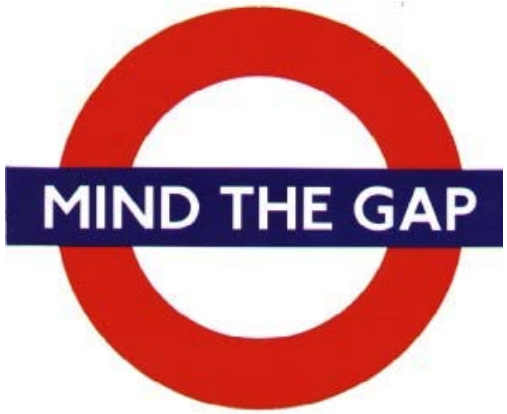
Some reflections on STEM at the interface between school and higher education

Delia Marshall

ASSAf Forum, October 2009



Some reflections on STEM at the interface between school and higher education

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Alarming first year university failure rates

'Schools failing to prepare students'

University preparedness reports get DG's goat

JO-ANNE SMETHERHAM

BASIC Education director-general Duncan Hindle has hit out at media reports about poor literacy and mathematics levels among first-year university students for "showing our youth in a negative light".

Hindle issued a four-page statement titled "Condemning our children doesn't help", in response to reports that most first-year university students – who were the first to write matric under the outcomes-[illegible]cation curriculum –

He highlighted the Quality Learning and Teaching Campaign, which obliges teachers to be in class on time and to do their jobs, pupils to do their homework and respect teachers, and parents to supervise their children's homework.

It also includes obligations of governing bodies and education administrators.

"If all this happened, we believe quality would improve dramatically," he said.

He pointed out that 77 percent of eligible children are now enrolled [illegible]

Shock report on literacy levels at universities

JO-ANNE SMETHERHAM

SHOCKING new test results show that most first-year students at universities across the country do not have the literacy skills, and only a tiny proportion have the mathematical skills, required in higher education.

The final pilot phase of the National Benchmark Tests Project (NBTP) is a damning indictment of the implementation of, and raises questions about the validity of, National Senior Certificate (NSC) results.

It also explains the high failure rate at tertiary institutions. Previous research has shown that fewer than one in three students at all [illegible] versity of the Witwatersrand and Rhodes. Over 300 academics have participated in the project.

Only about 7 percent of the students who wrote the mathematics test were found to be proficient, meaning they would not need extra help to pass their first year. The test assessed the skills needed to study first-year mathematics at university.

About 73 percent had "intermediate" mathematical skills and would need to take part in extended or augmented programmes to pass university mathematics. The remaining 20 percent had only "basic" skills and would need long-term support.

mediate skills in numeracy and one-quarter would need extensive support at university.

These skills were central to most university disciplines, where students had to be able to interpret tables and understand percentages and basic proportion and trends, the researchers said.

About 47 percent of the students who wrote the tests on academic literacy were proficient, 46 percent had intermediate skills and 7 percent had basic skills. This test assessed ability in English, the medium of instruction.

The results "strongly suggest that higher education institutions need to provide extensive support in language development – not only for

‘Gap’ between students’ capabilities and university’s expectations is not new

Previous study:

- only 55% of first year students graduated

Reasons given for failure:

- poor school preparation
- ‘weakness’ of university T&L

When?

- **1963**
- JMB-commissioned study (Akoojee & Nkomo 2007)

‘Gap’ between students’ capabilities and university’s expectations is not new

Previous study:

- 47% students failed at least one subject
- 25% more than 1 subject

Reasons given for failure:

- transition from school to HE
- inadequate university teaching

When?

- **1936**
- study commissioned by Minister of Education

(Akoojee & Nkomo 2007)

What is the nature of this ‘gap’?

Anecdotal comments - weaknesses

Students very weak in maths!

Poor maths skills underly the first year Physics failure

Can no longer memorise!

Less inclined to sit passively - ‘more restless and fidgety in class’

What is the nature of this ‘gap’?

Anecdotal comments - strengths

Students doing better in some science courses than before - eg. Chemistry, Intro to Engineering

Physics students more skilled and confident in lab work

Students far more engaging and interactive - ‘we used to have to coax students into co-operative learning groupwork’.

What is the nature of this ‘gap’?

Anecdotal comments - strengths

Student struggle more with maths manipulations, but seem more enthusiastic and less daunted than previously to tackle complex problems

Students more tolerant of others’ views when we discuss sensitive issues

These are Generation Y students - they have different aspirations; they’re more visually-inclined, techno-savvy…

Two studies on 1st years 2009: (1)UJ

‘The first OBE cohort in Physics 1: set up for failure?’

Physics 1 (major) class

- huge increase in enrolment in 2009, since more students met entry criteria

Findings:

- 2009 intake are scoring 8%-12% lower than 2008 intake

Implications:

- tighter selection criteria needed for SET programmes
- a 13th school year for talented learners, to be assembled at a few well-resourced schools

(Winkler, 2009)

First year performance 2009: (2)UCT

Mid-year results of physics-1 and mathematics-1 for engineering students over a 5 year period

Findings:

- not a sudden decline in 2009
- 'part of a gradual deterioration in the preparedness of incoming students'
- 2008 NSC cannot be solely blamed for the decline
- low correlation between NSC results and first year performance in maths and physics.

Implications:

- tighter selection criteria would **not** useful
- need to find educational strategies that will assist underprepared students to succeed

(Wolmarans *et al*, 2009)

Reflections on these two studies

(1)

- Tighter selection criteria needed for SET programmes
- A 13th school year for talented learners, to be assembled at a few well-resourced schools

‘Set up for failure?’:

…by OBE system…

(By unresponsive HE system?)

(Why was no change expected?)

(2)

- Tighter selection criteria would **not** useful
- Need to find educational strategies that will assist underprepared students to succeed in HE

Is this ‘gap’ unique to SA?

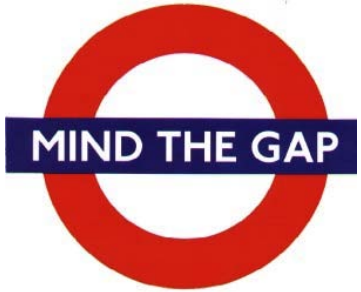
Introduction of new Physics curriculum in NSW, Australia

- Included context, and skills (writing and experimentation).
- Time spent on context and relevance of school physics …’appears to have left students **less well prepared for study in a demanding first year of university physics’**.

- But …the number of students taking physics is increasing …’changes in the curriculum had **added to the attractiveness of physics** at high school’.

(AUTC, 2005)

How should HE respond to the ‘gap’?



Option 1: It’s not HE’s problem

‘Mind’ the gap = avoid, side-step it

Option 2: HE needs to respond

‘Mind’ the gap = to attend to, have care or oversight of

Option 1: It's not HE's problem

- 'It's the schools' problem, not ours'
- Raise entry points, get better students
- 'Need to maintain standards'
- First year as 'filter' to 'weed out' those students who are 'not university material' - 'survival of the fittest'

But … stats show that these students **are** the cream of the crop (cf. CHE study)

(Scott *et al* 2007)

‘The cream of the crop’

Participation rates* in HE:

White	61%
Indian	50%
Coloured	12%
African	12%

Only 12% of age cohort of coloured and African students in HE!

Developed countries may be up to 70% or more

* All participants as % of 20-24 age-group

(Scott *et al* 2007, CHE study)

Retention and completion rates

First year attrition

- 30% drop out

Estimated completion rate

- **44% max**

So, less than 5% of the black age cohort succeed in any form of HE!

(Scott *et al*, 2007)

In terms of social justice, equity and national development, Option 1 is not defensible

Graduated in regulation time

The 3 year B.Sc/4 year B.Eng is NOT the norm

	Black	All students
Engineering	14%	32%
Life and Physical Sciences	11%	21%
Mathematical Sciences	13%	24%

(Scott et al, 2007)

The impact of low graduation in regulation time?

Psychological costs of failure

- loss of confidence
- impact of an unplanned longer degree vs. structurally extended degree (emotionally & financially)

Curriculum incoherence

- time-table clashes due to repeated subjects
- the interface with the mainstream

(curriculum coherence for the **minority** of students who complete in minimum time!)

Option 2: Higher education needs to respond

The problems are essentially systematic

- call for **structural** rather than peripheral or '**remedial**' responses (Scott *et al*, 2007)

'Deficit' model – students need to be 'fixed' by foundation/add-on courses

vs.

University itself needs to change mainstream teaching practices & institutional culture

(Boughey, 2007)

→ Rethink our curriculum structures and teaching approaches

Extended curricula/curricula reform needed

Rethink *entire* degree structure

– not just tack on extra year (else failure gets displaced to 2nd year)

An accelerated stream

– these students best able to deal with curriculum incoherence

Curriculum design, teaching and learning implications

Extending the degree alone is not sufficient

– need to look at the **design and pedagogy of the curriculum itself.**

Types of foundational provision:

1. More time more tuition (more of the same is *not* what is needed)
2. Add-on skills (eg. English, computer skills, life skills)
3. Integrated/infusion into disciplines

(Kloot *et al* 2008)

Research-based, scholarly approaches to curriculum design needed

Analysis of 2006 DOE Extended Curriculum Programme (ECP) submissions: (Boughey, 2007)

- lack of scholarly, research-based approaches
- mostly ‘add-on’ skills courses
- much ‘re-inventing the wonky wheel’

…despite international and SA research (80s and 90s) on limitations of ‘add-on’ skills

…despite international & SA literature on STEM undergraduate education reforms and Scholarship of Teaching & Learning (SoTL)

Theories on learning

Individual/cognitivist:

- focus on knowledge acquisition, 'mental models'; '*misconceptions*' & conceptual change

Socio-cultural:

- learning as not just a cognitive process, but
- a process of *identity* formation
- through accessing a disciplinary *discourse*
- and increased *participation* in the activities of a *community*

Complementarity of these perspectives NB

(Scott and Leach, 2003; Sfard, 1998)

Socio-cultural view on learning: implications for curriculum design

Creating communities

- from traditional lectures to classroom interactive engagement (eg. Peer Instruction, Harvard and elsewhere; SCALE-UP at MIT and elsewhere; in SA, SFP at UN…)
- mentoring

Greater participation in activities that mirror practices of scientists:

- inquiry-based labs vs. traditional 'cookbook labs'
  (eg. US-based ISLE project)
- authentic tasks (PBL, context-rich problems)
- undergrad research activities from 1st year
- eg. UWC Physics Extended Curriculum Programme

(see Allie *et al*, 2008 - SA paper by 21 university STEM lecturers)

Socio-cultural view on learning: implications for ‘academic literacy’

Learning as accessing a disciplinary discourse

- ‘academic literacy’ - not ‘skills’ but the social practices of discipline communities
- limitation of ‘stand-alone’ courses vs. infusion into the curriculum
- collaborations between AcLit specialists and discipline lecturers (eg. Engineering CPUT) (Jacobs, 2007)

Taking on discourse and participating in community -- identity formation :

eg. exposure to a range of possible identities as an engineer/chemist/mathematician…

A socio-cultural view on learning: implies ‘whole dept’ commitment

Learning as increased participation in a disciplinary community of practice

Whole Dept commitment to curriculum reform

rather than

separate courses taught by marginalised contract staff

eg. UWC Physics ECP

Reasons for resistance to curriculum reform and extended degrees?

(1) What matters in HE - research vs. teaching

(2) Fears about ‘falling standards’

(3) Concerns about financial implications

(1) What matters in HE - research vs. teaching

Educational expertise needed to design and implement effective curricula

(Scott *et al*, 2007)

HE as a ‘field’ - research valued over teaching and learning - constrains institutional change

(Kloot, 2009)

International focus on Scholarship of Teaching & Learning (SoTL)

(Boyer Commission - Educating Undergraduates in the Research University: Reinventing Undergraduate Education, 1999)

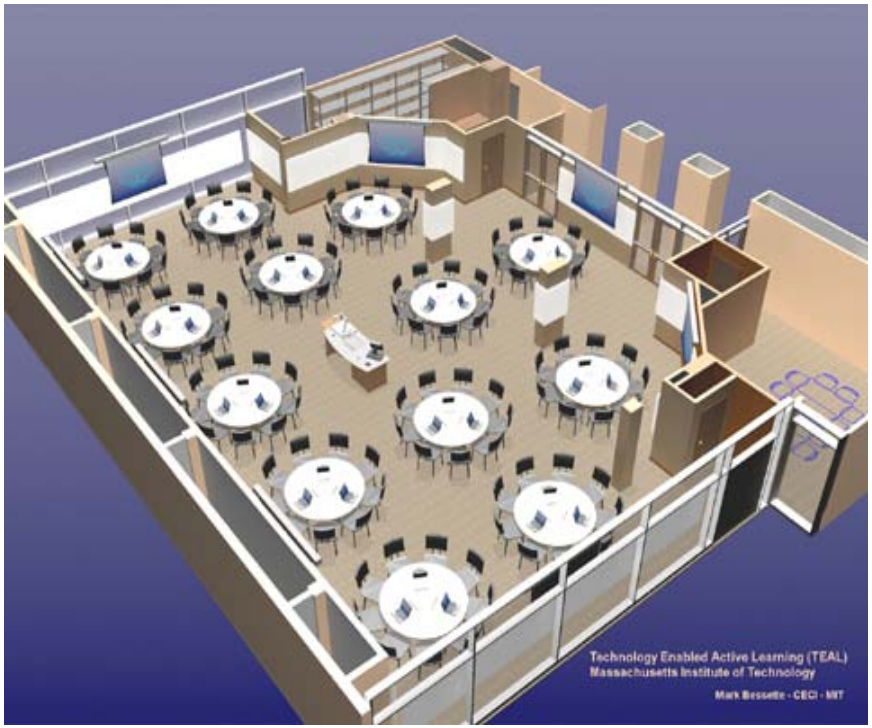
(2) Fears about ‘falling standards’

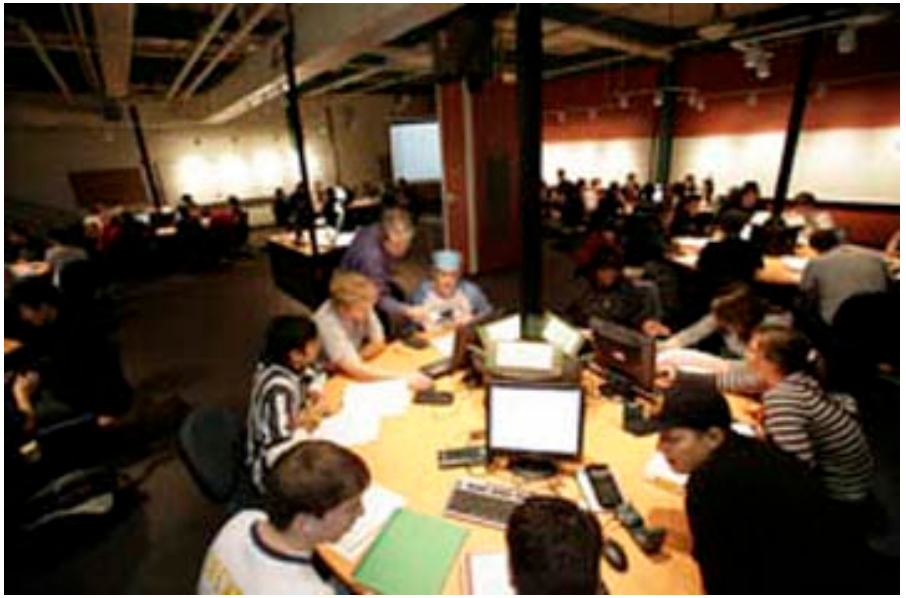
Maths and science curriculum reform = ‘dumbing down’, not maintaining international standards?

Examples: Harvard? MIT?

MIT
first year Physics no longer taught like this….

But like this…





MIT SCALE-UP classroom

Interactive engagement in classroom communities

Rethinking curriculum ’canon’

(2) Fears about ‘falling standards’?

MIT… Harvard … over 60 Physics Education Research Groups in USA Universities

Curriculum reform - based on research on how students learn best - benefits ALL students!

- Australian report

  Outcome: ‘curriculum needs to respond to changing students’

- Uppala, Sweden

  - 30 vs 300 students in regular vs extended Physics degree

(3) Financial implications

For the **state**: throughput stats show very poor returns on investment currently! Billions lost/year…

For the **student and community**: better throughput = less drop-out, less unplanned years

For the **universities**:

investment in ECPs and improving T&L

increased retention and throughput

increased output subsidies (good return on investment!)

Responding to needs for 21st century

Climate change, social justice, democracy, sustainability of financial systems etc.

New curricula to address challenges of 21st century

Need :

- creative, innovative thinkers (cf. science ed research on 'successful' students)
- science and engineering graduates committed to social justice and democracy (cf. Soudien Report, 2009; Badat, 2001; Jansen, 2009)
  - 'Public-good professional capabilities' (Walker, 2004)
- graduates for corporate capital vs. alternatives

Responding to students' concerns and aspirations

Students' motivations for choosing engineering degree:

- concern for social and environmental issues (Jawitz & Case, 1998; Reed & Case, 2003)
- alienation of good engineering students (Case, 2007)

Attract a wider range of talented students to STEM cf. the 'second tier' (Tobias, 1990)

What HE needs from schools

NSC curriculum intentions are laudable:

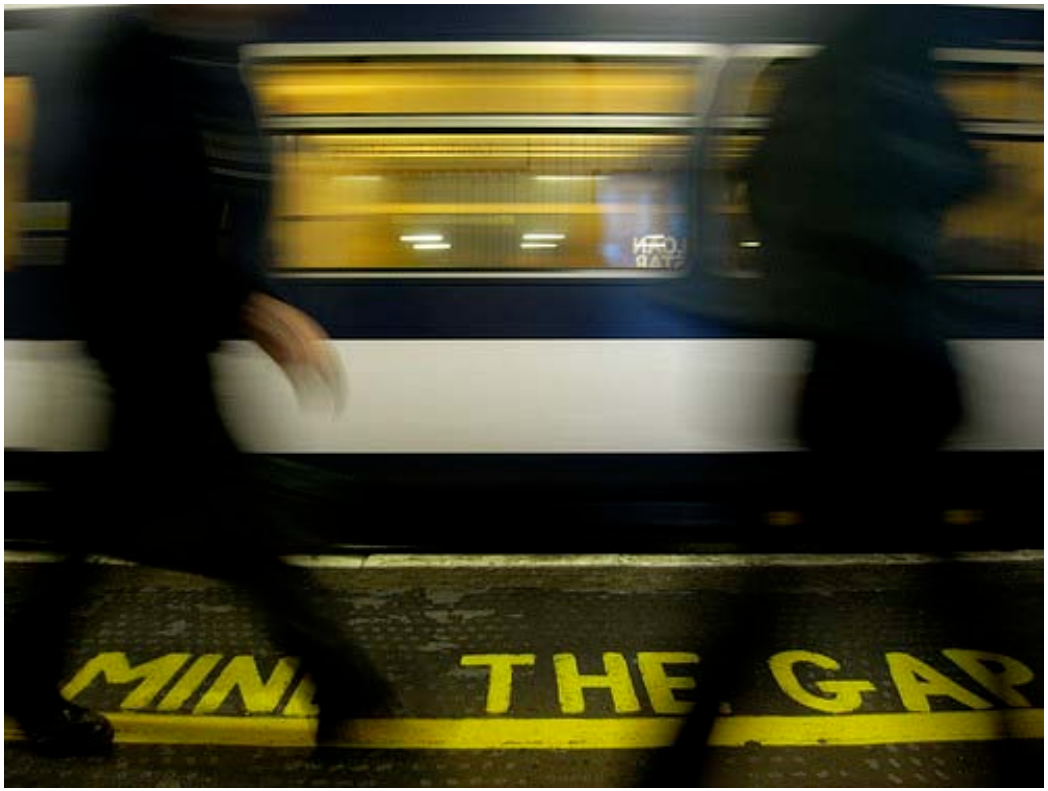
- emphasis on sense-making vs. memorisation
- relevance - interest in science and maths instilled

However,

- reduce overcrowded curricula: ‘Cover less, uncover more’ eg. Do students need calculus, semi-conductors..?
- ‘zone of feasible innovation’ (Rogan, 2007)

In summary … what needs to change in HE

- Rethink *entire* degree structure - ECP the norm?
- At 1st year, start where students *are at*, not where we think they *'ought'* to be
- Curricula need to be designed in scholarly way, taking into account research on STEM T&L
- Build on strengths of NSC - relevance, social contexts, investigation-based
- Respond to students' strengths (interest, interactive, technology-oriented…) and their aspirations
- Financial support for improving T&L crucial; SoTL a key focus in HEIs
- Rethink 'growth' models in HE - growth through improve throughput *vs.* increasing 1st year intake



Thank you!