Introduction to STEM-CIP

STEM-CIP

Science, Technology, Engineering, Mathematics-Curriculum Integration Program (STEM-CIP) is an innovative approach to the design of curriculum and instructional materials in which the disciplines of science, technology, engineering and mathematics are taught as one, rather than being distinct and separate as in the past. The natural connections among the four disciplines, which have always been there in the past in research labs and professional work, have not traditionally been emphasised in the design and process of present day education. The (upper primary, middle and high school) modules of the STEM Curriculum Integration Program have been designed to engage students in stimulating, authentic and contemporary problem-based STEM scenarios involving the life, physical, environmental, and earth/space sciences, technology and engineering, and mathematics. Drawing from the best in STEM pedagogy, the STEM-CIP modules provide students with the opportunity to learn age appropriate concepts, skills and processes, and to acquire STEM attitudes and "habits of mind".

Curriculum Design Template

All modules within STEM-CIP have been designed using principles of Understanding by Design (Wiggins and McTighe, 1998). Understanding by Design (UbD) is a well-known curriculum design process used to write units (modules of instruction) in a three-stage process — Desired Results, Assessment Evidence and the Learning Plan. Many departments of education, tertiary institutions and universities, and entire school systems advocate the use of Understanding by Design as a contemporary planning process for teaching and assessing applicable standards.

Many authors, among them Reeves (2003), Marzano, Pickering and McTighe (1993) and Lantz (2004) have been proponents of performance-based assessment in which students must demonstrate what they know and can do through the completion of meaningful performance tasks. All modules within STEM-CIP present opportunities for students to engage in performance-based tasks and assessments, along with more traditional forms of assessment, such as selected-response items.

5E Teaching, Learning and Assessing Cycle

A modified 5E teaching, learning and assessing cycle, incorporated into all STEM-CIP modules, is based upon research findings about how students learn science. These findings indicate that students learn best when they have an opportunity to engage in explorations in a hands-on/minds-on environment in which they make and pose explanations for their discoveries. Engagement, Exploration, Explanation, Elaboration and Evaluation are the recursive phases of the 5E teaching, learning and assessing cycle. A brief guide to the 5E model appears next.

The Original 5E Model – At-a-glance Guide (Trowbridge & Bybee, 1996)

Engage
This stage is designed to interest students in the learning, linking it with past learning and common background knowledge. It stimulates curiosity and promotes questioning, while linking the learning to real world experiences. This has a twofold purpose – it interests students in what is coming, while simultaneously showing them the purpose for the learning by situating it in their existing worldview. Teachers can guide this stage by asking specific questions to elicit prior knowledge from students.
Explore
This stage allows students to directly engage with key concepts by inciting them to probe, enquire and question, using their existing knowledge to connect it to new concepts and ideas. These connections may occur rapidly, or may need to be broken down several times before they are clear. The teacher is responsible for directing questioning appropriately and providing probing questions to push children in the right direction.

Explain
In this stage, students begin to logically sequence events and facts from their exploration, with a view to being able to communicate this information to others. The teacher can use this stage to act as a facilitator, offering further explanations and clarifying terms, etc, as necessary. This stage is useful in ascertaining the learner's development and grasp of the key ideas and concepts so far.
Elaborate
This stage allows students to expand what they've learned so far and to connect this directly with their prior knowledge and learning, hopefully reaching understanding. The teacher can therefore verify student understanding fully at this stage.
Evaluate
The process of evaluation should occur throughout the learning experience, allowing the teacher to determine whether the learner has reached the level of understanding needed at every stage. More formal evaluation, however, can now be conducted. If at any point the teacher decides that a student has not reached the desired level, they simply go back to the appropriate stage.

Breakdown of Activities by 5E

TITLE	TOPIC / CONTENT	5E
Module Engagement	Designer Genes	Engage, Evaluate
Activity 1	Take a Good Look at Yourself	Explore, Explain, Evaluate
Activity 2	What is Your Pedigree?	Explore, Explain, Evaluate
Activity 3	Are You My Phenotype?	Explore, Explain, Evaluate
Activity 4	The Language of Chromosomes	Explore, Explain, Evaluate
Activity 5	Cell Cycle and Mitosis	Explore, Explain, Evaluate
Activity 6	A Different Type of Cell Division: Meiosis	Explore, Explain, Evaluate
Activity 7	Dominant and Recessive Traits in Humans	Explore, Explain, Evaluate
Activity 8	In All Probability	Explore, Explain, Evaluate
Activity 9	Engineering a Hypothetical Baby	Elaborate, Evaluate
Activity 10	DNA Fingerprinting	Explore, Explain, Evaluate
Activity 11	Recombinant DNA	Explore, Explain, Evaluate

Levels of Inquiry

All the example standards (derived from the US National Science Education Standards, the US National Council of Teachers of Mathematics Standards, the US National Education Technology Standards for Students and the Standards for Technological Literacy) utilised in STEM-CIP modules call for teaching, implementing and assessing student understanding of inquiry throughout the curriculum. As a result, four scaffolded levels of inquiry are included in most modules, starting with the most structured form — confirmatory inquiry, moving on to structured inquiry, then to guided inquiry, and finally to open inquiry. As students learn the skills and processes, and the content of inquiry, they are challenged by activities that become increasingly more open.

Mathematics In STEM-CIP Modules

One of the goals of STEM-CIP is to develop mathematical power for all students through an integration of science, technology, engineering and mathematics. Exemplary STEM curriculum modules should include performance tasks that engage students and deepen their understandings of mathematics and its applications, and at the same time promote the investigation and growth of mathematical ideas. A key question that is addressed in all STEM-CIP modules is "What enabling mathematical knowledge (facts,

Mathematics Readiness Assessment

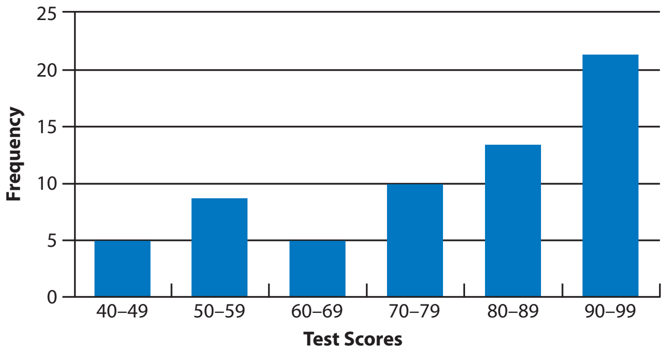
Necessary Mathematics Knowledge and Skills

The use of mathematics knowledge and skills is an integral component of this module. Administering this readiness assessment will help determine if students possess the necessary mathematics background to successfully complete the activities within *Chip off the Old Block*. Strategies should be developed to assist students if needed.

Analyse Data

Analyse data from a frequency table and make comparisons

Use the following graphs to answer questions 1–3.



1. Which interval has the highest frequency?
   D. 90–99

2. What is the total number of test scores?
   C. 57

3. How many more students scored at least a 70 than scored less than 60?
   C. 28

Use the table to answer questions 4–7.

Favourite Type of Book			
Type	Tally	Frequency	Relative Frequency
Fiction	𝍸 𝍸 II	A	B
Mystery	𝍸 𝍸		C
Romance	III		
Nonfiction	𝍸		

4. What is the total number of votes?
   D. 30

5. What is the frequency (A) for fiction books?
   D. 12

6. What is the relative frequency for fiction books (B) expressed as a fraction in lowest terms?
   C. $\mathbf{\frac{2}{5}}$

7. What is the relative frequency for mystery books (C) expressed as a decimal?
   C. $\mathbf{0.3\overline{3}}$

Activity 2: What is Your Pedigree?

Activity Description

"What is Your Pedigree?" is a structured and guided inquiry activity in which students explore, explain and elaborate upon pedigree charts. This activity builds upon "Take a Good Look at Yourself", and concepts of inherited traits are further explored.

WHERETO Elements

E How will we equip students to explore and experience the expected performances?

E-2 How will students self-evaluate and reflect on their learning?

Explain and Evaluate

2a. On page 23 of the SDRB, describe the offspring in the pedigree on page 8 of the SCM. In your description, be certain to include gender, age, relationship and eye colour. Also, what is the probability of having brown eyes based on that pedigree?

Assessment Rubric

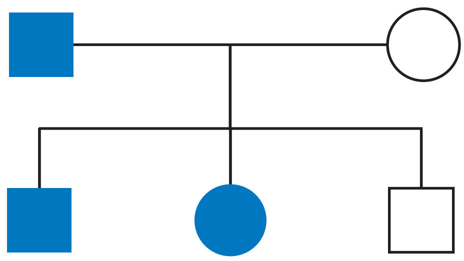
2 = Student states the pedigree shows that the male offspring (oldest) does not have brown eyes and the female (youngest) has brown eyes (1). The student states that, based upon the pedigree, the probability of having brown eyes is 50% (2).

1 = One of the two elements above is either missing or is incorrect.

0 = Not attempted

2b. To see if you really get pedigrees, on page 23 of the SDRB, draw a pedigree for the following description.

Description: Male parent with black hair, female parent without black hair, three offspring — the oldest child a male with black hair, the second child a female with black hair and the third child a male without black hair.



Assessment Rubric

3 = Complete and accurate pedigree shown on previous page.

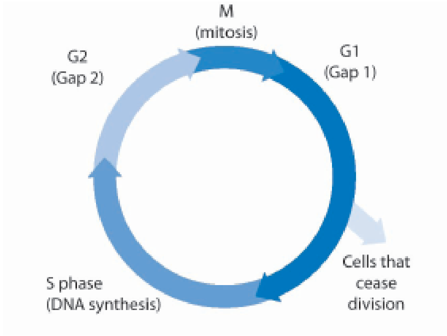
2 = One inaccuracy in pedigree

1 = Two inaccuracies in pedigree

0 = Not attempted

2c. On page 24 of the SDRB, you will find a more involved pedigree for brown eyes. Carefully examine the pedigree and write a complete description of it. Names have been assigned to individuals. Use them in your description.

5b. Draw a scientific drawing of the cell cycle on page 41 of the SDRB.



5c. Now review the simulation for the cell cycle and refine your scientific drawing.

Assessment Rubric

3 = Student thoroughly completes, in Cornell Notes format, information on the cell cycle and includes a drawing.

2 = Student mostly completes, in Cornell Notes format, information on the cell cycle and includes a drawing.

1 = Student partially completes, in Cornell Notes format, information on the cell cycle and includes a drawing.

0 = Not attempted

5d. Review the following website that describes mitosis in an animal cell. Use Cornell Notes format to describe mitosis on page 42 of the SDRB.

http://biog-101-104.bio.cornell.edu/biog101_104/tutorials/cell_division/wf_review_fs.html

Now, compare mitosis in an animal cell to that of a plant cell using the website below. Add this information to your Cornell Notes.

http://biog-101-104.bio.cornell.edu/biog101_104/tutorials/cell_division/onion_review_fs.html

Assessment Rubric

3 = Student thoroughly completes, in Cornell Notes format, information on mitosis in both animal and plant cells and compares the two.

2 = Student substantially completes, in Cornell Notes format, information on mitosis in both animal and plant cells and compares the two.

1 = Student partially completes, in Cornell Notes format, information on mitosis in both animal and plant cells and compares the two.

0 = Not attempted

Explore Mitosis and Evaluate

5e. On a blank sheet of paper, draw a circle (representing the nucleus of a cell) big enough to contain the four pairs of homologous chromosomes (pipe cleaners). Arrange the four chromosome pairs in a random pattern (they may overlap each other) in the nucleus of the cell.

Draw and label a model of your cell nucleus and chromosome on page 43 of the SDRB. You have just simulated Interphase.