use both methods to explore different facets of the same problem.
Gap fill	One method may not provide all the information required for the purposes of the research project - so use both.
Screening	A quantitative approach can be used to screen a large sample to search for people with the required characteristics for in-depth study.
Problem Identification	Use qualitative approaches to identify the problem and quantitative methods to map the extent of the problem. Alternatively, use quantitative methods to identify the extent of the problem and qualitative methods to explore possible solutions.
Illumination	Use qualitative research to illuminate or illustrate findings from a quantitative survey.
Speculation	Use qualitative research to explore possible explanations or relationships between the variables studied.

Further reading

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Brown, G. and Edmunds, S. (2011) *Doing Pedagogical Research in Engineering*, engCETL, Loughborough University. *This book provides more detailed advice on doing qualitative research in pedagogy as well as sections on quantitative research, ethical considerations, philosophical issues and getting published.*

Bryman, A. (2012) Social Research Methods 4th Edition, Oxford: Oxford University Press. *This book provides a thorough introduction to qualitative research and mixed methods research. It is a comprehensive text.*

Rabiee F. (2004) Focus-group interview and data analysis. *Proceedings of the Nutrition Society* 63(4). *This article provides a useful introduction to thematic qualitative analysis and framework analysis. It includes examples of coding interview transcripts.*

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Section 7: Diagnostic Testing

Ross Galloway, University of Edinburgh

One of the most powerful components in the toolbox of evidence-based education is the diagnostic test. These instruments facilitate quantitative exploration of student understanding, while being useful educational activities in and of themselves.

What is a diagnostic test?

A diagnostic test is quite distinct from the standard assessment tests which form part of any course of instruction (for example class tests or degree examinations). Degree exams typically make use of newly written questions; class tests may re-use questions or be drawn from a standard bank, but typically the questions themselves are instructor-generated with minimal external validation. The consequences of this are that standard course assessments will normally examine different material in different years, are tied closely to the specific curriculum of the particular institution, and can vary (sometimes dramatically) in difficulty. This means that they are ill-suited to making quantitative comparisons between the performance of students in different years, or between different institutions.

In contrast, diagnostic tests are standardised: they consist of a stable and persistent set of questions which are the same for all students. They are designed to be applicable widely across the discipline, so target core concepts and fundamental understanding rather than specific detailed content from any particular course. Because all students take exactly the same test, it is possible to conduct meaningful comparisons of performance, both within and between cohorts.

Also unlike standard course assessments, since a developed diagnostic test is likely to be used multiple times in multiple contexts, it is possible to subject the test items (questions) to greater individual validation and scrutiny than is feasible or desirable for course assessments. This validation process can be fairly involved (see later), but should result in a test instrument which is robust. For example, if hardly any students get a particular question on a degree exam correct then it may be the case that the general level of understanding of that topic is poor in the class. On the other hand, the particular question may simply have been too difficult, or may have been worded in a way which misled or confused the students. In a robust diagnostic test, the validation process should (as much as is possible) have addressed these issues, so that the instructor can be confident that the test results are painting a meaningful picture of the class performance.

In order to facilitate trustworthy comparisons between classes with different instructors, it is necessary to minimise (preferably remove) any variations due to human judgement in marking the test. Since enforcing inter-marker reliability is in general a hard problem, the usual approach is to adopt some objective marking scheme. By far the most common solution is to use multiple choice questions (MCQs), in which case the marking becomes entirely mechanistic and repeatable. This is not to say that all diagnostic tests follow a rigid MCQ formula: some use multiple response, or annotated diagrams or graphs. However, the objectivity level tends to be high: short answer or free-response questions are very seldom seen. It is very common practice for the incorrect MCQ answer options ('distracters') to be carefully chosen to correspond to widespread student misconceptions or common procedural mistakes. In this way, if a student gets a question wrong then, depending on which incorrect option they chose, it is possible to also gain some indication of *why* they got it wrong.

How are diagnostic tests employed?

Diagnostic tests are used to give a quantitative measure of ability or understanding in a class. They can be used in single-deployment mode, where the test is given only once to the class. This allows comparison between students - for example, students can see where their score sits in relation to their peers - and provides early warning to weaker students that further revision may be necessary. It also allows comparison between cohorts: instructors can compare class performance between calendar or programme years, and between institutions. This could allow, for example, a longitudinal study of average ability level on intake over a number of years.

Single deployment of a diagnostic test could be done at the start of a course: this informs the instructor of the baseline ability of the incoming class, and allows the class activity to be tailored more towards areas of weakness, and away from areas where the students are already adequately competent. Alternatively, the deployment could be kept until the end of the course, allowing an evaluation of the effectiveness of the instruction. One obstacle to this approach is that it is then difficult to deconvolve the impact of the course from variations in the baseline ability of the students: if test results increase one year, you do not know if you taught the course more effectively that year, or if the particular cohort were simply more able at the outset.

To address this latter issue, a widely used strategy is the pre- and post-test deployment (Figure 1). In this case, the test is given to the class before teaching (the pre-test). You can inform the students of their scores if you wish, but it is essential not to give them

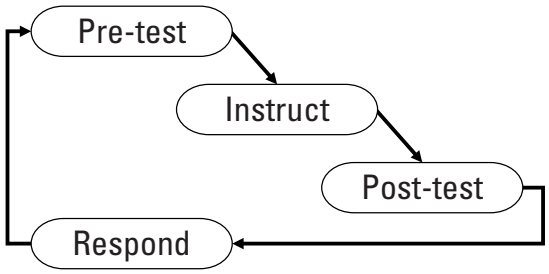

Figure 1: Pre- and post- diagnostic test deployment

the correct answers at this stage. After the period of instruction, the same test is given again (the post-test). Since you now have measurement points both before and after the course, it is possible to determine the change in student ability over the period of instruction.

The results of a diagnostic test give a quantitative measure of student ability: instructors can respond to this information in a variety of ways. For example, you might wish to identify students still performing poorly after standard instruction and provide additional tuition or resources. Alternatively, if some topics are a point of widespread weakness you might wish to modify or enhance the presentation of that material in future years.

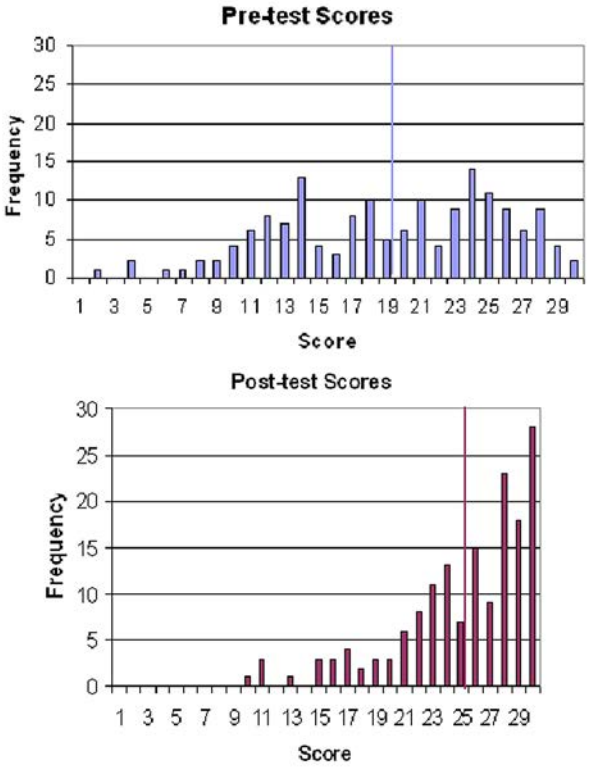

Figure 2: Pre- and post- diagnostic test scores.

Validity and reliability

The power of diagnostic tests lies in their robustness, which is in turn a consequence of rigorous evaluation of their validity and reliability. The **validity** of a test is essentially a measure of whether or not it actually tests what you intend it to. For example, suppose you wanted to evaluate students' understanding of standard deviation, and devised a question based on average numbers of runs scored in cricket matches. If a student could get the question wrong because they did not understand cricket scoring systems then it would be an invalid question. Validity issues such as these can be identified using student focus groups. Similarly, a test might be invalid if it neglects important elements of a topic, or contains ambiguities. Evaluation of a prototype test by subject experts and students can address these sorts of concerns.

The **reliability** of a test is a measure of its reproducibility. Suppose a student was to complete the test, then somehow we were able to erase any memory of the test-taking process and immediately administer it again. If the test is reliable then the student should in principle record an identical score. Obviously this process is inaccessible in practice. However, with a large enough student cohort (and some assumptions about its homogeneity) it is possible to simulate this approach to some degree through statistical means.

Mature diagnostic tests should have been subjected to an evaluation of their validity and reliability and shown to perform adequately.

Published versus 'do it yourself'

There are a great number and variety of published diagnostic tests in the literature, which cover a huge range of disciplines and topics.

Advantages of using a pre-existing test:

- It can be used 'straight off the shelf' with little additional effort.
- The extensive and involved process of rigorous validity and reliability evaluation has already been done.
- It is usually possible to compare your own results directly with other published findings.

Disadvantages:

- There may not exist a test for the topic you wish to examine.
- Existing tests might not evaluate the very specific aspects you are interested in.
- Existing tests might not have appropriate coverage: they may examine material which does not feature in your course.

The last point is an important one: validity and reliability evaluation is done on a test as a complete instrument. It is potentially dangerous and generally inadvisable to 'mix and match' test items, since a partial test might not be valid and reliable (even though the complete instrument is). For this reason,

you generally cannot simply discard test items which are not appropriate for your curriculum.

If a suitable pre-existing test cannot be found, you may wish to construct your own bespoke test.

Advantages of constructing your own test:

- It can be focussed on exactly the concepts or skills you are most interested in.
- It can be tailored to your specific curriculum requirements.

Disadvantages:

- Additional development workload will be added to your research project.
- Validity and reliability evaluation must be addressed.
- It will not be immediately possible to compare your outcomes directly to other published test results.

Developing a 'production quality', fully robust and publishable diagnostic test can be a substantial undertaking, and requires time and access to subject experts and a suitable cohort of students for pilot deployments. Details of the process are beyond the scope of this briefing article; the interested reader is directed to the 'Useful links' section for further information. While a substantial project, the process is informative and rewarding, and the end result will contribute to and enhance the available body of diagnostic tools in the discipline.

On the other hand, it may be the case that the needs of your particular research project are more modest: a fully validated, global-deployment-ready diagnostic test might be impractical or simply unnecessary. So long as you are willing to restrict its use to your own project, and are aware of the caveats, a much more limited development cycle can be acceptable. Even in this case, it is still highly advisable to perform light-touch evaluation of the instrument with experts and some students to weed out serious omissions or ambiguities and boost your confidence in the robustness of the test.

Conclusions

Diagnostic tests are informative to the instructor, allowing a quantitative evaluation of the effectiveness of their teaching and the attainment of their students. They are also beneficial to students, giving them direct feedback on their current understanding and identifying any weaknesses. In allowing direct comparisons across educational levels, institutions and contexts, they can also offer a truly global perspective, with corresponding impact. Perhaps one of the most celebrated examples is Richard Hake's landmark 1998 study of student understanding of Newtonian mechanics in physics, which helped motivate large scale adoption of 'active engagement' methods in tertiary physics teaching. Extensive diagnostic testing has definitively established that such methods are significantly more effective than more traditional instruction. In summary, diagnostic tests are a valuable tool and make a perfect addition to the evidence-led instructor's armoury.

Useful links

Bates, S. & Galloway, R. (2010) Diagnostic Tests for the Physical Sciences: A Brief Review. *New Directions in the Teaching of Physical Sciences* 6, 10-20. Available online: http://www.heacademy.ac.uk/assets/ps/documents/new_directions/new_directions/newdir6_bookmarked.pdf (accessed 11 November 2013). *A review article on diagnostic testing in the physical sciences (but still very relevant for other disciplines) containing a large number of references to further reading.*

Ding L., Chabay R., Sherwood B. & Beichner R. (2006) Evaluating an Electricity and Magnetism Assessment Tool: Brief Electricity and Magnetism Assessment", *Phys. Rev. Spec. Top. Physics Education Research*, 2 (1), 10105. Available online: http://prst-per.aps.org/abstract/PRSTPER/v2/i1/e010105 (accessed 11 November 2013). *A fairly accessible summary of some of the statistical tests and techniques used to evaluate validity and reliability of diagnostic instruments.*

Engelhardt P.V. (2009) An Introduction to Classical Test Theory as Applied to Conceptual Multiple-choice Tests in Getting Started in PER, edited by C. Henderson and K. A. Harper (American Association of Physics Teachers), *Reviews in PER*, 2. Available online: http://www.per-central.org/document/ServeFile.cfm?ID=۶۳07 (accessed 11 November 2013). *A very detailed account of the entire process of developing a diagnostic test.*

Hake R.R. (1998) Interactive-engagement Versus Traditional Methods: A Six-thousand-student Survey of Mechanics Test Data for Introductory Physics Courses. *Am. J. Phys.*, 66 (1), 64-74. Available online: http://web.mit.edu/rsi/www/2005/misc/minipaper/papers/Hake.pdf (accessed 11 November 2013). *Richard Hake's landmark paper on active engagement.*


B2

Section 8: Pedagogical Research and Quality Control: What About Validity?

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Simply put, the technical term 'validity' refers to mechanisms used in research to ensure that the work is trustworthy, robust and credible. We might think of it as being and/or providing quality control. A demonstration of soundness and quality is, after all, an important part of claiming a rational, defensible position when you disseminate and that certainly helps with making sure that others sit up and take good notice of your findings.

Whether your approach is quantitative or qualitative (or both), here we explore what a good researcher should try and do to make their findings worth taking account of, in other words, ensuring it is believable and trustworthy. Pure intentions are a good starting point – the resolve to do a thorough and honest job where the work is well presented and the argument within clearly and logically progressed – but is this enough? However sound your professional instincts for what is happening in the teaching and learning contexts you find yourself in charge of, there are many sceptics out there only too ready to dismiss small scale pedagogic research, particularly where there has been a qualitative approach, as anecdotal. A clear demonstration of validity helps to convince others that you have found out something real and attention worthy.

Establishing pedagogic research of quality is not always easy but there are a number of educational research experts out there who write very accessibly on what can be a complex and technical subject. In my view, Colin Robson's book 'Real World Research' (2002) contains a particularly useful chapter, which, although it goes into considerable detail, is a good introduction for anyone serious about pedagogic research.

Here we consider the mainstay of what ensuring validity amounts to, paying attention to the difference between quantitative and qualitative approaches.

Getting started

Achieving a robust end point means building in demonstrations of legitimate action from the start. Legitimacy means that your procedural plans (i.e. precisely what you are going to do to recruit a sample, capture data and analyse) should transparently demonstrate throughout that all the choices made by you the researcher had the authenticity and worth of the research as the paramount and only concern. To use the terminology of the experimental paradigm, this is not a million miles from saying 'we need to make it a fair test', but it is more than that. Social research usually involves navigating a complex landscape of phenomena some of which are clearly in view and some of which are hidden, and validity is often about recognising where there is potential for the research to become an unfair test, to become tainted, biased and rendered unreliable and invalid by circumstances that could have been controlled for or (to avoid the experimental lexicon) be mitigated against. Precisely what this means and entails will become clearer as we look at specific mechanisms and examples.

Before we look at the technical detail, it is important to recognise that quantitative and qualitative approaches to research are very different and therefore the way we try and ensure validity in each case can (and should) be noticeably dissimilar. In other words, we should be prepared to engage with the quality control mechanisms that are appropriate to the genre and not try and use approaches that are a poor fit just because we think they are in themselves strong displays of robustness. Particularly, qualitative research has methods and approaches all of its own for demonstrating good quality and is not improved by the importation of mathematical techniques from the experimental paradigm, even though some people mistakenly believe that the non-applicability of certain tests to qualitative data 'proves' it is nothing more than anecdotal. Not so. After all, you wouldn't use a set of scales as a demonstration of an umbrella's worth and value. One of the reasons I like Robson's chapter so much is that he provides a way of looking at quantitative/qualitative approaches to validity as a series of approximate equivalences, which really helps with understanding what you are trying to do.

Quality control in quantitative pedagogic research

To make things straightforward, let's suppose that your quantitative pedagogic research is a questionnaire comprised of closed answers or an observational survey of student behaviours. The following are all forms of validity that a good researcher will attempt to demonstrate in such a study:

- **Reliability** - that the data capture tool measures with consistency and is therefore reliable.

- **Construct validity** – the extent to which what you set out to measure has actually been measured (rather than something else being measured).
- **Internal validity** – the extent to which a causal relationship can be demonstrated, including the extent to which the data capture tool permits this.
- **External validity** - this means generalisability, i.e. findings are generally applicable, are representative.

Let us explore each of these in turn in greater detail.

Reliability

A reliable questionnaire or survey inventory will measure with consistency, and you can test how reliable a tool it is by carrying out a test-retest procedure. That is, use it with one pilot group on two separate occasions, and then test for any variances in the two data sets that suggest your instrument is unreliable. That means that in a questionnaire, the questions that are clear, straightforward and easy for your respondent to handle are more likely to yield the same answers on two separate occasions. Questions that are confusing, and/or ambiguous and open to interpretation will not be so reliable – answers from the same person may be wildly different on two separate occasions. Likewise with an observational survey, there needs to be complete clarity as to what behaviours you are looking for, and importantly, what you will actually count as instances of those behaviours.

There are some potential threats to reliability that will be anticipated by a good researcher at the planning stage. They will make sure that these threats are eliminated as far as is possible by the design of the instrument as well as by the type of environment they create for data capture. Threats to reliability are essentially:

- **Participant error**, which means something in the external environment influences how the respondent behaves and makes the engagement perhaps atypical and certainly affected. This could be anything from problems with the venue or a particularly unhelpful time of day to carry out research, just to give just two examples.
- **Participant bias**, which means anything that causes the respondent to try too hard or give what they think is the correct answer or to exhibit a certain 'expected' behaviour. Questions that are leading and contain assumptions are often the cause of participant bias, as is a research environment in which the researcher has an authoritative presence (such as a classroom!) or is in some other way dominant.
- **Observer error** is fluctuation in a researcher's attention or engagement due to external circumstances such as a distracting or non conducive environment or an unexpected event.
- **Observer bias** is a conscious or unconscious interpretation of meaning that is to do with a researcher's own beliefs and experiences rather than what might actually be happening. A remedy for this is 'blind' testing whereby the researcher is not privy to any information that might cause a bias.

Construct validity

Essentially, can you show that the method/tool used has allowed you to measure what you set out to measure? The establishment of construct validity is a case of demonstrating not only that is it intuitively reasonable to assume that what you have by way of an instrument can do the job sufficiently well (face validity), but that can it can be used to make accurate predictions (predictive criterion validity). In addition, a valid instrument will have concurrent validity, that is, the data yielded by your instrument will correlate well with data yielded by pre-existing instruments already proven to be valid. So construct validity is sometimes a case of running the mathematical tests necessary to demonstrate that the instrument is a good predictor and is in line with established measures and a thorough researcher will do these tests. At other times, it is about making sure that you have:

- Thought through constructs sufficiently, in other words have paid enough attention to the ways in which hard-to-measure ideas are operationalised.
- Not made your research vulnerable by running single or limited versions of programmes or interventions when testing grounds would be better – the same also applies to the tests used: is one too limited and narrow when two would give you a more rounded, informed picture?
- Considered the potential impact of any other interventions your participants are subjected to, possibly concurrently.
- Considered whether the data capture, or test, has becomes part of what's impacting on scores or outcome. This is when the measure becomes part of the intervention in an unhelpful way and it is impossible to know whether it is the intervention itself or testing for impacts that is causing the results.

Internal validity

This is a demonstration that the proposed causal relationship between a (in this case) pedagogic intervention and outcomes is validly assumed. If we were working experimentally, we'd be talking about how independent variables and dependent variables can be shown to be interacting. In other words, are the findings a legitimate show of the intervention causing the outcomes, or is there room to argue that the data shows us that something else happening? Ensuring

internal validity is not so much as case of 'checking the maths' as is the case with construct validity, but is more a case of really reflecting on the context and environment of data capture, as well as who you've got in your sample and what else is happening to them:

Threats to internal validity are many:

- **History:** Events in and changes to the participant's environment that are nothing to do with the intervention can be causative of effects that muddy the water. A teacher may be overjoyed that their new reading scheme is making a demonstrable difference to a pupil's reading age, until it is discovered that the parents engaged a private tutor to bolster literacy skills within the same timeframe.
- **Test effect:** New knowledge or change in attitude can be gained via exposure to the test itself, which again muddies the water in terms of what difference the actual intervention is having.
- **Instrumentation:** Alterations or mutations of a measure used in pre- and post-test situations can affect the validity of results.
- **Regression (to the norm):** A subgroup of participants with atypical responses/behaviour whereby this atypicality is important to the research might, for some reasons unknown, perhaps pure chance, produce less unusual scores than anticipated, thus flattening the data.
- **Attrition:** Some degree of participant drop out is normal and should be compensated for by over recruiting, but researchers need to be wary of identifiable and/or selective drop out that may skew results – an overly simplistic way of understanding this is to see how a student satisfaction survey would be rendered invalid if all female students or all third years dropped out.
- **Maturation:** People alter with age, hopefully grow up and become more skilled and competent – in longitudinal studies, it is sometimes hard to see what change and growth is attributable to interventions, and what is natural maturation.
- **Selection bias:** if a sample is selected in such a way that you end up with an faulty sample, this will affect the validity of the data.
- **Ambiguity:** lack of clear demonstration of causal direction - does A cause B or is it the other way round?

Trying to achieve internal validity is about identifying potential threats in advance and attempting to eliminate them, or at worst being honest about their presence. Social scientific research means having to cope with vast complexities and a context for research where you can't control all the variables, it is not about trying to replicate laboratory conditions.

One thing a good researcher will do is to transparently signpost possible threats, reflect on their potential impact and thus allow readers to make their own mind up as to any loss of validity. This is particularly crucial when applying interpretations to data.

External validity

This means the extent to which the findings are generally applicable – generalisability. Generalisation from a proper random sample (i.e. probability sample) to the research population from which the sample was drawn is a straightforward case of statistical inference and there are a variety of treatments depending on the precise design of your study. Generalisations in other contexts, i.e. where there is no proper random or probability sample are not so straightforward. People often use stats to try and demonstrate external validity when they shouldn't, when the practice is not really admissible due to the sampling technique used in the first place. There are other ways of legitimately demonstrating transferability of findings with non-probability samples and these are discussed below.

Threats to external validity included errors or faults inherent in the supposed random sampling or selection of participants, leading to the findings being specific to the group actually recruited….this is why existing lists which contain any kind of order are a poor basis for random sampling. Supposing you alphabetically listed the population of a town according to each Mr followed by the corresponding Mrs, and then 'randomly' sampled by choosing every 10th person – you would end up with a predominance of women!

Other threats to external validity include research design weaknesses where findings are dependant on context. This is why any good research project wanting to understand 'the student experience' would make sure that the study recruited a wide enough variety of institutions to properly represent the rich and exhaustive typology of institutional types out there. Finally, history can affect the generalisability of findings if the data set is contaminated by a specific or unique historical event that limits the extent it can be used as a measure of what's typical.

Quality control in qualitative pedagogic research

Whereas validity in quantitative contexts amounts to reliability, construct validity, internal validity and external validity, in qualitative contexts the same intentions in principle can be summarised as dependability, integrity, credibility and transferability. Robson (2002) summarises the approximate equivalence or the synergy of these as per the following:

Quantitative	Qualitative
Reliability	**Dependability**
Construct validity	**Integrity**
Internal validity	**Credibility**
External validity	**Transferability**

Table 1: Equivalences of validity

Dependability

Analogous to reliability, dependability is necessary for credibility. It is not valid to work with a test-retest mentality with qualitative data but an equivalent sense of whether or not your approach is dependable, in other words reliable and can be achieved using triangulation. Do you get a similar story or similar themes arising from using different data capture methods and/or from different stakeholders? Another way of checking for dependability is to audit the work: check your processes used to see if they are in line with accepted standards of transparency and clarity (and this is where literature searching existing work is vital). Are processes clear, systematic, well-documented and do they provide safeguards against researcher bias?

Integrity

Dealing with the potential for researcher bias or interpretation in qualitative approaches takes some doing – social science cannot escape the fact that it is humans researching humans. Integrity, or the extent to which your research measures what it purports to measure in qualitative contexts, is about considering the some complex phenomena. For example, 'truth value' or the complicated issue of veracity. Regardless of the extent to which you may or may not personally concur with what your participant self reports during an interview, a good researcher makes sure that findings are grounded in what participants have offered, and won't attempt to test for or establish some other external immutable 'truth'. Such an approach would have no integrity. This is particularly the case for experiential or phenomenological approaches, the sole aim of which is to make evident and value the experiences of the individual(s) in question. Overall, researcher neutrality is an important ingredient in establishing that the findings are determined by the participants' responses and contexts rather than the perspectives, biases, motivations, and interests of the enquirer.

Credibility

Credibility is a demonstration of a transparently correct understanding of the relationships at play in the data; in other words accurate identification and description of what is going on in terms of effects and relationships. Prolonged involvement in the research activity, persistent observation, triangulation, peer debriefing and member analysis (checking back for meaning with participants) all help to establish that the conclusions you draw from your data sets are the correct ones, rather than ones contaminated by any unhelpful biases and belief systems of your own that may just creep in unless you are vigilant.

Transferability

Transferability is akin to external validity or generalisability. Whether or not your findings are transferable to groups beyond your sample is not always the aim of qualitative work, but it might be useful to be able to make a credible suggestion that there is benefit in thinking about the whole, or a greater group, on the basis of looking at a sample. It is inappropriate to use inferential statistics with non-random (non-probability) samples, and qualitative work often relies on samples that are other than proper random. Therefore, mathematical treatments and levels of significance can't be used to generalise from the sample to the research population. Instead, demonstrations of potential transferability can be provided, such as when the same results are gained by working with a different yet carefully and well-matched subsequent group and so on. This amounts to making a case by establishing sufficient detail about similarities so that the decision to claim transferability is possible and moreover reasonable. Clearly this is a philosophical argument as to what is intuitively and logically reasonable rather than a mathematical demonstration, but then the very different ethos of qualitative work absolutely permits this.

In summary

Guaranteeing **invalid** pedagogic research is quite easy. The researcher will be a careless, casual and uncommitted enquirer who pays no attention to proper planning, thoughtful reflection or the procedural checks and balances necessary to good research. Their study will not provide any real opportunity for participants to authentically respond so there may be lack of meaningful involvement on their part, and the research may even be heavily contaminated by the researcher's own views - the whole endeavour will have no value or integrity whatsoever! Although the necessity of paying attention to the mechanisms of establishing validity can be time consuming and complex, its worth is when doing so adds great value to your research endeavours.

References

Robson, C. (2002) *Real World Research* 2nd Edition, London: Blackwell.

Section 9: Ethical Considerations in Pedagogic Research

Lou Comerford Boyes, University of Bradford

What are ethics in the context of pedagogic research?

Ethics are the values or principles that guide how research should be conducted so that the work has integrity: careful reference to ethical standards should direct all aspects of your research so that it, and everyone involved in it, are protected from anything that might call into question its merit and worth. Ethical research is therefore *better* research, and ethical sufficiency is as important as methodological robustness.

Whereas all researchers should pay attention to ethical fundamentals such as 'freedom from harm', the specific ethical practices that govern good *social* research will differ in detail from the guidelines that attend laboratory research with insentient subjects such as cells. Pedagogic research falls into the canon of social research because teaching and learning and enquiry into it are social processes, and far from being a neutral medium, social research is a complex business.

This means that planning social research will involve thinking about complex human dynamics and 'what ifs'. One of the interesting (yet also sometimes frustrating!) aspects of ethics is that, whereas there are many questions and much to consider, there aren't always clear cut and definitive answers.

When should ethical considerations emerge?

Careful thought as to what is ethical should arise at all stages of your research endeavours. At the start, ethical considerations should help shape your aims, objectives and overall design. In particular, they should inform as to how you might go about recruiting participants for primary data gathering[1] (and how you will treat these participants once you have them) as well as how you might get access to and use secondary data.[2]

1 Primary data is data you will be collecting for yourself, for example, by interviewing participants.

2 Secondary data is that which already exists which it might be very useful for you to use or refer to.

Being as ethical as possible should also be your aim when it comes to processing raw data and how you share your research findings. It is definitely worth giving the latter some careful thought: on the face of it your findings may appear to be entirely benign, but once you have released your work into the public domain you lose control over how other people might attempt to use your findings, so it is worth taking the time and trouble to think through dissemination very carefully. For example, it can be so tempting to make very firm assertions as to a difference made by an pedagogic intervention, but it is ethically important to make sure that audiences get a proper sense of the scale of your project (sample sizes, recruitment mechanisms used, etc.) so that they do not fall into the trap of taking forward an overly rigid and prescriptive 'cause and effect' message due to lack of information on your part.

Getting started

Many universities have a written policy on ethics, so, as a first step, check what your institution has in place in the way of ethical guidelines. Some institutions insist that all proposed research endeavours need to be checked for ethical compliance and have committees in place to deal with this – the most senior person for research in your department (perhaps the Head of Postgraduate Research and/or the Associate Dean for Research) should be able to signpost you. Although the necessity of getting a formal green light to go ahead with your research might feel off putting, it is an important 'box to tick' as it means your institution will be in a position to support you in the rare case of something going awry during the course of your project.

If you don't work in higher education, then similarly it is important to check out and adhere to the ethical guidelines in place in your sector. For general information as to what is ethical, there are some very useful published guidelines available from the Social Research Association (2003), the British Psychological Association (2009) and the Economic and Social Research Council (2012) .

Getting to grips with the fundamentals

Philosophically speaking, ethical standards can be approached from different positions. A sustained exploration of this is not possible here, but it is nevertheless interesting to note that ethics include reference to:

- What is considered categorically right and wrong: this 'deontological' approach has social norms as its underpinning frame of reference, a practical example being the necessity of keeping participants safe from harm.

- The consequences of actions in specific circumstances: this 'consequential' approach is more concerned with the consequences of actions in specific circumstances, for example, guarantees of confidentiality and anonymity given to research participants must be honoured *unless there are clear and overriding reasons to do otherwise* (British Sociological Association, 2002, paragraph 37).
- Pragmatics, wherein a 'pragmatic' approach to developing ethics suggests that which is considered ethical is subject to change and is dependent upon on the era and society in question.

As interesting as this is, what most people want to know is simply "*What must I do to make sure that I'm doing my research ethically, because I would like to get on with the project!*", and the remainder of this section looks at five fundamental and common requirements. As we shall see, even they can be complex and need careful consideration.

Freedom from harm

This sounds simple but it means freedom from any harm, not just physical danger. Is there any way in which your research might inadvertently cause emotional or intellectual discomfort, social unease or general feelings of disadvantage or actual disadvantage? All ethical researchers will anticipate such eventualities and design an approach to prevent these things from happening. A good researcher will bear in mind that discomfort, offence, confusion and even boredom can count as harm, and will be careful to avoid anything remotely crass or insensitive, or even just disordered and careless in the enquiry that they are designing.

Let us look at an example where the 'freedom from harm' requirement may be something quite subtle. Due to the sway that the experimental paradigm still has in research overall, reliance on the *intervention versus control group* approach feels robust because of the belief that comparing results from two different groups can yield persuasive data. Where the difference between what two groups are exposed to is a naturally occurring phenomenon there isn't an ethical issue as such. However, the minute a practitioner starts to manipulate the experiences of one group compared with another, in particular to purposefully deny one cohort access to an intervention thought to be beneficial for the sake of retaining a control group, then ethical issues associative of 'harm' (i.e. disadvantage) are unfortunately created. It might take more time and creativity to design a study that avoids the pitfall outlined above, but it will be worth it in the long run when you have avoided anything that might attract criticism.

Freedom from harm includes freedom from being judged. Humans typically adopt value positions and within the social dynamic that is social research it may be that participant views are wildly at odds with our own. Regardless of the match between what we believe and what the participant asserts, an ethical researcher should override any physical manifestation of their own feelings and views (such as facial expression, body language, tone of voice, etc.) either way. To exhibit negative feedback is to judge, which potentially inhibits, offends or damages the participant's self esteem (i.e. causes harm), and, conversely, to exhibit agreement is to lead the participant - which makes vulnerable the validity of the research. Better to be entirely neutral throughout, it being perfectly possible to be neutral without being cold.

Before we move on, a quick look at something that many aspirant researchers worry about: supposing you are carrying out some data collection and an interviewee, for example, becomes very upset? Surely it is only human nature to step out of your researcher role and offer advice and counselling? This would not be good practice as hard as it might be to rein in your desire to help (and this is particularly hard if the participant is known to you, as often happens in pedagogic research with your own students and/or you have professional counselling skills). In cases like this, it is advisable to gently but firmly bring the interview to a close, reassuring the participant that this is not a problem. Once you have checked that the participant is generally ok, they will then need to be signposted to the relevant support in as helpful and compassionate way as is possible. Moreover, it is best research practice to have identified in advance where there may be potential sensitivities in the subject matter and to make sure that all participants are aware of the help and support on offer, should they end up needing it, before the data collection starts.

Confidentiality

It is important to specify to your participants exactly what will remain confidential. Whereas it is usual for participant identity to be a confidential matter between researcher and participant (see the section on Anonymity below), the whole point of research is to put findings and knowledge into the public domain, so to say that what passes between the researcher and participant will remain confidential is not realistic or desirable. Raw data, albeit unattributed, may or may not remain confidential depending on the nature of the study (appendices often contain examples of raw data and raw data sets as this is one mechanism for achieving transparency i.e. validity) and participants need to be made aware of what written reports will contain.

Planning for research should include careful consideration as to how to keep participant contact details and raw data secure so that confidentiality is not breached in this way.

One ethical dilemma that needs careful consideration is: can confidentiality be honoured in all circumstances? What if a child discloses, or someone admits to, a

serious crime? However remote the chances are that someone will give you a piece of information that you are morally obliged to act on, a good researcher will know in advance what their responsibilities are and how they must act in the event of certain occurrences. Ethically speaking, it is as well to make sure that your participants are aware that there are some sorts of information that cannot remain a confidential matter – but how you bring this to the attention of the participant will depend on individual research contexts. It is not uncommon to write a general clause about this into the informed consent form you might use with your participants.

Anonymity

All participants in your research project have the right to remain anonymous. Anonymity is not just about leaving names out, it means being vigilant about any potential identifiers particularly if the study is of small size whereby a detail such as job title might reveal the identity of a participant. Direct quotes even when rendered anonymous should only be used with the permission of the speaker – again just in case the quote reveals the identity of the participant in a way that you cannot see.

As with confidentiality, the anonymity of participants should be protected by very careful data storage arrangements.

Informed consent

The important word here is informed – the people taking part in you study cannot give informed consent unless they have been properly briefed as to certain particulars: the point of the research, including who is doing it and for whom; what participation will entail; what will happen to the data they give, and importantly, what will go out into the public domain and in what form. An ethical researcher should be able to answer any questions as to the nature of the research at this stage.

The parents or guardians of young people under the age of 16 need to give informed consent in addition to the young person themselves agreeing to be part of the study. Sometimes schools have a pre-arranged *in loco parentis* arrangement whereby the school can give consent for things like researcher visitors, but this will vary from school to school and needs to be checked out.

Right to withdraw

The basic standard assertion is that participants should be afforded the right to withdraw themselves and any data they have given without suffering any consequences. It is always disappointing for a researcher when a good data set is withdrawn from a study especially if the data supports a hypothesis in a particularly striking way, but it is unethical to try and persuade or coerce people into remaining in the study when they would rather not – whatever their reasons, and their data, however valuable, must not be used.

Withdrawal can also be a complicated business: during the phases of sample recruitment and data collection it may be frustrating to lose someone, but if they wish to withdraw after you have processed and synthesised the data then this is pretty disastrous for the researcher's workload as it means starting the analysis again! One very simple way to avoid this is to make sure that the informed consent you obtain from participants includes a clear understanding on their part that withdrawal after a certain point will not be possible. Sometimes ethics means being as reasonable as it is possible to be but within sensible, pragmatic perimeters: they key is to be clear and transparent with participants so that you are giving them enough information to make informed decisions for themselves.

In pedagogic contexts, the temptation to collect data from your students without really thinking through the implications of their right to withdraw can be quite strong. Students are a usefully captive audience and they won't mind a little questionnaire now and then, surely? However, this attitude has more to do with convenience to the researcher than what's truly ethical. Putting aside the teaching and learning related monitoring and assessment practices that you would normally and habitually do in class, eliciting data sets from your students over and above this requires them to give informed consent and to be free to withdraw without negative consequence, including anxiety, loss of face or embarrassment. Any good practitioner knows the difference between ongoing assessment and research - the latter is often identifiable as a bigger and/or non-routine 'ask' of students. There is nothing wrong with approaching your class as an opportunity sample who might want to take part, but separate your data collection from your classroom, and give them a real choice as to whether or not they take part.

In summary

The above are the mainstay of being ethical in your research – the need to work with respect and transparency and so protect your participants and yourself from harm and mishap, as well as protecting the integrity of your research. Looking at the ethics of both what you are doing and how you intend to go about it sometimes means dealing with uncertainties and complexities and this can, at times, lead us into fairly philosophical and esoteric domains. Having said that, if you reflect carefully enough on what you are doing as a researcher, there is often a pragmatic solution that allows you to mitigate against more complex issues, should you anticipate them arising.

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Section 10: Securing Funding for Pedagogic Research

Michael Grove, University of Birmingham

Introduction

One of the barriers often cited by individuals to undertaking pedagogic research is failure to secure an appropriate source of funding. While a grant can greatly enhance pedagogic research in terms of the depth and breadth of activities it allows to be undertaken (Figure 1), it is by no means essential as a first step for those wishing to develop a pedagogic research profile within the STEM disciplines. STEM individuals often begin their pedagogic research careers at a local level by implementing changes to their teaching practices and seeking to explore the impact of these in an evidence based manner. For many, their first starting point may have been through the evaluation of a project.

The Funding 'Escalator'

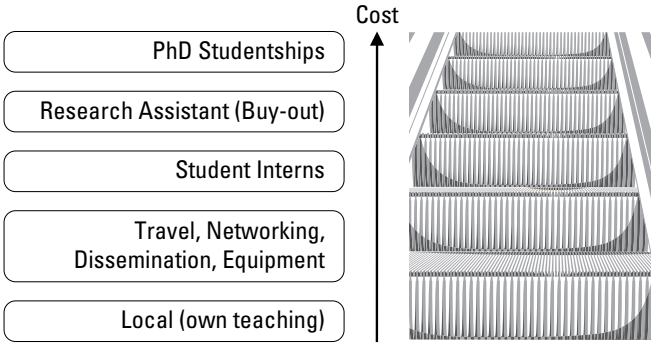

Figure 1: The Funding 'Escalator'

However, obtaining even a modest grant can be advantageous to the quality of the research undertaken and the recognition of the researcher. Successful grant applications enable the purchase of equipment (for example, for recording interviews), travel and networking (to meet with like-minded individuals), and to buy in specialist skills (for example the transcription of interviews). Further, they allow the researcher to develop a portfolio of activity and begin the development of an active pedagogic research profile.

Research vs. evaluation

Research and evaluation share several core features. Both are based around the objective of trying to answer a question related to an activity or intervention and share similar methodologies for data collection and analysis. However, while there are common features, there are also fundamental differences, most notably in their purpose.

An evaluation is undertaken to improve an activity or service and/or make a judgement about whether it should continue to be supported, whereas research is undertaken to develop generalisable new knowledge about a particular phenomenon by addressing clearly defined research questions or hypotheses. Evaluation and research also diverge when it comes to dissemination: for evaluation dissemination is typically to key stakeholders associated with the activity or intervention, whereas for research results are publishable to a wider and sometimes more specialised audience.

What funding sources are available?

Funding for pedagogic research alone, certainly within the UK, is limited, and while the Economic and Social Research Council[1] offer large-scale grants, these are very competitive and often difficult to access for those who are new to pedagogic research. Organisations such as the Higher Education Academy[2] and professional bodies offer grants to support pedagogic research, and while these too can be limited in scale and again highly competitive, the level of available funds do at least provide an opportunity for an individual to begin their pedagogic research journey.

One approach that those new to pedagogic research might consider is whether they can collaborate with others who are more experienced as part of a larger-scale pedagogic research project. Such an approach offers a number of benefits. It enables those who are new to work as part of a larger team and so benefit from advice, support and mentoring, and at the same time allows experienced researchers to potentially increase the size and diversity of the dataset they can collect. To participate in such opportunities it is important that those who are new to pedagogic research begin to network with like-minded individuals at conferences and events (see Section 11).

While funding dedicated to pedagogic research might be limited and highly competitive, the similarity between the methodologies associated with research and evaluation present an opportunity for an individual wishing to make their first steps towards undertaking pedagogic research to do so. Funding for educational enhancement activities is often more widely available, and in addition to the Higher Education Academy and disciplinarily professional bodies mentioned above, other funding sources become possible, particularly within universities where they may be accessed at

1 www.esrc.ac.uk

2 www.heacademy.ac.uk

central (for example education enhancement units or alumni funds), faculty or departmental levels.

Undertaking an educational enhancement project will also require its lead to undertake some form of evaluation and to do so effectively requires a rigorous and evidence informed approach. The opportunity therefore exists for those wishing to develop a profile in pedagogic research to start to do so through such an evaluation, and think about how the findings from this work might be more widely and generally shared (see Section 11) in order to influence and inform STEM sector knowledge and practices. Project leads should think very carefully about requesting sufficient funds to enable a rigorous evaluation to be undertaken for any educational enhancement activity.

Planning for success

There is a perception that ideas for projects and activities (either pedagogic research or educational enhancement) are only formulated and finalised when a funding opportunity is announced. In reality for the most successful projects, their planning and preparation takes place well in advance of any single funding opportunity becoming available. To be successful in securing any form of funding, it is important to plan for success, and to do so early.

Completing a grant or funding application for an educational activity is not easy, even for those who may have been successful in securing funds for their disciplinary research. With the funding becoming increasingly scarce over recent years, funders have an increasing range of high quality project ideas to choose from, and are also asking for information that may not have been previously requested at proposal stage, such as ethical considerations, how any intervention might be sustainable or what its longer-term impact will be. Even with a generous deadline to complete an application, it is essential to start early as there are a number of preparatory activities that are required to demonstrate a project is well thought through.

Building a project team: From a funder perspective there are additional benefits and less risks associated with a project that involves multiple individuals. Multiple contributors mean that should any one project member become unexpectedly unavailable, there is a higher likelihood the project will continue. From an impact and sustainability perspective, the activities will impact a greater number of individuals (and their practices), departments, institutions and learners; the value for money offered is therefore increased. However, building an effective project team with complementary skills and clearly defined roles takes time, and it is necessary to be clear in a grant proposal 'who will do what' and how the activities will be effectively managed or co-ordinated.

Ethical approval: Funding applications for pedagogic research or educational enhancement activity are now typically required to demonstrate ethical implications have been considered at the outset; this, however, is one area of proposals that is often weak. While ethics is discussed in Section 9, many universities require research activities to undergo 'ethical approval', often involving submission to a dedicated committee. If this is required, this can take time and there may not be a mechanism (i.e. a meeting of the committee) in place to seek formal approval before any proposal needs to be submitted. It is therefore well worth checking what mechanisms are required for ethical approval within your institution.

Need for an activity: Any successful funding proposal needs to argue clearly and concisely why any activity or research is necessary and perhaps what the risks associated with not undertaking the activity are. To do this, you may need to compile some evidence or data which can really enhance the case, for example relating to student engagement or satisfaction; such data may be readily available, it may need to be analysed, or it may need to be collected. Either way, obtaining this data and using it to enhance your case takes time and consideration.

Horizon scanning and alignment: Funding calls are often related to a particular theme in order to help focus activities in a manner that helps them meet the priorities of the funder. Any proposal needs to be aligned with an appropriate theme, and it is important to clearly articulate how it meets these priorities. Such priorities might be institutional or national, and it is important to not only find out what they are, but also what the funder is looking to achieve from the work. This may mean that you have to rethink and refocus your proposal to ensure alignment.

Prior work and literature: It has sometimes been said that there are 'no new ideas in education', and while this is clearly an exaggeration, it is the case that many proposals for funding continue to be submitted that detail almost identical activities to those already underway elsewhere. While this should not preclude funding, after all 'But it is not happening here…' is a very valid argument, it is essential to demonstrate that you are not only aware of such prior work, but that you have considered how you might build upon these examples of practice and research. To do this it is worth undertaking a literature review related to each of your ideas; this will allow you to demonstrate knowledge of the field but also allow you to identify unique 'gaps' into which you can position your own activities and research.

Developing the core ideas

Related to any educational enhancement activity there are six key areas that any project proposer needs to

be rigorously clear on, both in terms of the idea itself and their articulation within a funding proposal.

Aims, objective, outcomes and outputs are all essential components of any funding proposal but are quite often confused.

Aims and objectives: Aims should describe the intended changes that will arise from successful completion of an activity and should describe what the activity is hoping to achieve or what will be enhanced as a result. While aims may be quite specific or high level, objectives describe the specific activities that will be undertaken to achieve the intended changes described within the aims (Table 1). There is often more than one objective for each aim.

Aims	Objectives
Expand the range of STEM specific careers resources available to those within the HE sector.	Commission a short guide for university careers advisors demonstrating graduate opportunities in Chemistry.
Disseminate effective practice in relation to student engagement with the STEM Curriculum.	Run event showcasing examples of current practice in how departments of mathematical sciences can enable students to contribute to the development of their curricula.
Develop curricula to enable lifelong learning and CPD by those within the chemical engineering workplace.	Undertake a scoping study involving employers from the chemical sector to identify content for inclusion in an appropriate foundation degree programme.

Table 1: Aims and Objectives

Outcomes and outputs: For any educational enhancement activity both the outcomes and outputs should be defined. The outcomes describe the specific changes that an activity is intending to bring about; they are intrinsically linked to aims (Table 2), and where possible should always be observable.

Aims	Outcomes
Expand the range of STEM specific careers resources available to those within the HE sector for use with schools and colleges.	A greater number of HEIs using subject specific careers resources when working with schools and colleges.
Disseminate effective practice in relation to student engagement with the STEM Curriculum.	Greater awareness by the HE STEM sector of the range of opportunities for engaging students within the STEM curriculum. Effective practices and approaches in student engagement being transferred between, and adopted by, HE STEM departments.
Develop curricula to enable lifelong learning and CPD by those within the chemical engineering workplace.	Development of a foundation degree for those in the chemical engineering workplace that is offered by HEIs and well attended by learners.

Table 2: Aims and Outcomes

Outputs are intrinsically linked to objectives and describe the physical items, products or services that will be produced or take place if an objective is successfully achieved (Table 3).

Objectives	Outputs
Commission a short guide for university careers advisors demonstrating graduate opportunities in Chemistry.	A 12 page guide published.
Run event showcasing examples of current practice in how departments of mathematical sciences can enable students to contribute to the development of their curricula.	One-day workshop offered with appropriate supporting resources available online.
Undertake a scoping study involving employers from the chemical sector to identify content for inclusion in an appropriate foundation degree programme.	Publication of key findings and recommendations for content made available to HE STEM Community in paper and online forms.

Table 3: Objectives and Outputs

It is worth noting that because a project meets its objectives (i.e. it produces its required outputs), this

does not necessarily mean it will have achieved its aims as the required changes (outcomes) may not have been realised. This leads naturally to another important concept: **success measures**. Measures of success are criteria that will demonstrate the impact of the work undertaken and will indicate whether the desired outcomes have been successfully achieved and whether the project has made any difference.

Measures of success can be qualitative or quantitative, but they need to be observable in some form. They also need to be considered well in advance of the start of any activity as they are related to the data and evidence that needs to be collected; without considering what success 'looks like', it is difficult to evaluate. For example, if the purpose of a mathematics support intervention is to *'improve the experience of undergraduate engineers learning mathematics'*, then one success measure might reasonably be that the confidence of the learners to using and applying mathematics increases. As there is a need to measure a change, the researcher will need to design some form of instrument (see Section 7) to try and assess the extent of this change by measuring student confidence pre and post intervention.

Sustainability: For educational enhancement activities more so than pedagogic research, funding applications now typically ask those proposing projects to discuss how their activities will be sustainable, that is how the activity will have some form of influence after the funding has ended. Sustainability needs to be considered carefully. For example, will the activity continue as part of your 'core practice', i.e. replace a previous approach or provide a new way of doing things? How will any developed resources or materials be used? Will it be extended to other colleagues within a department or faculty or to different modules and programmes of study? Will it be used to help change to a departmental, faculty or institutional strategy? Funders like to see that their work will leave a legacy, and while expressing a commitment to securing additional funds to extend the work is certainly a positive, indicating that you will try to obtain funds to sustain it is not since a failure to do so implies the activity itself will cease.

Writing and structuring a grant proposal

When applying for a grant it is likely that there will be some form of template to help structure your application. Supporting this there is likely to be written guidance on how to complete the application, and it is important that this is followed as it will also indicate the basis upon which your application will be assessed. It is also likely there will be a contact with whom your can discuss your ideas for an activity and who can provide guidance on completing any application form. It is worth taking advantage of any such support, including any briefing meetings, to check your ideas align with the objectives of the funding call; a large number of grant applications are unsuccessful because the activities they propose fail to align with the outcomes funders are seeking to achieve.

It is important to complete all sections of the application form fully, noting word limits, and ensuring a meaningful attempt is made with all sections; remember, grant applications are typically ranked relative to each other when determining the distribution of funds. If a template isn't available, for example you may be developing a proposal for business or industry to support rather than as part of a dedicated funding call, then a possible structure for your proposal could be similar to that within Figure 2.

Structuring a Proposal

1. Title (short)
2. Abstract (high impact)
3. Project Team
4. Aims & objectives
5. Outcomes & outputs
6. Rationale
7. Measures of success
8. Activity outline/timetable/milestones
9. Evaluation & ethics
10. Dissemination
11. Budget
12. Sustainability/impact
13. Risk analysis
14. Supporters/references

Figure 2: Structuring a Proposal

In writing the proposal, the following are some general tips that are worth considering:

- Write for the target audience using language of an appropriate style. It is possible that those reviewing the proposal will be non-specialist in the activity area you are proposing.
- Write concisely but demonstrate your knowledge of existing activity and practice in the area of the proposal including your own. Be clear about how this proposal differs or adds additional value to existing activity or practice.
- Sell the project: Make its potential impact clear in the short, medium and longer terms. Ensure you are clear about how your project aligns with the aims of the funding call.
- Be explicit about impact: What will be achieved as a result of undertaking the project? What will change?
- Try to avoid overly technical 'jargon' and be careful when using acronyms. Use short and well-structured sentences referencing any relevant material (such as websites or academic papers) in an appropriate style.
- Use headings and structure to help aid the reader along with an appropriate font and line spacing.
- Be careful not to over commit; ensure you are realistic about what your project can achieve for the available funds and in the available time. Similarly, avoid speculative claims that aren't explained and

clearly justified within the proposal (such as a project being 'transformative') or suddenly introducing new ideas without a rationale or explanation.

- Ensure timescales are realistic; in particular does your project need a 'start up' or 'stand down' period?
- Be explicit about the specific activities that will be undertaken, and ensure methodologies for capturing and analysing data and evidence are clearly defined.
- Consider any risks: What factors might prevent your project from either progressing or being successful? Consider their potential impact and ways of mitigating against these effects.
- Diagrams, captions and figures can help explain ideas but consider how these look within the document, particularly if they contain colour. Ensure they are clearly referenced.
- Dissemination is important (See Section 11). Consider an appropriate dissemination strategy throughout the entire lifetime of a project (i.e. not just at the end).
- Start the writing early: Multiple drafts of a proposal might be needed before the final version is obtained. Try to involve others in the development and checking of the proposal.

It is worth considering the issue of 'costing' a proposal separately. While there are some general tips you can follow, many funders will make a 'value for money' judgement by considering the activities proposed relative to the costs. It is therefore not only important that all costs can be justified, but that they relate clearly to the activities described within the proposal. This is another area where it is important to consult any available guidance:

- Costings need to be realistic and detailed. If requesting funds for the buy-out of staff time try to ensure these are based upon actual salary costs unless another mechanism for calculating them is given in the guidance. Ensure you follow any agreed institutional rates (for example for postgraduate teaching assistants) and note that overhead or indirect costs may not always be allowable.
- Be clear what can and can't be funded by the grant. Are purchases for equipment (such as computers) allowable? It might be that the grant will only allow 'non-routine' items of equipment to be purchased. Ensure you are clear about why any equipment is needed. What about overseas travel?
- While some costs may need to be estimated (for example workshop or travel costs) try to articulate how the amount presented has been derived.
- Articulate any contributions in kind. For any grant, it is likely there will additional costs associated with the project that aren't being requested; these will either be met by you or your institution. These might include:
  - Additional staff time.
  - Facilities, such as teaching space or room hire for workshops.
  - Equipment.
  - Indirect or full economic costs (fEC).

What happens after submission?

Once a grant proposal has been submitted, hopefully the final outcome from the review process will be positive, but either way it is important to seek feedback and it is not unreasonable to do so. Use the feedback to identify the strengths and weaknesses of the proposal and identify any areas for improvement. Try to use this feedback immediately to develop and refine your ideas and approaches. It is also worth exploring whether a resubmission might be welcome; if not, consider how you can either modify your ideas or prepare them for submission elsewhere.

If you have been successful, congratulations and good luck for your project's successful implementation!

Section 11: Generating Engagement With Your Work: Dissemination

Michael Grove, University of Birmingham

Joe Kyle, University of Birmingham

Introduction

When the word 'dissemination' is used in the context of an educational project it is often perceived to be an activity that takes place towards its conclusion, typically when findings and results are usually well known and the 'next steps' are being considered. Sharing learning and findings is an essential part of the scholarship of learning and teaching but shouldn't take place only at the end of a project. Dissemination can be undertaken throughout a project's lifetime and used to enhance its overall impact.

Dissemination: Audiences and messages

The purpose of dissemination is to make information on a particular topic widely known, but doing so effectively involves thinking carefully about both the message to be communicated and its target audience. There will most likely be a range of messages and different audiences, and so it is important each is considered as part of an overall dissemination strategy that runs throughout the lifetime of the project.

While dissemination may take a range of forms, for example writing newsletter articles, academic papers, presenting at conferences, or participating in meetings and seminars, they won't be effective if the message isn't correct for the particular audience it is aimed. Equally, for the audience to be receptive to the message that you are trying to convey, they need to find something within it that benefits or interests them. To help structure your approach to dissemination, consider the outcomes you are looking for, i.e. what you are trying to achieve by undertaking dissemination:

Dissemination for awareness: Here the purpose might be simply to highlight that a particular piece of work is taking place with a view to generating interest and discussion. It can also be a starting point in developing collaborations and becoming part of active learning and teaching networks.

Dissemination for engagement: Involving others in the activities of a project is highly desirable to enhance its outcomes. This might be to help identify examples of previous practice upon which a project lead can then build, to enable other individuals to contribute to the design, development and delivery of activities, or to pilot and evaluate the developed practices.

Dissemination for understanding: Here the purpose is to help others understand the impact of the work taking place and in particular any new knowledge or understanding that has been generated. Such dissemination is often linked to emerging findings from educational research or evaluation, but could equally be related to explaining the need or rationale for a project to be undertaken at its outset.

Dissemination for action: Most educational enhancement activities are undertaken with a view to changing practices and approaches. Bringing about wider change, that is change beyond the scope of the original project, can however be difficult and requires the involvement of other colleagues who need to clearly understand the benefits and wider potential for scalability of the work. Such benefits might be financial, a more efficient way of doing things, or a greater impact over previous approaches.

Dissemination for promotion: Developing either an individual or institutional profile in pedagogic research takes time and can only be achieved through visibility. It is therefore important that those new to pedagogic research are active in their approach to dissemination and take advantage of any opportunities available to disseminate their work.

For each of these outcomes, it is important to consider the audience who might be targeted if the desired outcome is to be successfully achieved. Your audience might consist of departmental or disciplinary colleagues, where technical language and a detailed approach might be appropriate; if the audience is institutional colleagues from a range of diverse disciplines then it is perhaps more appropriate to focus upon the generic ideas rather than the specific disciplinary details. If the audience is internal to your university, you might be able to talk more frankly and openly about what you have found or any challenges or barriers you have faced; externally, you may wish to be more circumspect!

In seeking to bring about change, senior management teams and those at policy level are important audiences, but here it is important to convey your message quickly and concisely. Focus upon the key generic details, avoiding overly technical language or jargon, and communicate the impacts that have been achieved, the evidence-based benefits of supporting or extending the activity and the real risks of failing to do so. Getting to know your audience and their expectations and interests is therefore vital.

When to disseminate

With dissemination having a range of different purposes, it can be undertaken effectively at different times; from before a proposal for a project or activity is submitted to after it has concluded.

When developing a proposal for a project, you may wish to bring together interested individuals to discuss the ideas and approaches; this is a form of dissemination as it has already engaged others in the development of the project and forms a natural group of individuals who you can legitimately say are interested in the project and its outcomes if it is supported. Once a project has been established dissemination can take place at its outset to identify examples of similar practices that have been undertaken elsewhere, and so provide a starting point upon which you can build, or to enable other individuals to contribute to the design, development and delivery of activities thereby increasing the size of the project team. As the project progresses, dissemination can take place to share and test findings, and explore possibilities for wider activity. For example, a project might be exploring the impact of a developed resource or methodology for supporting student learning and it would be beneficial to identify other colleagues who might be willing to pilot the approach with their learners in order to increase the size and diversity of the research dataset.

Once a project has concluded, dissemination can be used to share findings and conclusions: what has been the impact of the work? What new knowledge or understanding has been generated? What conclusions can be drawn and are there recommendations for future activity or research? Such dissemination should not only focus upon what has worked effectively, but also what has been less successful as it is likely others can learn a lot from this. Whereas the dissemination of emerging findings during a project can include anecdotal information or opinion, dissemination that takes place near its conclusion should be based upon robust data and evidence.

Developing a strategic approach to dissemination

Hopefully what the above discussion has highlighted is that dissemination needs to be approached in a strategic manner at the earliest stages of a project or pedagogic research study. In fact, the most successful approaches to dissemination are often ones that have been designed prior to the project or activity commencing.

An effective dissemination strategy will address the following key questions:

1. **Goal:** What is the purpose of undertaking dissemination? What do we want a successful approach to dissemination to achieve?
2. **Messages:** What information do we want to disseminate and why? What language and level of information (detail) is appropriate?
3. **Audience:** Who do we wish to disseminate to and what are the reasons for this? Who is most interested in the activity and how can they contribute to achieving a successful outcome for the project?
4. **How:** What methods can be used to effectively reach the target audience and convey the desired message(s)?
5. **Timing:** When should each dissemination activity take place?
6. **Who:** Who will be responsible for undertaking the dissemination activity? Are there others who might be able to help?
7. **Networks:** What existing networks, communication channels or relationships exist that might be utilised to support or enhance the dissemination activities?
8. **Resource:** What level of financial and human resource is required to enable the dissemination activities to be undertaken effectively? Where will this come from?
9. **Evaluation:** How will you know if successful dissemination has been achieved? What does success look like?

Once you have developed a dissemination strategy, don't be afraid to share this with other colleagues and seek their views; obtaining feedback can greatly aid its development and this too is a form of dissemination!

Effective approaches to dissemination

We have deliberately left consideration of the various methods of dissemination until the end to reinforce the idea that they should not be seen as the starting point for any dissemination strategy; they are merely a mechanism by which key messages can be communicated to the appropriate audiences. There are a range of possible dissemination approaches you can consider:

Networking: Attending workshops, conferences and events, even if you are not formally presenting provides an opportunity to engage in networking with other like-minded individuals to informally share ideas and findings and develop collaborations.

Working or special interest groups: Establishing a working or specialist interest group can act as a focus for like-minded individuals to come together to share practices and ideas throughout a project. Such a group might be established in a broader thematic area related to the project, for example 'assessment and feedback' to bring together a wider range of expertise.

Departmental or institutional seminars: Many universities have established seminars to which you can contribute; these too act as a focus for bringing together those with particular areas of interest and expertise.

Committee meetings: The activities of educational projects can be discussed at learning and teaching committees through formal or informal updates. Such an approach provides an opportunity to consider how they might become embedded (sustainable) as a part of departmental or institutional practices.

Websites: Many projects establish a website to aid communication beyond their host institution and these form an effective reference point for anyone wishing to find out more. It is not, however, essential to set up an entirely new website; many universities will create appropriate webpages as part of their main websites in support of a project.

(Electronic) Mailing lists: There exist a range of existing email lists (such as the @jiscmail.ac.uk lists) to which you can post details of your work and ask questions of others.

Newsletters: A short paper-based or electronic newsletter can be developed and sent to a mailing list of interested individuals. Such a newsletter present details of your work or project, perhaps with that of others, in an accessible manner. Newsletters provide a handy first reference for those wishing to understand more about your work.

Posters: Many conferences provide the opportunity for delegates to submit abstracts for poster displays. Posters are particularly useful for conveying the intent of a project, its approach or methodology and any key or emerging findings. They are concise so help focus the messages the project is trying to communicate.

Guides and briefing documents: Such documents can bring together learning and findings with a view to influencing and informing policy and practice. They are typically, although not always, produced near the conclusion of an activity or project.

Perhaps, however, two of the most important forms of dissemination when you first begin undertaking educational enhancement or pedagogic research are **Writing for Publication** and **Conference Presentations**. Writing for publication is considered within Section 12, and so we conclude this section by offering suggestions on how to deliver effective and engaging conference presentations.

Developing and delivering conference presentations

Conference and seminar presentations are important mechanisms for generating engagement with your work. They provide opportunities for you to share your learning and findings with both a specialised and non-specialised audience, test ideas, seek feedback, and gain wider exposure and acknowledgement for your academic endeavours.

Speaking at a conference can be a daunting experience, particularly if it is for the first time or if the nature of the conference is different to those you usually attend. While you may be nervous, this can be quickly overcome by knowing that you fully understand and can justify the material you will present; preparation is therefore key.

Knowing your audience: While it is not always possible to know exactly who will attend your presentation, you can find out about the types of people who are likely to attend. For example, if the conference is a dedicated education conference, it is likely your audience will consist of a number of people with significant expertise in educational research; perhaps not in the area you are presenting but certainly in social science research methods. If it is a presentation within a department or at a disciplinary research conference, then your audience will most likely comprise of people who are interested in your work but who are not experts in educational research. In both cases, the detail you need to provide and the language used will vary. For example, for a disciplinary audience you may use discipline specific terminology but may need to explain, and justify, any social science research methodologies and perhaps even focus upon this aspect.

Presentation format and timing: Are you delivering a presentation or a workshop? If you are delivering a workshop, participants will, quite naturally, expect some level of interaction, and you therefore need to prepare tasks for them to undertake or points to discuss and debate. How long is the presentation? This will determine how much material you can reasonably present and discuss. A 10minute talk allows only one or two key ideas to be introduced, whereas a one-hour seminar enables a number of key ideas to not only be introduced but also rigorously explained and justified with supporting evidence.

Preparing your message: A talk should not attempt to replicate an academic paper; listeners cannot analyse, understand and retain the same amount of information as readers. Further, maintaining listener interest over an extended period is a challenge, particularly if the material is not presented at the correct level. Plan your talk at a level that all can understand, perhaps first year PhD level, and think about how much material you yourself can realistically take away from a talk. Listeners need to understand the significance of your work and its context; ensure any relevant background material is covered and any specialised elements are explained. Try to keep in mind: what your audience already know about the topic; what they don't know; what they might want to know; and, most importantly, why should they care?

Know your topic: It is essential you not only fully understand all material and ideas you present but that you can explain, and if necessary, defend these. Identify the key messages, points or findings you want your presentation to convey and then think about any questions you might be asked. If using material or findings from others to reinforce or justify your arguments, make sure you know how these were obtained and any restrictions upon the data or conclusions; if you don't know, someone in the audience might and may be only too happy to raise a caveat you hadn't considered!

Talk structure: Be clear about what you want the audience to know by the end of your talk and there is no harm in telling them upfront how it will be structured. Start by addressing the motivation for your work, in particular why it is important and relevant to them, before discussing any important background material. Spend the majority of the talk discussing your work and findings; focus upon the broader results and conclusions, in particular those that have wider applicability beyond your own students or institution. Make sure you reinforce the key points and ideas, using evidence and data, and direct your audience's attention towards these throughout. End your talk by summarising the key findings or conclusions, and ensure you allow an opportunity at the end for questions.

Consider interactivity: Even in the most interesting of talks it is difficult for an audience to maintain focus for long periods of time. You may therefore wish to think about how you can incorporate into your talk opportunities for the audience to be involved. This may be as simple as seeking questions, but could involve incorporating discussion questions, allowing the audience to discuss and analyse a particular piece of data or evidence and offer their thoughts or observations.

Supporting materials: For most talks presenters prepare accompanying slides or visual materials. While these can help present the message of the talk more efficiently and effectively, they can also be to its detriment if their use is not carefully considered. There are therefore a number of points to keep in mind:

- How many slides to use? Many people time their talks by working through slides. It is important not to go over your allocated time or rush through your concluding slides if running out of time. A general rule is to allow a minimum of two minutes on average per slide.
- Slides should not replicate what you are intending to say. They should complement it and convey information or ideas that are better presented in a visual format.
- Slides conveying background information need to be tailored to the audience for your talk to ensure it is accessible.
- Each slide should contain a single message – think about what this is. The key (take-away) message or idea should be written on the slide.
- Use images, figures and diagrams on the slides to enhance the points you are making; in particular ensure these are clear and visible.
- Limit the number of words on each slide and try to make the text as large as possible; choose a font (style and colour) that offers maximum clarity and contrast. There is no need to write in structured sentences and think carefully whether a piece of text needs to be included – could it be better said?

Developing a presentation helps you to structure the key ideas you wish to convey, and this is one of the real benefits of preparing supporting materials or slides. Once you have developed your presentation, you then need to deliver it effectively. The following are some hints and tips to help you do just that:

- Practice make perfect. If you are nervous about giving your talk, or are unsure of timings, try practising first. This might be with friends or colleagues. You could prepare for a conference presentation by first giving a seminar within your department or institution.
- Set-up in advance. Before the talk upload your slides on the computer you will be using and check it works with the projector. In case of problems, ensure you have a back-up plan (for example handouts or overhead transparencies).
- Don't read from your slides. Know your material well enough that you don't need to read from your slides or your notes.
- Engage with the audience. Make eye contact with your audience and talk to those in the room. Don't stand still, move around and use appropriate gestures to reinforce your points. While people may ask questions during your talk, do not allow this to compromise your ability to finish your presentation in the available time; be polite, but firm, about moving on.
- It's not what you say but how you say it. Consider how you can use vocal effects to emphasise key points. Use pauses, vary the volume, pitch and pace at which you speak. Don't be afraid to repeat and reinforce key points.
- Be enthusiastic and smile! After all, if you don't appear interested in what you are saying why should your audience

While delivering a conference presentation can be a daunting experience, it is an essential part of the dissemination for your project or research activity. While this section can provide 'hints and tips' there is no substitute for experience. Look out for conferences that provide a friendly and welcoming community for those beginning pedagogic research within the STEM disciplines and register to attend and present. Examples include the Annual UK CETL-MSOR Conference for teaching and learning within the mathematics sciences in higher education, and the annual Variety in Chemistry Education/Physics Higher Education Conference (ViCE/PHEC). Hopefully we will see you there!


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Section 12: Writing for Publication

Tina Overton, University of Hull

There are many reasons why you might be considering publishing your work in the area of teaching and learning. You may want to disseminate your ideas to other practitioners and share what you believe to be good practice; you may be wanting to build your CV or make a case for promotion; you may be working towards some other form of recognition, such as a national or university teaching fellowship; you may want to be taken seriously for your scholarship in the academic environment; you may be working towards having publishable output for consideration in the research excellence framework, or whatever comes after it. All of these are entirely valid and relevant reasons and, indeed, your motivation may encapsulate them all.

It is often argued that it is scholarship, in its various forms, that defines universities and sets them apart from, for example, a HE in FE (higher education in further education) establishment. For those not participating in disciplinary research, the scholarship of teaching and learning (SoTL) is a valid and engaging alternative that should directly benefit the student learning experience. SoTL can be defined as "*the treating of teaching and learning as serious intellectual work*" and to engage in it effectively academics should treat their teaching in the same way as they would experimental research, that is, carry out research or development, write up results, apply for funding, present at conferences and establish a reputation. Publishing your work is the cornerstone to these activities.

There are several types of educational publications: magazines, so called 'grey' publications and peer reviewed research journals. Appendix 1 provides a detailed list of possible publication routes, including hyperlinks, for educational research within the STEM disciplines.

Magazines and other non-peer reviewed outputs include publications such as institutional publications, newsletters, and e-bulletins. Examples from the sciences include *Education in Chemistry, Physics Education, Mathematics Today, RSS News* and Higher Education Academy output such as newsletters and the *Exchange* magazine. This class of publications typically publishes opinion pieces, book reviews, information about the discipline, experiments, and details on learning and teaching activities. These publications can be a good place to start your publishing career as the barriers to publication can be quite low as they do not typically require articles to contain large amounts of data and evidence.

Grey publications are peer reviewed but often with a light touch. They may report new approaches in learning and teaching, be conference proceedings or reports, but will not typically have an impact factor or be of sufficient quality to warrant submission to the UK's Research Excellence Framework (REF)[1]. They are a good place to publish your novel ideas in learning and teaching if you have some evidence of success but do not want to work your innovation up into a full research project. These publications are also a good way to inform practitioners about your work, rather than educational researchers. Examples in the sciences include *New Directions in Physical Sciences Teaching, Bioscience Education e-Journal, Active Learning in Higher Education, MSOR Connections*, and *Planet*.

If you have work to disseminate that goes beyond innovation and evaluation, that starts to say something about how people learn, that presents meaningful research data, perhaps of a longitudinal study, then you should consider reporting it in a reputable research journal with an impact factor. Submissions to these journals will be rigorously peer reviewed. There are many to choose from: discipline-specific, science-specific and generic. Some examples from the sciences are *Chemistry Education Research and Practice, Physical Reviews Special Topics - Physics Education Research, Journal of Chemical Education, International Journal of Science Education, Journal of Research in Science Teaching, Teaching Mathematics and its Applications, International Journal of Mathematical Education in Science and Technology*, and the *International Journal of Engineering Education*.

Some generic journals that you might consider include *Research in Higher Education*, and the *International Journal for Scholarship of Teaching and Learning*. These journals all have impact factors but the field of education traditionally has low values when compared to disciplinary research in the sciences. For example *Chemical Education Research and Practice* has an impact factor in 2011 of 0.889 whereas *Nature* has a value of 34.480. We are therefore not comparing like with like.

You must start by considering whether what you have is worth publishing. Ask yourself some key questions:

What problem are you trying to address or investigate?

Try to articulate this very clearly and succinctly. "*I'm interested in lab work*" isn't specific enough.

Is it worth doing? Has it been done before?

Not considering these questions is the surest way for your paper to be rejected. The work is only worth

1 http://www.ref.ac.uk

publishing if your ideas or results are applicable beyond your own context, that is your students, in your institution, in your environment. If the work has been done before why should anyone publish it unless you have reframed or extended it? For example, there is well regarded work published on the value of peer-assisted learning in a wide range of disciplines, so your implementation of it may be novel to you but not to the sector as a whole. Most importantly, do a literature review to see what has been done before and set your work in that context, just as you would in experimental research.

What did you do?

Just as in experimental research, make sure your methodology is clear.

Did it work?

Make sure that you have meaningful evidence that goes beyond the 'happy sheet', i.e. some form of a questionnaire administered immediately post-intervention. "*The students liked it*" is not meaningful evidence. Further, be aware of the Hawthorne Effect[2], a term referring to the tendency of some people to work harder and perform better when they are participants in an experiment or working under novel conditions.

What was the impact on learning?

The motivation for taking part in the scholarship of teaching and learning should surely be about improving student learning, whether in terms of their conceptual understanding, skills development or motivation and attitude. If you cannot demonstrate any impact of this type then your work is unlikely to justify the page space within any reputable learning and teaching journal.

In order to be successful in getting your work published ensure you:

- Carry out a thorough literature review.
- Check your innovation hasn't been undertaken elsewhere before.
- Place your work in the context of others.
- Demonstrate that it is practical and transferable to other practitioners' contexts.

There is a publication 'journey' that can get you relatively painlessly into publishing your scholarship (Figure 1):

- Present at a conference and appear in the proceedings.
- Publish a short report of your work in one of the grey publications.
- Build in more evaluation and background context. If you have lots of meaningful data develop further for publication in an international research journal.

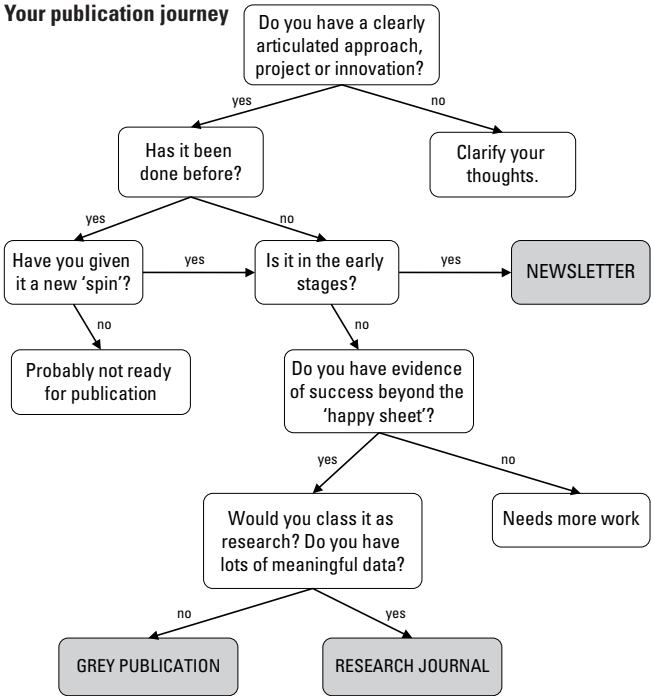

Figure 1: The publication journey

If you are still unsure about what a paper in your area might look like and about where to publish then browse some of the publications mentioned in this article. Look at where your peers publish, if you don't know, ask them, as these are the kinds of people you would want to read your work. Some further suggestions are available in Appendix 1.

Good luck.

2 en.wikipedia.org/wiki/Hawthorne_effect

Appendix 1: Journals in which to Publish STEM Educational Research

Interdisciplinary and Generic

1. Research in Education
   http://www.manchesteruniversitypress.co.uk/cgi-bin/scribe?showinfo=ip018
2. Theory and Research in Education
   http://tre.sagepub.com
3. Public Understanding of Science
   http://pus.sagepub.com/
4. International Journal of Scientific Education
   http://www.tandf.co.uk/journals/titles/09500693.asp
5. British Journal of Educational Technology
   http://www.blackwellpublishing.com/journal.asp?ref=0007-1013
6. Higher Education Quarterly
   http://www.wiley.com/bw/journal.asp?ref=0951-5224
7. Higher Education: The International Journal of Higher Education Research
   http://www.springer.com/education+%26+language/higher+education/journal/10734
8. Innovative Higher Education
   http://www.springer.com/education+%26+language/higher+education/journal/10755
9. Research in Higher Education
   http://www.springer.com/education+%26+language/higher+education/journal/11162
10. Teaching in Higher Education
    http://www.tandfonline.com/toc/cthe20/current#.Ub2GQr9gMII
11. Journal of Applied Research in Higher Education
    http://www.emeraldinsight.com/products/journals/journals.htm?id=jarhe
12. Higher Education Review
    http://www.highereducationreview.com
13. Journal of University Teaching and Learning Practice
    http://ro.uow.edu.au/jutlp/
14. Practice and Evidence of the Scholarship of Teaching and Learning in Higher Education
    http://www.pestlhe.org.uk/index.php/pestlhe
15. Research in Learning Technology
    http://www.alt.ac.uk/publications-and-resources/publications/alt-journal-research-learning-technology
16. Assessment in Education: Principles, Policy & Practice
    http://www.tandfonline.com/toc/caie20/current#.Ub2Iq79gMII
17. International Journal of Teaching and Learning in Higher Education
    http://www.isetl.org/ijtlhe/

Biology and Health Sciences

1. Bioscience Education
   http://journals.heacademy.ac.uk/journal/beej
2. Health and Social Care
   http://journals.heacademy.ac.uk/journal/hsce
3. Journal of Biological Education
   http://www.tandfonline.com/toc/rjbe20/current#.UcFyxr9gOII
4. Journal of Microbiology and Biology Education
   http://jmbe.asm.org/index.php/jmbe

Physics

1. Physics Education (Note: schools and college focus)
   http://iopscience.iop.org/0031-9120/
2. New Directions (HEA)
   http://www.heacademy.ac.uk/physsci/publications/newdirections
3. European Journal of Physics and Physics Education
   http://ejpe.erciyes.edu.tr/index.php/EJPE
4. Physical Review: Physics Education Research
   http://prst-per.aps.org

Chemistry

1. RSC Education in Chemistry
   http://www.rsc.org/education/eic/
2. Chemistry Education Research and Practice
   http://pubs.rsc.org/en/journals/journalissues/rp#!recentarticles&all
3. New Directions (HEA)
   http://journals.heacademy.ac.uk/journal/ndir
4. Journal of Chemistry Education
   http://pubs.acs.org/journal/jceda8

Engineering

1. Engineering Education
   http://journals.heacademy.ac.uk/journal/ened
2. Journal of Engineering Education (JEE)
   http://onlinelibrary.wiley.com/
   journal/10.1002/(ISSN)2168-9830
3. Europ ean Journal of Engineering Education (EJEE)
   http://www.sefi.be/?page_id=20
4. Global Journal of Engineering Education (GJEE)
   http://www.wiete.com.au/journals/GJEE/Publish/
5. International Journal of Electrical Engineering Education
   http://www.manchesteruniversitypress.co.uk/cgi-bin/scribe?showinfo=ip023
6. Journal of Applications and Practices in Engineering Education
   http://japee.net
7. Journal of Professional Issues in Engineering Education and Practice
   http://ascelibrary.org/journal/jpepe3
8. Education for Chemical Engineers
   http://www.icheme.org/ece
9. International Journal of Engineering Pedagogy (iJEP)
   http://online-journals.org/i-jep

Mathematics and Statistics

10. International Journal of Mathematical Education in Science and Technology
    http://www.tandfonline.com/toc/
    tmes20/current#.Ub2FYb9gMII
11. MSOR Connections
    http://journals.heacademy.ac.uk/journal/msor
12. Research in Mathematics Education
    http://www.tandfonline.com/toc/
    rrme20/current#.Ub2I079gMII
13. Teaching Mathematics and its Applications
    http://teamat.oxfordjournals.org
14. Journal of Statistics Education
    http://www.amstat.org/publications/jse/
15. SERJ - Statistics Education Research Journal
    http://iase-web.org/Publications.php?p=SERJ
16. Journal for Research in Mathematics Education
    http://www.nctm.org/publications/jrme.aspx
17. RSS News
    http://www.rssenews.org.uk/category/
    members-area/rssnews/

Appendix 2: Developing an Action Plan for Pedagogic Research

1. Initial Intent

Describe your reason for wishing to engage in pedagogic research. In particular, describe/list or define the educational area(s) that you would like to explore more deeply through pedagogic research.

2. Research Questions

Write the research questions you intend explore.

3. Research Methodologies and Approaches

Define the research methodologies you intend to use to explore your research questions. Consider not only the methodologies themselves, but the sources of evidence you might collect (and their scale), or any challenges that need to be overcome.		
Methodology	**Sources of Evidence or Focus**	**Challenges**

4. Ethical Considerations

What are the potential ethical implications of your research? How might these be addressed before, or during your pedagogic research activity?	
Ethical considerations	**How Addressed?**

5. Publication

What are the outputs that might result from your work? Define the potential titles or focus of any academic papers or publications. Where might these be published?	
Potential Publications	**Source of Publication**

6. Quality Control

How will you ensure the quality of your research? What checks and measures will you put in place to monitor quality and consistency throughout your work?

7. Funding Sources

From where might you attract funding to support your research? Is this from a single source, or could multiple sources support different components of your work?	
Funding Source	**Research Component**

8. Dissemination

What methods of dissemination (internal and external) will you use to communicate the outcomes and outputs from your work? Who are the potential target audiences and what is the purpose of targeting them?		
Dissemination Activity	**Target Audience**	**Purpose**

9. Timeline

What is the schedule for your pedagogic research activity? What are the individual milestones and how will you know each has been successfully completed?			
Target Activity	**Start Date**	**Completion Date**	**Indicator of Completion**

About the Editors

Michael Grove is currently Director of the STEM Education Centre at the University of Birmingham and was Director of the National HE STEM Programme throughout its three-year period of operation. He was a member of the team that developed the proposal for the More Maths Grads initiative and oversaw its delivery as part of the Project's Executive Committee. He also teaches mathematics at university level, primarily to first year students, and is involved with providing mathematics support to undergraduate students as they make the transition to university.

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The National HE STEM Programme

The National Higher Education Science, Technology, Engineering and Mathematics (HE STEM) Programme was a three-year initiative funded by the Higher Education Funding Councils for England and Wales through an activity grant to the University of Birmingham in August 2009. Working across the higher education sector in England and Wales, with a particular focus upon the disciplines of Chemistry, Engineering, Mathematics and Physics, the Programme supported higher education institutions in encouraging the exploration of new approaches to recruiting students and delivering programmes of study. It enabled the transfer of best practice across the higher education STEM sector, facilitated its wider adoption, and encouraged innovation. Through collaboration and shared working, the Programme focused upon sustainable activities to achieve longer-term impact within the higher education sector.

The Higher Education Academy

The Higher Education Academy (HEA) is a national body for learning and teaching in higher education. We work with universities and other higher education providers to bring about change in learning and teaching. We do this to improve the experience that students have while they are studying, and to support and develop those who teach them. Our activities focus on rewarding and recognising excellence in teaching, bringing together people and resources to research and share best practice, and by helping to influence, shape and implement policy - locally, nationally, and internationally.

The **sigma** Network

The **sigma** Network champions the cause of cross-university mathematics and statistics support, and provides developmental activities, resources and mentoring for those who work in this area (http://www.sigma-network.ac.uk).

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