Exploring the Scope of Practicing Basic Science Process Skills in the Creative Problem-Solving Experiences through Modular Cube Robotics Technologies in Students across Various Educational Levels

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#CreativeProblemSolving
#STEAM
#EduRobotics
#EducationalRobotics

Problem Statement

- Promoting a "world community of **scientifically and technologically literate citizens**" was a top priority for the global **Conference on Education for All**, held at Jomtien in 1990 (Layton, Jenkins, & Donnelly, 1994).
- Developing **fundamental science process skills, including observation, classification, communication, measurement, inference, and prediction (Turinam et al., 2012)**, is a key component of science education. These abilities span a variety of cognitive, psychomotor, and affective abilities that enable **students to engage effectively in scientific inquiry and exploration** (Bybee, 1997).
- **Modular Robotics** are user-friendly artifacts that allow students to design, build, and program robots, providing an **engaging and hands-on learning experience in science classrooms** (Papert, 2020).
- **The creative problem-solving (CPS) experiences** using modular cube robotics of students at different educational levels can be different as well. **Elementary students** often approach problems intuitively and may struggle with abstract reasoning (Syawaludin, Gunarhadi, & Rintayati, 2019). **Middle school students**, according to Lin and Chiu (2004), tend to apply more systematic problem-solving strategies. **High school students**, as reported by Choi, Jung, and Baek (2013), often demonstrate higher-order thinking skills and a more analytical approach to problem-solving.
    - *Despite the potential advantages of Modular Robotics in science education, little is known about how its application affects students' experiences in developing fundamental science abilities at various educational levels.*

Research Objectives

- Research Objective 1 (RO1). To investigate how students of different educational levels **experience** practicing basic science process skills while CPS through modular robotics.
- RO2. To **identify and compare** the differences in the CPS experiences of elementary, middle school, and high school students when using Cube Robotics in science classrooms to practice basic science process skills.

Creative Problem Solving (CPS) Procedures in CreaCube Tasks

Through the robotic cubes that the subjects' control in this ill-defined CPS task, mediated by tangible interactive technologies, we can observe the development of new ideas, their evaluation, their inhibition, and their transformation across the CPS process (Romero, 2022). The participants engage in two crucial processes, **Divergent Thinking (DT)** and **Convergent Thinking (CT)**, demonstrating a specific creative intention and endurance in preserving it throughout the task (Leory & Romero, 2021). The process of idea generation relies on divergent thinking, a fast, implicit system grounded in prior information and actions. In contrast, idea evaluation through convergent thinking demands more effort due to the learner's persistence and motivational orientation toward desired outcomes. Ultimately, **the creative outcome, if predefined**, guides implicit processing and encourages further creative behaviors through explicit processing, ultimately leading to the desired outcome (Romero, 2022).

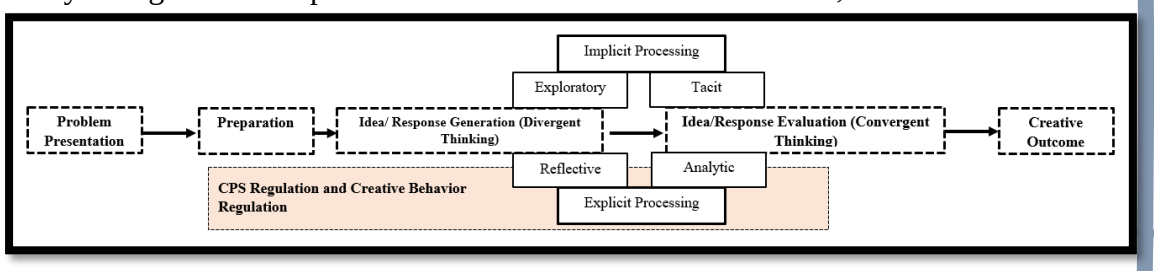


Figure 1. **CPS Process of Simultaneous Divergent and Convergent Thinking (Romero, 2022).**

Six Basic Science Process Skills (*The Science Process Skills | NARST*, n.d.)

The six basic science process skills are *Observing, Inferring, Measuring, Communicating, Classifying, and Predicting* (Turiman et al., 2012). A brief explanation of the process skills is as follows-

Observing- Observing is the process of learning about an object or event by using one's senses.

Inferring- Making an "educated guess" about a thing or an event based on previously obtained data or information is known as inferring.

Measuring- Measuring describes an object's or event's dimensions using conventional and ad hoc measurements or estimates.

Communicating- Using words or visual symbols to describe a process, a thing, or an event is known as communicating.

Classifying- Classifying is the process of gathering or arranging things into categories based on characteristics or standards.

Predicting- Speculating on a future event's result based on a pattern of evidence is known as a prediction.

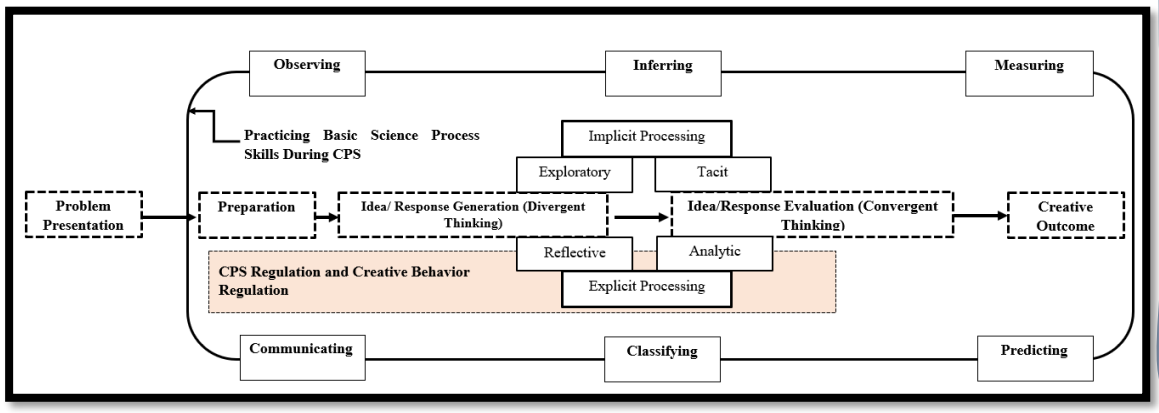
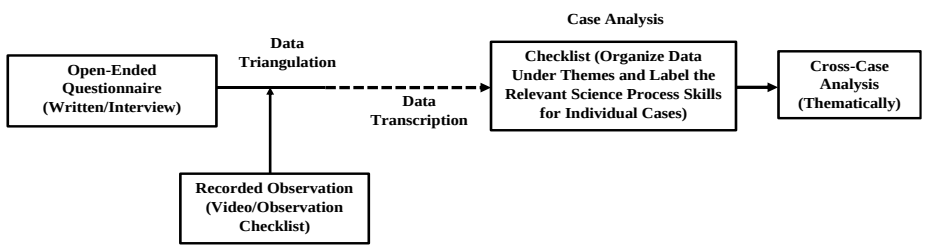


Figure 2. **Conceptual Framework of the Study.**

Sl	Research Questions (RQ)	Source of Data	Sample Size=06	Sampling	Instrument	Analysis Strategy
RQ 01	**How do** students of different grades (e.g., elementary, secondary, and higher secondary) **practice basic science process skills** while solving creative problems through Modular Cube Robotics?	Elementary Level	2 Students	Purposive, Convenient	Open-Ended Questionnaire + **Checklist**	Case Study, Cross-case Analysis, and Thematic Analysis
		Secondary Level	2 Students	Purposive, Convenient		
		Higher Secondary Level	2 Students	Purposive, Convenient		
RQ 02	What are the **<u>similarities</u>** in the ill-defined creative problem-solving experiences among elementary, middle school, and high school students when engaging with Modular Cube Robotics in science classrooms to practice basic science process skills?	Elementary Level	2 Students	Purposive, Convenient	Open-Ended Questionnaire + **Checklist**	Case Study, Cross-Case Analysis, and Thematic Analysis
		Secondary Level	2 Students	Purposive, Convenient		
		Higher Secondary Level	2 Students	Purposive, Convenient		
RQ 03	What are the **<u>differences</u>** in the ill-defined creative problem-solving experiences among elementary, middle school, and high school students when engaging with Modular Cube Robotics in science classrooms to practice basic science process skills?	Elementary Level	2 Students	Purposive, Convenient	Open-ended Questionnaire + **Checklist**	Case Study, Cross-case Analysis, and Thematic Analysis
		Secondary Level	2 Students	Purposive, Convenient		
		Higher Secondary Level	2 Students	Purposive, Convenient		

Methodology Matrix for This Qualitative Study

Figure 3. **From Data Collection to Analysis (Flow of Ideas)**



Implications

- will advance knowledge of how educational robotics can be successfully included in science education to improve fundamental science process abilities.
- Will help to refine hypotheses which may lead to further large-scale research.

Limitations

- The sample size of the pilot is limited.
- Variables (e.g., gender, socio-economic background, previous experiences with modular cube robotics) will be controlled.

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