Promoting and carrying out research in science education.

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First requirement: Institutional Support

- Research intensive university
- Nexus between teaching & learning
- Scholarly activities in T&L
- Promotion guidelines include teaching performance

The cultural change encouraged by these activities is a slow process but it is happening.

At the Faculty of Science level

- First to create a T&L committee
- First to offer teaching awards
- First to offer teaching development grants

On the basis of nearly ten years of encouraging scholarly developments, Faculty set up a research group, SciFER. The mission is to work collaboratively, investigating issues of student learning.

Faculty Teaching Development projects (2000-2004)

- Resources e.g. CDROMs,
- Web assessment materials, especially formative assessment
- Web learning modules
- Virtual Learning Environments
- PBL developments
- Collaborations with Uni Melbourne in chemistry
- Benchmarking between national unis

SciFER Research Projects (2000 - 04)

- How tertiary-level students learn and conceptualise quantum mechanics
- Integration of science courses in first year
- Role of memorising in learning science
- Development of an instrument to test the transferability of mathematical skills
- First Year Student Experience in Physics and Biology: the 2001-2002 HSC Syllabus changeover
- Learning from feedback: student interpretation and use of feedback on first year assignments
- Role and use of educational multimedia and communications technologies

UniServe Science 1995 -2004

- Originally national focus & 3 years national funding
- Continues to promote innovation in teaching (Newsletters)
- Move to support scholarly investigations into science teaching (Conference)
- Work within NSW School system (Syllabus Resources)
- Teaches in Professional Development Programs (China Science Program)
- Significant role in project management (Skills; Tutor Training; Service Teaching)

Moved from a show and tell clearinghouse to an organization involved in encouraging and supporting scholarly enquiry into T&L
Research in Biology Education & Training

• Set up in 2000 in response to a review of the School
• Mission statement includes investigation of ways of teaching that will lead to learning improvements
• Projects include:
  – HSC syllabus changes
  – Attitudes to science writing
  – Learning from feedback
  – Evaluation of non-traditional teaching materials
  – Use of ICT materials/online resources in learning

RIBET has established educational research within a science discipline at the University that is successful and productive.

Sydney University Physics Education Research

• SUPER group established 1993
• Set up within the School of Physics.
• Graduate students gain degrees (MSc and PhD) in physics, not education.

Questions that had to be answered at the start.

• Is education research useful to a physics department?
• Is it best done in a physics department or an education faculty?

Is physics teaching in conflict with education research?

• Innovative methods are rarely used.
• Scientists mistrust the methods of education research.
• University teachers have ownership of their courses.
• The process of teaching cannot be divorced from the content.

Education research has much to offer physics teaching

• Learning theories can help teachers guide their students’ learning.
• Teaching strategies can give teachers different ways of achieving learning.
• New technologies can expand the experiences students learn from.

This research can best be done in a physics department

• Learning science is different from other learning.
• There are teaching strategies uniquely suited to physics.
• The way information technology is used can be discipline-specific.
Educational Research Guidelines

• Important principles:
  – For science discipline teachers, such research is informed by personal teaching experiences
  – Reflective teaching and learning offers basic research questions
  – Choice of methodology will reflect one’s comfort zone in the social sciences

Types of research methodologies

• Quantitative methods
  – within our comfort zone; answers questions that are numerical in style; looking for statistical analysis e.g. “how many”?

• Qualitative methods
  – Less within our comfort zone; asks questions more concerned with understanding perceptions of the world; looking for insight rather than statistical analysis e.g. “why; how; when”?

Examples of qualitative methods

• Action research model
  – Uses a cycle of plan, act, describe, review

  Thus this is emergent and iterative

• Case study method
  – Observations of events, community, etc
  Collects extensive data to answer “how”, “who”, “why” questions

• Narrative enquiry model
  – Collection of stories, using interview techniques
  Collects extensive data on one or two events/people

Choosing the approach

<table>
<thead>
<tr>
<th>Quantitative Research</th>
<th>Qualitative research</th>
<th>Grounded theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature review</td>
<td>Literature review</td>
<td>Research question(s)</td>
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<tr>
<td>Hypothesis</td>
<td>Choosing an approach</td>
<td>Design &amp; choice of methods</td>
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<tr>
<td>Data collection</td>
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<td>Data collection</td>
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<tr>
<td>Analysis of findings &amp; discussion</td>
<td>Literature review (again)</td>
<td>Analysis, discussion &amp; literature review</td>
</tr>
<tr>
<td>Conclusions</td>
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<td>Conclusions</td>
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</table>

Collection of data

Depends on the research you are doing

• Surveys – paper based; online; telephone
• Focus group meetings
• Online discussion boards
• Lurking online in course discussions
• Interviews – structured; unstructured; semi-structured
• Observations
• Diaries
• Anecdotal

Analysis of data

Depends on what sort of data you have collected

• Numeric analysis of scored data (general statistics)
• Content analysis
• Attitude scales Likert scales
• Differential scales
• Closed items
• Open ended items
Some methods of analysing data

- Paper-based questionnaires
  - Multiple choice (quantitative) statistics, correlations, etc
  - Open-ended (qualitative) phenomenology, phenomenography

Gathering information from a class survey

- Interviews
  - Are often used as a follow-up to information gathered some other way.

The transferrability of mathematical skills

**SECTION A**

1. Solve the following equations for \( x \):
   - \( x^2 = 8 \)
   - \( |x| = 3 \)
   - \( x^2 + 2x + 1 = 0 \)
   - \( 2x + 3 = 4 \)
   - \( \log(x + 2) = 0 \)
   - \( x^2 - 1 = 0 \)

2. Negligible the expression:
   - \( x^2 + 2x + 1 \)
   - \( \log(2x + 3) \)
   - \( \log(x^2 + 2x + 1) \)

**SECTION B**

Certain bacteria in food are killed by heat. When a bacterial culture dies, the cell count decreases exponentially. Hence, the number of bacteria in the culture decreases by a factor of \( e \) after the bacteria is heated to a temperature of \( T \). Then,

\[ n = n_0 e^{-kt} \]

where \( k \) is a positive constant which depends on the properties of the bacteria. The Oral Bacterial Reduction Time, \( t \), is the length of time required for the cell concentration to decrease to one-tenth of the original value at a given initial temperature \( T \).

1. Express \( k \) in terms of the bacterial reduction time \( t \).
2. The graph below shows how the cell concentration \( N \) (cell/ml) of the bacterium *Escherichia coli* increases in a medium of another cell before it increases exponentially.

![Graph showing cell concentration over time](image-url)
Some methods of analysing data

• Observations
  – Example: a project to evaluate teaching in a computer laboratory.

Gathering information for a course evaluation

<table>
<thead>
<tr>
<th>Task</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>To define the objectives of the course in terms of teacher expectations, and to ascertain whether, and how well, those expectations were met.</td>
</tr>
<tr>
<td>Questionnaires</td>
<td>To determine the students' attitudes towards their own skills/knowledge, and to determine the effectiveness of the course.</td>
</tr>
<tr>
<td>Observation</td>
<td>To describe the students' performance and activities during the class.</td>
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</tbody>
</table>

Gathering information on computer usage

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talking to tutor on task</td>
<td>30%</td>
</tr>
<tr>
<td>Talking to student off task</td>
<td>2%</td>
</tr>
<tr>
<td>Talking to tutor off task</td>
<td>9%</td>
</tr>
<tr>
<td>Operating hardware</td>
<td>8%</td>
</tr>
<tr>
<td>Reading screen</td>
<td>19%</td>
</tr>
<tr>
<td>Writing or drawing</td>
<td>14%</td>
</tr>
<tr>
<td>Reading a book</td>
<td>9%</td>
</tr>
<tr>
<td>Thinking</td>
<td>8%</td>
</tr>
<tr>
<td>Doing something else</td>
<td>1%</td>
</tr>
</tbody>
</table>

Some methods of analysing data

• Examination scripts
  – Example: investigating the correlation between qualitative understanding and marks in an exam.

Examination question

“In a spaceship orbiting the earth, an astronaut tries to weigh himself on bathroom scales and finds that the scale indicates a zero reading.

However, he is also aware that his mass hasn’t changed since he left the earth. Using physics principles, explain this apparent contradiction.”
Some methods of analysing data

- Concept maps
  - Example: investigating student understanding of physical optics.

Concept map items (Optics)

- amplitude, diffraction,
- frequency, electromagnetic field,
- intensity, interference,
- light, phase,
- polarisation, ray,
- reflection, refraction,
- refractive index, resolution,
- superposition, wave,
- wavefront, wavelength

Theories of learning

- To apply your research, you need a view about how students learn.
- In science teaching, main approaches are behaviourist or constructivist.
- Theoretical background is more important in an Education Faculty than in a science department.