STEM Pedagogy

Teaching
Thinking
Processes
Learning
Assessment
STEM pedagogy: the application of good practice

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STEM Education Research Group

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STEM Education Research Group

- 34 staff working in STEM areas
- disciplines and integrated
- research, development, teaching, supervision
STEM Education Research Centre

DIGITAL

Technology and Engineering

Science

Mathematics

iSTEM

TECHNOLOGIES
The nature of STEM

- integrated subjects
- student centred
- collaborative
- process focussed
- within the curriculum
- project / problem based
Processes

- Problem based
- Project based
- Inquiry
- Design

Processes are diverse

Processes are complex
STEM Processes

Problem based
Project based
Inquiry
Design
MODELS

STEM Processes

Problem based
Project based
Inquiry
Design
STEM Processes

MODELS
Problem based
Project based
Inquiry
Design
Stages of problem solving/innovation, barriers and paths

Thought Initiators, stimuli, needs

1. Problematic Situation
2. Envisioning Possible Solutions
3. Model Development
4. Development of Approach Strategies
5. Develop Time & Activity Plan
6. Execution of the Plan
7. Evaluation of the Results
8. New Problematic Situation

A → B → C → D → E → F → G
Processes are complex

Aspects of all processes:
- generate ideas
- research and investigate
- evaluate
- modelling
- solve problems
- document
- produce
- communicate
- identify need
Implications

Don’t expect too much too soon from students
Implications

Don’t expect too much too soon from students
The skills take a long time to teach
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Do not try and teach them all at once
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Teach bits at a time
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Build up a repertoire of skills in students
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The skills take a long time to teach
Do not try and teach them all at once
Teach bits at a time
Build up a repertoire of skills in students

Begin with a large group
ownership
input
Processes are diverse
processes can begin and end at different places

- *depends on the outcomes*
processes can begin and end at different places

- depends on the outcomes
- relate to different ability levels
processes can begin and end at different places

- depends on the outcomes
- relate to different ability levels
- begin – situation, problem, brief, need, product
processes can begin and end at different places

- depends on the outcomes
- relate to different ability levels
- begin - situation, problem, brief, need, product
- end - a model, prototype, system, graphic
support the required process skills

- generate ideas - brainstorming
support the required process skills

- *generate ideas - brainstorming*
- *researching - survey design, indexing*
support the required process skills

- generate ideas - brainstorming
- researching - survey design, indexing
- documenting - sketching skills, analysis
support the required process skills

- generate ideas - brainstorming
- researching - survey design, indexing
- documenting - sketching skills, analysis
- evaluation - metacognitive skills, critique
focus on content over process can prevent students learning from failure

- learning is through the process
- learning may not be adequately represented by the content
- assessment needs to reflect this
Teaching

teaching for learning is student centred
teaching for learning is student centred

Implications:

Student activities should be significant
- useful, productive, intentional, integrative, inventive
- personally meaningful and purposeful
teaching for learning is student centred

Implications:
Some students require open ended tasks and others need more structure
teaching for learning is student centred

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Teach using a variety of methods
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Make all aspects explicit to students
teaching for learning is student centred

Implications:
- Some students require open ended tasks and others need more structure
- Teach using a variety of methods
- Make all aspects explicit to students
- Involve students in decision making
Thinking

development happens through the interaction between thinki...

students think creatively in series not in parallel

extrinsic motivation is detrimental to creative practice
development in thinking happens through the interaction with doing
Interaction of Mind and Hand

Thinking (inside the head)

Start with initial (hazy) idea

Explore new idea, enhance the idea

Clarify and validate idea

Critically appraise idea

Potential for more developed thinking

Doing (in real world)

Talk to others, make drawings, sketches, notes, graphs of idea

Make a rough model to represent an idea or prediction

Make a prototype and test it in several situations

Potential for more developed solutions
Implications

Structure activities to move between thinking and doing
Implications

Structure activities to move between thinking and doing
Minimize separation of theory and practice
- timetabling
- examinations
- design of work spaces
- teaching methods
students think creatively in series not in parallel
parallel

IDEA
IDEA
IDEA
IDEA

BEST IDEA

series

IDEA → IDEA → IDEA → IDEA →
extrinsic motivation is detrimental to creative practice
- context must be interesting and relevant
- high level of student choice
Learning

- Students learn best when they are interested
- Learning is context dependent
- Students learn most effectively if they are taught at the time of need
students learn best when they are interested
Student interest?
student ownership of projects
Student interest?
student ownership of projects
open ended briefs/problems
Student interest?
student ownership of projects
open ended briefs/problems
student input into:
assessment
group formation
Student interest?

student ownership of projects
open ended briefs/problems
student input into:
  assessment
  group formation
make the context real and authentic
students learn most effectively if they are taught at the time of need
Implications

Manipulate the students to the point where they think they need what you want to teach them
Implications

Manipulate the students to the point where they think they need what you want to teach them

Appropriate timing for teaching skills
- support tasks for long projects
- opportunity for immediate application
Implications

Manipulate the students to the point where they think they need what you want to teach them

Appropriate timing for teaching skills
- support tasks for long projects
- opportunity for immediate application

Appropriate timing for teaching new knowledge
- ‘teacher knows best’ not good enough
- need to know
learning is context dependent
Implications

- provide an explicit context for activities
- allow practice of skills in a range of contexts
- allow student input into the context
Assessment

- Holistic assessment is more valid than atomized...
- Formative assessment is more effective if it is feedback and...
holistic assessment is more valid than atomized assessment
Implications:
- trust teachers to know what good learning looks like
- consensus on what is good
- specific criteria may be used for diagnostics
formative assessment is more effective if it is feedback and no grade
Implications

- separate assessment and testing
- *doesn’t* mean you can’t grade