Innovation and creativity in science and mathematics education

Graeme Oliver
Australian Science & Mathematics School

www.asms.sa.edu.au
How do we prepare students for their future?
AUSTRALIAN SCIENCE & MATHEMATICS SCHOOL

Is this a school showing us the future now?

www.asms.sa.edu.au
INNOVATIVE LEARNING ENVIRONMENTS PROJECT
CENTRE FOR EDUCATION RESEARCH AND INNOVATION PROGRAM
OF OECD, 2013

“Particularly noteworthy features” –
Cohesion between the educational vision and the pedagogical approaches, and the innovative learning environment

http://www.oecd-ilibrary.org/education/innovative-learning-environments_9789264203488-en
learning
professional environment
leadership selecting
students commons
eportfolios
tutor virtual achievement
learners curriculum
innovation partnerships
distributive development
evidence collaborative ubiquitous
online community
teaching
teaching individualisation ict
classrooms role grouping
pathways leadership selecting
innovation partnerships
distributive development
evidence collaborative ubiquitous
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teaching individualisation ict
classrooms role grouping
THE AUSTRALIAN SCIENCE & MATHEMATICS SCHOOL IS A SPECIAL PURPOSE SCHOOL

“...a mission for innovation and reform in the teaching and learning of science and mathematics.”
A MISSION FOR INNOVATION AND REFORM

Advancing science education for a healthy, sustainable and prosperous Australia

Ian Chubb
Chief Scientist for Australia, 2013
A MISSION FOR INNOVATION AND REFORM

To promote engagement of young people into:

• Science research
• STEM employment
• A scientifically literate society
Platforms of Innovation at the ASMS

- Learning Environment
- Innovation in Teaching and Learning
- Professional Learning
- Learning Programs
- Student Learning
WELCOME TO THE ASMS
PLATFORMS OF INNOVATION AT THE ASMS

Action research
Curriculum development
Pedagogical development
Outreach services

LEARNING ENVIRONMENT

INNOVATION IN TEACHING AND LEARNING

PROFESSIONAL LEARNING
Self-directed
Metacognitive
Inquiry oriented
Capabilities

STUDENT LEARNING

LEARNING PROGRAMS
Open
Flexible
Collaborative
ICT Rich

Interdisciplinary
Authentic
Innovative
Personalised
PLATFORMS OF INNOVATION AT THE ASMS

LEARNING ENVIRONMENT
- Vertically grouped classes
- Team teaching
- Virtual classrooms
- On-line assessment & reporting

INNOVATION IN TEACHING AND LEARNING
- Central Studies teaching program
- Demonstrations of learning – Earth Summit, Nano-Expo, TechnoHistory Museum
- Extensive Tutor Group program
- On-going PLP

PROFESSIONAL LEARNING
- Professional Learning Plans / Research Agenda
- Scientific Studies in SACE
- Inquiry Based Learning
- Building New Sciences
- Primary Science/Maths Program

STUDENT LEARNING
- Self-directed learner inventory
- Reflective journals in maths
- Fertile Questions
- ASMS Certificate of Graduate Capabilities
DEEP LEARNING

Development of rigorous thinking

Unfamiliar context
- Transfer and application
  - orientation to problem solving
- Focus on innovation
  - orientation to creativity

Familiar context
- Focus on facts
  - orientation to mastery of basics
- Analysis and interpretation
  - orientation to research and experimentation

The model for deep learning used at the Australian Science and Mathematics School.
CENTRAL STUDIES PROGRAM

Order & Chaos
Biodiversity
Biotechnology
Earth & Cosmos
Communication Systems
Student Inquiry Project
Nanotechnology
Sustainable Futures
A Technological World
Reasoning & Relationships
The Body in Question
INQUIRY DRIVEN BY FERTILE QUESTIONS

- Should humanity control diversity?
- How can we achieve a sustainable future?
- Where lies the final frontier?
- Is it all a matter of perspective?
- Where is the power in communication?
- Why Invent?
- Is there order in chaos?
- Is there chaos in order?
AUTHENTIC DEMONSTRATIONS OF LEARNING

• NanoExpo

• TechnoHistory Museum

• International Science Fair
Invent a new product based on the principles of nano science

Develop a business plan and market plan for the product

Sell the product to an audience of industry experts, the general public and their peers.
• Present an artefact for display in the TechnoHistory Museum
• Explain the scientific, historical & social significance of the item.
• Present the display to the general public

HISTORY WEEK
INTERNATIONAL SCIENCE FAIR

• A week of working in collaboration with students from our global network of partner schools
• Shared science research activities
• Problem based learning activities
• Presentations of extended research projects
A recognised pattern of results

Chemistry
Scientific Studies
History
Biology
Mathematics
Philosophy
Physics
English
Research Project

SACE (ATAR)
INNOVATION AND REFORM AT THE
AUSTRALIAN SCIENCE & MATHEMATICS
SCHOOL

Does all of this really work?
ARE THERE INDICATIONS THAT THE ASMS IS BEING SUCCESSFUL IN ACHIEVING ITS MISSION?

A cultural context in which learning is the prime endeavour was strikingly evident over several days of observing the school in action and talking with staff and students. The establishment of such a culture clearly represents a major achievement.

(ACER report, p 14)
“a secondary curriculum that is contemporary in its engagement with current issues and developments in science, and in its use of scientists and other community members to provide connectedness with issues and ideas beyond the classroom setting” (p. 51)
THE STATUS AND QUALITY OF YEAR 11 AND 12 SCIENCE IN AUSTRALIAN SCHOOLS

GOODRUM ET AL FOR THE AUSTRALIAN ACADEMY OF SCIENCE, 2012

ASMS is a featured case study addressing the curriculum ideals of:

• The science curriculum is relevant to the needs, concerns and personal experiences of the students.
• The teaching and learning of science is centred on inquiry.
• Assessment serves the purpose of learning and is consistent with good teaching.
Australian Institute of Teaching & School Leadership (AITSL)

Illustrations of Practice case study (September 2013)
• Inspirational teaching in mathematics

AUSTRALIAN CURRICULUM STUDIES ASSOCIATION (ACSA)

GARTH BOOMER AWARD (2013)

For promoting a negotiated curriculum:

• curriculum intentions should be made explicit to students
• students should be 'actors' and not just 'acted upon'
• curriculum, including assessment, must involve collaboration between teacher and student
• power relationships in the classroom, school or system should be examined.
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9. The ASMS curriculum is engaging and is fun

- 85% of students report that they are highly satisfied with their experience at the ASMS
- 92% of ASMS students go on to further study
- 85% of students continue study in STEM related pathways
INNOVATION IN EDUCATION

Unbiased opinion…awfully good…clearly misunderstood…intelligent catchphrase…negative growth
The future is not a place we are going,
But a journey we are sharing.

James Schaar
CHANGING SOCIAL ENVIRONMENT
CHANGING LEARNING ENVIRONMENT
<table>
<thead>
<tr>
<th>Logical</th>
<th>Intuitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deductive/Inductive reasoning</td>
<td>Abductive reasoning</td>
</tr>
<tr>
<td>Requires proof to proceed</td>
<td>Asks what if?</td>
</tr>
<tr>
<td>Looks for precedents</td>
<td>Unconstrained by the past</td>
</tr>
<tr>
<td>Quick to decide</td>
<td>Holds multiple possibilities</td>
</tr>
<tr>
<td>There is right and wrong</td>
<td>There is a better way</td>
</tr>
<tr>
<td>Uncomfortable with ambiguity</td>
<td>Relishes ambiguity</td>
</tr>
<tr>
<td>Wants results</td>
<td>Wants meaning</td>
</tr>
<tr>
<td>Critical reflection</td>
<td>Feedback loops</td>
</tr>
</tbody>
</table>

(from Centre for Creative Leadership, 2009)
IMPROVE  INNOVATE  TRANSFORM

S-Curve: raised goals or different goals?

1. Architected future
2. Scaling for growth
3. Operationalizing results
4. Extracting efficiencies
5. Closing / Transitioning
6. Jumping and transforming
TRANSFORMING EDUCATION
LEARNING FROM THE EXTREMES (HANNON 2012)
TRANSFORMING LEARNING PROGRAMS AT ASMS (MODELLED ON HANNON, 2012)

- Informal Learning
- New Providers
- Reinventing

- Formal Learning
- Existing providers
- Improving

SACE Australian Curriculum

- Informal Learning
- Existing Providers
- Supplementing

Learning Enhancement Opportunities

- Formal Learning
- New Providers
- New paradigm

MOOCs, Innovation Space

University Extension Studies

ASMS Blend
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SACE Australian Curriculum

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ASMS Blend

(University Entrance)

ATAR
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SACE Australian Curriculum
Learning Enhancement Opportunities
ASMS Blend
MOOCs, Innovation Space

University Extension Studies

(University Entrance)
How do we prepare students for their future?
Their futures are a journey of constant change
How do we get out of the way of students who are preparing themselves for their futures?
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South Australian Department
for Education and Child Development
T/A South Australian Government Schools
CRICOS provider number 00018A

www.asms.sa.edu.au