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# **Position Paper Justifying the Necessity of Teaching Science at the Primary Level and Suggesting Aims, Content Strands, Teaching-Learning and Assessment Strategies**

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## **Justification of Teaching Science at the Primary Level:**

From the *traditional science* to recent popular *science for all* movements, teaching science shifts a lot and towards constructivist philosophy (Bybee, 2009). Constructivist philosophy refers students to learning from prior knowledge and experiences to build new ones that have "immediate and obvious personal and social relevance to the learners" (Fensham, 1985). Again, the Science for All slogan aims at developing scientifically literate citizens through science education (OECD, 2003). Scientific literacy is what the Programme for International Student Assessment (PISA) defines as the "*capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions*" to make informed decisions (OECD, 2003).

Developing learners in such a way, science education can't emerge suddenly in secondary or higher education. But to continue the constructivist approach, it is necessary to make the learners capable of relating science to their daily lives at an early age (Ryle, 1949). Also, different studies suggested that elementary science is the doorway to developing scientific-minded students who can serve both the demands is to being future scientists and the other is to be scientifically literate in the next stages of education life (Hodson & Reid, 1988). On the other hand, Fensham (1985) urged to meet the societal demand for specialized manpower to successfully implement the philosophy in action. However, he offered final year schooling for elites on specialized science rather than differentiating the curriculum in school. Therefore, to insert the love, interest, and motivation for science inside the learners is what elementary science should work for and is the most crucial part of science education towards developing scientifically literate citizens.

## **Aims of Science Education at Primary Level (What Should Be) with Rationales:**

The most difficult task I have been facing since my enrollment into my undergraduate on Education is defining Education on my own. After every semester, I usually feel that my definition should be changed or modified. When I completed the whole 3 years consisting of 6 semesters, I felt the necessity of defining education on my own with the option to revise, modify, and further add options. So I have posted a formal definition of education on my Facebook wall with the privacy status "only me" so that I can make it public only when I am satisfied with my definition. I also have an informal definition of education which is much easier to understand but very deeper in meaning.

In my informal opinion,

*"Our Education is the process through which our thoughts come to the practice (e.g. speech, behavior, etc.)"*

My formal definition is so big but consists of all my thoughts from the last 4 official years of academic life (more than 4 years due to the pandemic). Here is all my 4 years' philosophical structure-

*“Education is the process of creating critical thinkers who have knowledge, understanding, interests, skills, and mindsets to revise beliefs and existing knowledge to create new knowledge or modify old ones and to form values and attitudes within themselves.”*

Integrating the ideas from my **aim of education** into the **aim of science education**, therefore, will consist of the facts of creating critical thinkers who can think scientifically and have the scientific temper to justify any natural phenomena scientifically to make informed decisions based on the evidence in their daily life. To create critical thinkers who have interests in natural phenomena, should have adequate scientific knowledge, understanding, interests, skills, and mindsets to revise beliefs and existing knowledge to construct/modify/create new knowledge, understanding, and skills and to form values and attitudes within themselves.

As UNESCO sees elementary science as a pathway toward achieving its aims (Hodson & Reid, 1988), Smith (2005) advocates for starting citizenry training at the primary level of science education. Hence the general aim of elementary science education should be as follows-

*“Developing scientific tempered learners who feel interested in natural phenomena, try to address the world within which he/she interacts and beyond scientifically and feel responsible. ”*

To sum up, the aims of elementary science should be

- ❖ Developing scientific tempered learners.
- ❖ Arising learners' interests in science.
- ❖ Inserting inquiry mindset among learners.
- ❖ Developing autonomy and responsibility within learners.

These aims I have mentioned have the core tendency to push learners towards autonomy and scientific literacy at the elementary level. In other words, creating a self-directed learner who can direct himself/herself toward lifelong learning. In the next section, the rationale for thinking such as mentioning multiple literatures has been explained.

### **Suggested Content Strands:**

I would like to refer to the three content strands that are defined in the Australian science curriculum. Also, many other developed countries (e.g., Canada, Ireland) think of such content strands as very conducive to what science education aims for. Alongside, aligning the content strands with appropriate content, I have also undertaken some big ideas in mind to give the content strands a more understandable shape. The interrelated content strands are- Scientific Knowledge and Understanding, Scientific Inquiry Skill (very conducive to attaining the science process skills (Bybee et al., 2009)), and Science as Human Endeavor (mainly focus on assigning the knowledge, understanding, and skills with what affective learning demands). The big ideas considered from what Harlen (2015) has explained are- Matters and Universe, Force and Change in Movement of the Objects, Diversity of Organisms and Evolution, Environment and Ecosystem, and Health and well-being. There should not be separate books for biological

science, physical science, Health Science, etc. Rather, an Integrated curriculum is referred to where the textbook will be considered as supportive than the end state. Therefore the content strands will be as follows-

**Table-01**

*Suggested Content Strands for Teaching Science in Primary Level*

Big Ideas	Contents		Three Content Strands	Brief Explanation
Matters and Universe	Matters we encounter in our daily life, their recognizable properties, wondering How big the universe is.	Inquiry Based Activities should be designed around the big ideas considering the three content strands encompassing all the three domains of learning (Krathwohl, 2002)- Cognitive, Psychomotor and Affective	Scientific Knowledge and Understanding	Facts, concepts, principles, laws, hypotheses, and models established by Scientists over time are referred to as scientific knowledge. This strand provides the information that allows students to acquire key science conceptual knowledge and understanding in circumstances that are appropriate for them
Force and Change in movements of the objects	Pull, push or twist objects, the change on objects' movement doing such, Equal forces in opposite directions has no effect When two forces are unequal, how can the effect be (through car accident example).			
Environment and Ecosystem	Living and Non-living things, relation, food chain, food web, solar energy and its role in the ecosystem, Pollution, Effects of pollution on ecological imbalance.		Scientific Inquiry Skills	Hong Kong Science Curriculum Development Guide (2017) mentioned 5 steps-questioning, predicting, conducting an investigation, conclusion from evidence, and reflecting. Through these skills, learners explore, become curious, ask questions, make and share observations, and describe and share what happened scientifically.
Diversity of Organisms and Evolution	Living things produce offspring of the same kind, but offspring are not identical with each other or with their parents. Many living things went extinct, many survived and many emerged. Darwin's theory.		Science as Human Endeavor	Understanding the nature and development of science as scientific knowledge has evolved as a result of many people's actions as an enterprise. How scientific knowledge and applications impact people's lives, including their work, as well as how science is influenced by society and can be utilized to inform decisions and actions.
Health and Wellbeing	Body parts, Importance of cleanliness, food, nutrition, food pyramid, common diseases and remedies			

## **Teaching Learning and Assessment Strategies:**

### **Teaching-Learning Strategies::**

Scientific Inquiry: Problem-based, Activity Based teaching learning encompassing investigation;

Weekly Plan

### **Scientific Inquiry:**

Hong Kong Science Curriculum Guide (2017) mentioned 5 steps of a successful Inquiry as follows-Asking questions related to a given phenomenon, formulating hypothesis based on study and prior knowledge, making conclusions on the findings based on the shreds of evidence, reflecting on the whole process and proposing alternative ways to study the issues in further. From other research, it has been also said that inquiry learning emphasizes the development of thinking skills inside and outside the classroom through engaging learners in investigation, discussion, reflection, and making contextual connections of the learnings (Wilson et al., 2010; Stoddart, 2000).

**Weekly Plan:** Students will design their weekly plans on their own or in groups. This is the concept taken from the Dalton plan (Hargrave, 1928), where students get flexibility in choosing what to learn, how to learn, and when and where to learn themselves. If they fail to carry out the whole plan, they are held responsible and reschedule their learning on the previous reflections.

**Figure 1**

*Sample of a Weekly Plan*

Activities		Expected Occurance	SUN	MON	TUE	WED	THU
Peer Work		2			1	1	
Group Work		2	1	1			
Individual			★		★		★
Digital Content		2h	30min	30 min	30 min	30 min	
Library		1h	30 min	30 min			
Teacher's Session		Optional			★		

It (Figure-01) is just a sample of a directed weekly plan. Where the teacher will give directions to the list of activities on a specific unit, students can individually or group-wise choose the time and activity they need. However, the teachers have to play crucial roles as the learners are only learning how to be more responsible. So, to make things at ease, authority can also be controlled by the teachers to assist learners in the best possible way.

This kind of weekly plan formation will enable students to choose flexible times and paths on their own. A collaborative effort can also be necessary. Through this procedure, students will enrich, develop, and upgrade decision-making abilities, Collaboration, and Responsibility.

Students will take full responsibility for their learning and can address their lackings. Why a weekly plan?- If we go for a daily plan, it will be rigid and if we go for a monthly plan, it will be very hard to control or maintain. So a weekly plan will be easier to maintain for students

themselves. Students can choose multiple ways to learn (eg. individual work, group work, set the goals themselves, and direct their learning on their own. The teacher gives directions and helps students to locate appropriate materials where needed. After the whole activity, students submit their reports and based on which, they define their learning. Henceforth, the whole process is flexible yet directed by the teacher to achieve the required competencies.

Teaching in this model is simply assisting learning. The teacher will take the teacher's session to describe the activity (Which procedures may help, from where students can get appropriate materials, etc.). If students need any assistance during the activity, the teacher may help. After the teacher's session, the teacher may ask questions to check students' understanding of the activity.

### **Teaching Learning Methods:**

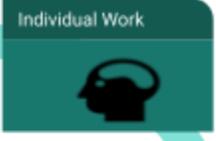
Three models have been suggested to cope with the emerging demand from technologies. All the models are highly applicable considering inquiry-based teaching-learning. These are-

- A. Station Rotation.
- B. Flexible Playlist. &
- C. Flipped Instruction.

- A. Station Rotation: It starts with the teacher's session. After providing the information and instruction needed, the teacher checks the understanding of the students. Then students do their activities through station rotation.

### **Figure-02**

*Station Rotation (How it works)*

Activities		SUN	MON	TUE	WED	THU
Teacher's Session		30 min				
Understanding Check		10 min				
Individual Work						
Peer Work						
Group Work						Presenta tion
Digital Content Station						
Library						

Here, the station can be a library, peer work, group work, digital content station, etc. After that, students submit the outcome of their work. Station rotation simply provides many pathways toward learning. It is a blended learning strategy that makes the classroom, and class time flexible for both teachers and students.

- B. **Flexible Playlist:** Like station rotation, it starts with the teacher's session and understanding check. After that, it provides a playlist of multiple ways of learning. Students can choose their suitable way to learn. More than one playlist is even possible. Here, we only show a playlist as a sample.

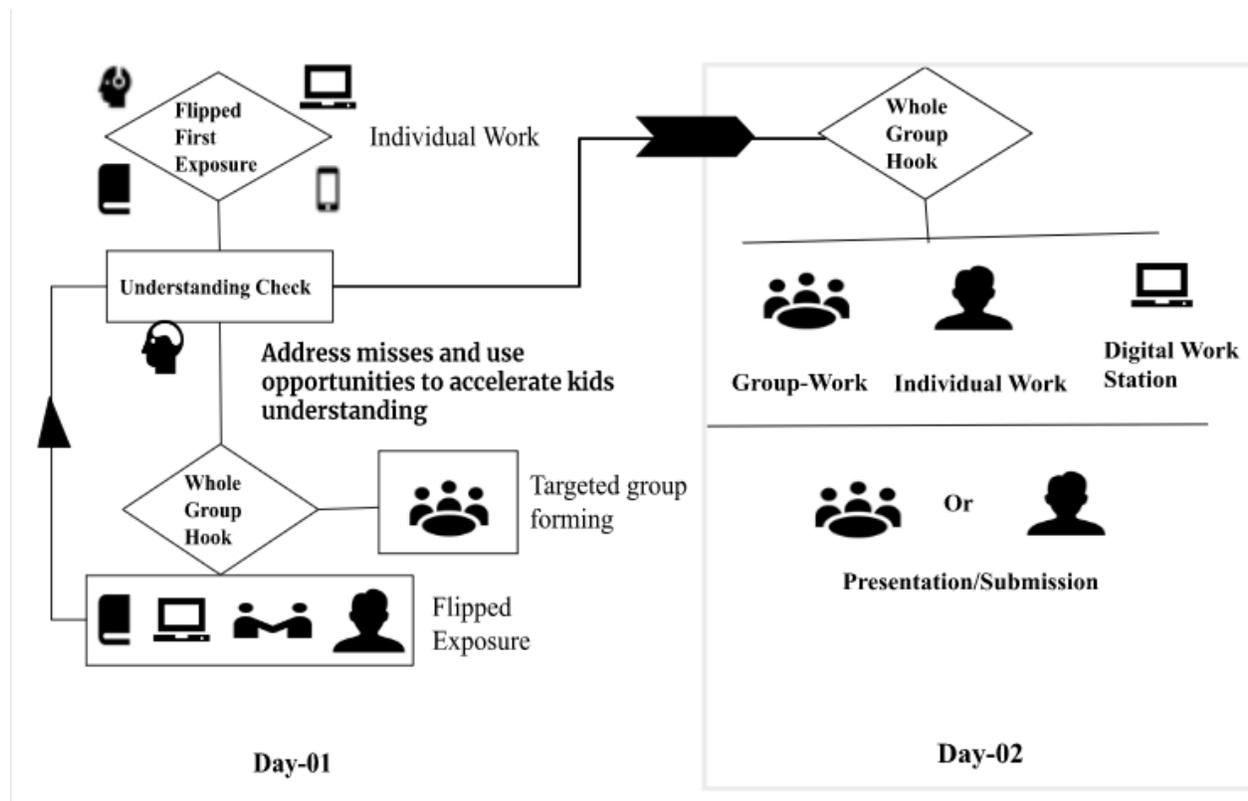
Figure-03  
*Flexible Playlist (How it works)*

Activities		SUN	MON	TUE	WED	THU	
Teacher's Session		30 min					
Understanding Check		10 min					
Individual Work			<div style="background-color: #2e8b57; color: white; padding: 5px;"> <b>Playlist 1</b>   Peer Work   Group Work   Digital Content Station   Library   Individual Work </div>				
Peer Work							
Group Work							Presentation
Digital Content Station							
Library							

C. Flipped Instruction: Unlike the first two models described, flipped instruction starts with individual work named first flipped exposure. Students gain an initial understanding of a topic by themselves in a way/s they feel suitable and flexible. Then the teacher checks their understanding of the topic and identifies the lacking and further necessity of information that needs to be provided. Then the teacher's session or the whole class happens. After acknowledging the needs of the learners, second, flipped exposure comes forth. This time group/peer work can take place along with individual work.

**Figure-04**

*Flipped Instruction (How it works)*



Then after checking their understanding level, the teacher can arrange another whole group hook. After that students complete their work through multiple means, for example, digital content stations, group work, etc. and finally submit their work. After checking students' understanding, teachers can choose individuals for group forming.

**The similarities among these three learning models are:**

- They are blended in nature.
- Provide access to multiple ways of learning.
- Allow a participatory and collaborative approach towards forming responsible students.

**Assessment Strategies:**

- Graded Formative Assessment with Effective Feedback
- Peer Graded Assessment (Feedback/comment with grade).
- Self-graded assessment with opportunities to metacognition (Thinking about thinking, part of self-assessment)

**Graded Formative Assessment with Effective Feedback:** Formative assessment occurs throughout the activity and is maintained by the teacher. Every school must have a scanning

corner with an assistant. Students will scan and submit their individual/Group works in the form of reports, pictures, graphs, etc. Teachers will provide effective feedback when and where needed so that feedback can be provided timely.

Again, to measure learning in all three domains which I have planned to achieve through inquiry-based teaching strategies, there is no alternative to the formative assessment.

**Peer Graded Assessment:** It is simply assessing the peers based on some criteria. Peer-graded assessment helps individuals to go through different perspectives of their peers on the same topic which deepens their understanding. It can also be considered as one of the multiple learning pathways discussed before.

Students will scan and submit their work. Then, the teacher will forward each work to at least 3 students to grade.

**Grading will be based on the questions following:**

Does he/she address the problem? (Yes/No)

Does he/she recommend at least three solutions as per criteria? (yes/No)

Write a special feature you have found here.

**Self-graded Assessment with Opportunities to Metacognition:** Self-assessment is a reflective action of the learner on a specific work or activity. It enables learners to understand their weaknesses or where they need to improve.

**Grading will be based on the questions following:**

Did you complete all your tasks? (Yes/No no, write your lackings)

Did you assess at least three of your peers? (Yes/No)

What are the main ideas (at least three) you found in this unit/activity?

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