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BACKGROUND INFORMATION FOR TEACHERS

DETAILED LEARNING PLAN

ASSESSMENT/EVALUATION

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	Aliens Aren't Always From Outer Space	Engage, Evaluate
Activity 1	Hitchhikers Create Menace	Explore, Explain, Evaluate
Activity 2	Water is Amazing	Explore, Explain, Evaluate
Activity 3	How Dense Are You?	Explore, Explain, Evaluate
Activity 4	Build and Calibrate a Hydrometer	Explore, Explain, Evaluate
Activity 5	Chesapeake Bay and its Watershed	Explore, Explain, Evaluate
Activity 6	Look What Cargo Ships Dragged In	Explore, Explain, Evaluate
Activity 7	Chesapeake Bay: Home to Many	Explore, Explain, Evaluate
Activity 8	Stop the Invasion	Elaborate, 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.

Overview of *The Great Mixing Bowl* — Stage Two of UbD (Assessment Evidence)

Module Performance Task

Summary written in (GRASPS) form – Goal, Role, Audience, Situation, Product and/or Performance, and Standards for Success

"*The Great Mixing Bowl*" is a study of the largest estuary in the United States, the Chesapeake Bay, and how the physical properties of its water impact the distribution of organisms within the Bay. Of particular interest is the zebra mussel and whether this organism could spread into the waters of the Bay. The goal for these upper primary to middle school students is centred on an authentic environmental engineering problem about invasive species, and in particular the zebra mussel. Students must develop a persuasive letter on whether the zebra mussel could spread into the Chesapeake Bay ecosystem. The students act as researchers conducting investigations and gathering information on the Chesapeake Bay, fresh, salt and brackish water, invasive species, and the zebra mussel.

The audience for the persuasive letter is the Citizens of the Chesapeake Bay Watershed, an environmental watchdog group. This group is concerned about the environmental health of the Bay. The watchdog group will evaluate the persuasive letters of the students using the rubric developed for the module culminating activity.

Key Criteria

Students:

- Students follow step-by-step procedures for conducting confirmatory and/or structured investigations.
- Identify and controls variables in all investigations.
- Read to be informed and use digital resources for gathering, organising and evaluating information.
- Engineer, use and re-engineer a hydrometer for recording densities of various liquids.
- Use evidence from investigations and research to support a position on the possible invasion of the Chesapeake Bay by the zebra mussel.

Other Evidence

Students:

- Use mathematics to solve scientific and engineering questions and problems.
- Work successfully within cooperative groups.
- Perform satisfactorily on end of activity assessments.
- Perform satisfactorily on the end-of-module summative assessment (e.g. facts, concepts and applications of forms of energy, chemical reactions and well-designed investigations).