LEARNING TO TEACH NATURE OF SCIENCE

in Early Years Education in the United Arab Emirates

SCIKIDS PROJECT

Sibel Erduran, Olga Ioannidou & Rachel Takriti | 2024

UAEU
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Background information:

These resources were produced as part of the SciKids project which ran from 2021-2023. The project was a collaboration between the United Arab Emirates University, UAE and University of Oxford, UK.

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OUTLINE OF WORKSHOPS ON NATURE OF SCIENCE

for early years teachers

SESSION OUTLINES

SESSION 1

INTRODUCTION TO NATURE OF SCIENCE IN EARLY YEARS EDUCATION

LEARNING GOALS:

1. Introduce views on the nature of science
2. Discuss the objectives of science education in early years education
3. Introduce the Family Resemblance Approach to Nature of Science (FRA)

SESSION OUTLINE (180 MINS)

Topic	Activity	Time
Introductions & Outline	PowerPoint presentation	10 mins
Brainstorming ideas about nature of science	Breakout rooms in groups, using posted notes Guiding question: • *What is science about?*	10 mins
Introduction of FRA Wheel and descriptions of categories	PowerPoint presentation	10 mins
Extension of post-it activity and discussion	Breakout rooms in groups	15 min
Reflection on FRA Wheel	Plenary discussion	15 mins
Break		10 mins
Curriculum statements	Group discussion on placing curriculum learning objectives to FRA categories	20 mins
Extension activity: Jigsaw groups	Circulate in groups to share group's ideas and learn about other groups' work	20 mins
Brainstorming for presentations	Presentation groups	20 min
	• *How can FRA enrich how the curriculum is taught?* • *How can FRA be adapted in early years?*	
Break		10 min
Group presentations	Presentations by teachers	45 min
Summary	PowerPoint presentation	5 mins

SESSION 2:

AIMS, VALUES AND SOCIAL ASPECTS OF SCIENCE

LEARNING GOALS:

1. Introduce examples on the Aims & Values, as well as the Social Aspects of science
2. Discuss possible ways of introducing meta-cognitive strategies to learning science in preschools

SESSION OUTLINE (180 MINS)

Topic	Activity	Time
Introductions & Outline	PowerPoint presentation	10 mins
Aims of science	Breakout rooms Guiding questions: • *What is science about?* • *How is science being taught in preschools in UAE?*	10 mins
Teaching and Learning Science	PowerPoint presentation	5 mins
KG1 & KG2 Standards	PowerPoint presentation	5 mins
Family resemblance approach (FRA)	PowerPoint presentation	15 mins
Aims & values of science	Breakout rooms Guiding question: • *Do you think that scientists' values can influence their research? If so, in which way?*	20 mins
Break		10 mins
Bias and subjective prejudices	PowerPoint presentation	5 mins
Social aspects of science	PowerPoint presentation	15 mins
Social aspects of science	Whole group discussion	5 mins
Break		10 mins
Values in early years curriculum	Breakout rooms Guiding question: • *How can we integrate epistemic (knowledge), cognitive (reasoning) and social values of science in early years?*	25 mins
	Whole group discussion	10 mins
Teaching approaches to NOS in early years	Breakout rooms Guiding question: • *What pedagogical approaches can we use to teach about values?* • *How do you teach values about science? How can the extend what you already do in your teaching?*	30 mins
Summary	PowerPoint presentation	5 mins

SESSION 3:

WHAT IS SCIENTIFIC KNOWLEDGE?

LEARNING GOALS:

1. Introduce a discussion on scientific knowledge
2. Discuss the ideas of Hypotheses, Theories, Laws and Models
3. Explore possible ways of introducing theories, laws and models to early years students

SESSION OUTLINE (180 MINS)

Topic	Activity	Time
Learning goals and recap of previous session	PowerPoint presentation	15 mins
The role of knowledge in school science	Whole group discussion	15 mins
Knowledge in early years science	PowerPoint presentation	5 mins
Hypotheses, laws and theories	PowerPoint presentation	5 mins
Knowledge in science- Hypotheses	Breakout rooms What are materials made of? • *How would you explain this example in your classroom? (optional role play)* • *How would you teach about the atomic theory?*	20 mins
Break		10 mins
Nature of knowledge[3]	PowerPoint presentation	10 mins
Models in science	PowerPoint presentation	5 mins
Models in early years science	Breakout rooms Guiding question: • *Can you think of any other models that can be used in early years classrooms?* Drawings used as representations are also types of models. If you asked your students to draw the heat that the sun generates to Earth, how would these drawings look like? Try to recreate student's drawing using the jamboard	30 mins
Summary	Summary of discussion & PowerPoint presentation	5 mins

CONTINUE →

Nature of knowledge in popular culture	Breakout rooms 1. Watch the video: https://www.youtube.com/watch?v=nVW9QOIeqQg and discuss: b. the curriculum themes that could be discussed c. the NOS ideas that can be discussed 2. Look up for other stories, videos and comics that could be used to teach a session incorporating the NOS ideas discussed earlier	20 mins
Summary	PowerPoint presentation	5 mins

SESSION 4:

TEACHING SCIENTIFIC METHODS AND PRACTICES

LEARNING GOALS:

1. Introduce methods and practices in science
2. Explore ideas about hypothesis testing and manipulation of variables
3. Introduce Brandon's Matrix
4. Discuss possible ways of introducing hypothesis testing and manipulation of variables to early years students

SESSION OUTLINE (180 MINS)

Topic	Activity	Time
Learning goals and recap of previous session	PowerPoint presentation	15 mins
Practices in science[4]	PowerPoint presentation	10 mins
Methods in science[5]	PowerPoint presentation	10 mins
Brandon's Matrix	PowerPoint presentation	10 mins
Break		10 mins
Practical activities in early years	Breakout rooms Watch the video and discuss: https://www.youtube.com/watch?v=-6AOthayETs 1. How can these activities fit into Brandon's matrix? 2. How could they be conducted in order to fit other categories?	30 mins
	Activity on Kahoot.com Match the activity with a category from Brandon's Matrix	15 mins
Practical activities in early year	Whole group discussion	10 mins
	What are some challenges in teaching hypothesis testing and manipulation of variables in early years?	
Break		10 mins

CONTINUE →

Lesson planning	Jigsaw activity Topic : Plant growth 1. 4 groups based on Brandon's matrix categories. Each group designs an activity based on one category (expert group) 2. Mixed groups with experts discuss a set of activities on the same topic that include all 4 BM categories (home group)	40 mins
Summary of activity	Whole group discussion	15 mins
Summary	PowerPoint presentation	5 mins

SESSION 5:

SHARING TEACHING PRACTICE AND RESOURCES (POTENTIAL WORKSHOP WITH INPUT FROM TEACHERS' OWN PRACTICES TO ENHANCE COMMUNITY OF PRACTICE AND SHARE RESOURCES AND EXPERIENCS)

LEARNING GOALS:

1. Present examples of teaching NOS in early years
2. Provide peer feedback
3. Review findings from student data

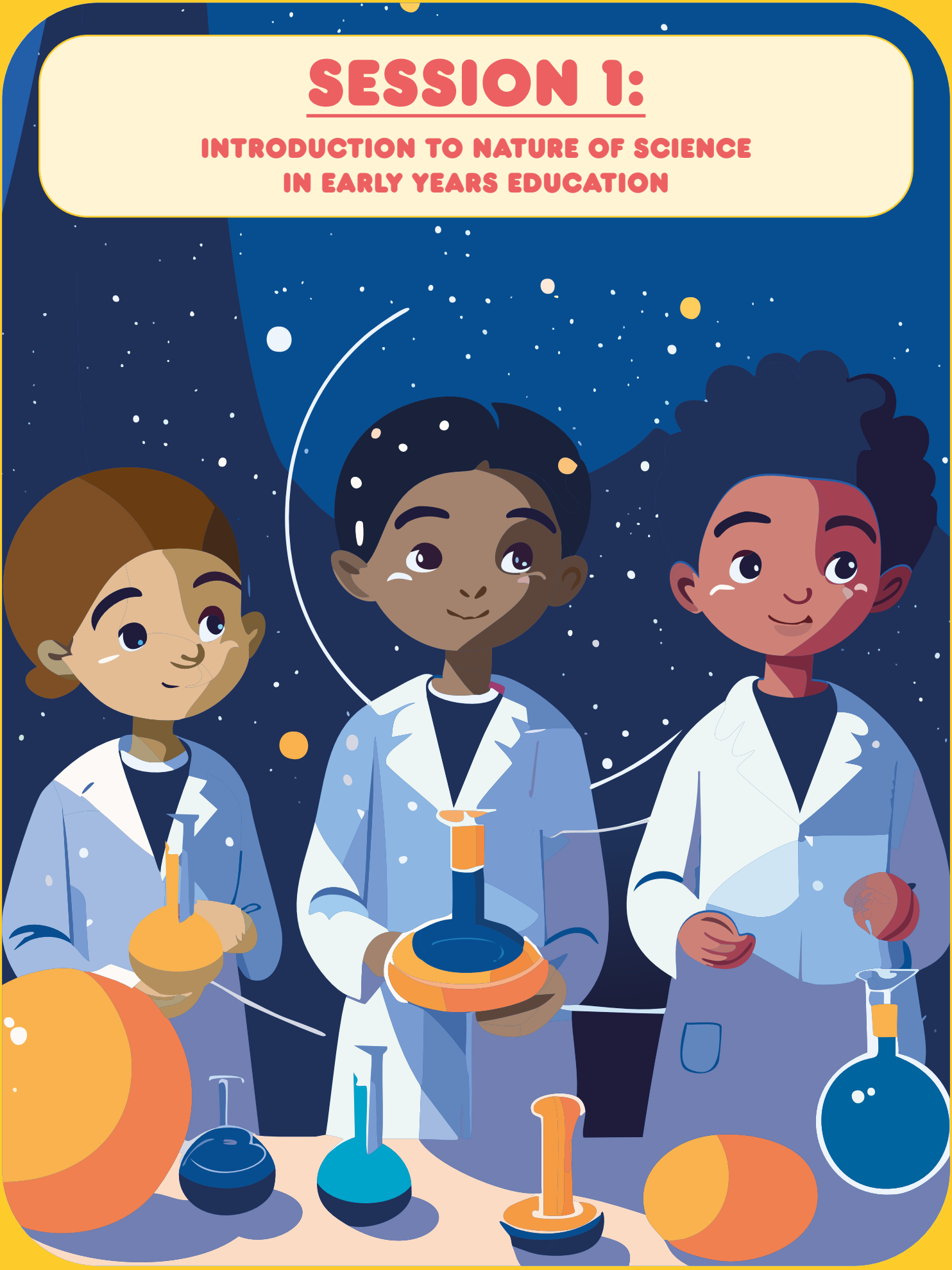
SESSION OUTLINE (180 MINS)

Topic	Activity	Time
Learning goals and recap of previous sessions	PowerPoint presentation	20 mins
Reflection on teaching sessions	PowerPoint presentation & demonstrations from teachers who have used NOS approaches in teaching science'	40 mins
Break		10 mins
Reflection on teaching sessions	Whole group discussion- Guiding question: • *What worked well?* *What could be improved?*	40 mins
Break		10 mins
Findings from student data	PowerPoint presentation	20 mins
Findings from student data	Whole group discussion	20 mins
Summary	PowerPoint presentation	10 mins

RESOURCES FOR POWERPOINT SLIDES

SESSION 1:

INTRODUCTION TO NATURE OF SCIENCE IN EARLY YEARS EDUCATION



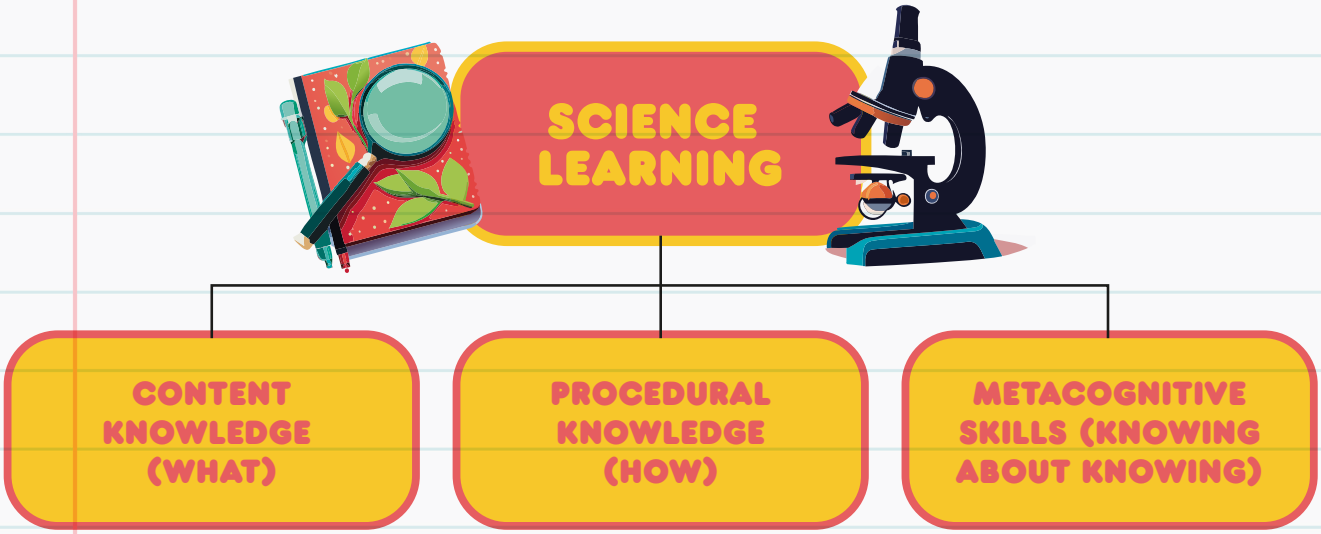
LEARNING OBJECTIVES

1. Discuss different views on the nature of science
2. Discuss the objectives of science education in preschool
3. Introduce the Family Resemblance Approach (FRA) to Nature of Science (NOS)
4. Discuss possible ways of introducing meta-cognitive strategies to learning science in preschool

BRAINSTORM ACTIVITY

- What is science?
- What makes science different from other disciplines of inquiry (e.g., religion, philosophy)?
- What should preschool students know before entering primary school with regard to science?
- How is science being taught in preschools in UAE?
- How can science be taught in preschools in UAE?

TEACHING AND LEARNING SCIENCE



NATURE OF SCIENCE (NOS)

- *Science is both a body of knowledge that represents current understanding of **natural systems** and the **process** whereby that body of knowledge has been established and is continually extended, refined, and revised. Both elements are essential: one cannot make progress in science without an understanding of both.*

- *Likewise, in learning science one must come to understand both **the body of knowledge and the process** by which this knowledge is established, extended, refined, and revised.*

(Duschl, Schweingruber, & Shouse, 2007, p. 26)

KG1 SCIENCE STANDARDS

1. Use methods of scientific investigation
2. Process and communicate information
3. Recognize some common animals and plants
4. Know the external parts of their bodies
5. Know that keeping clean is important to good health
6. Recognizing our world
7. Use their senses to make observations
8. Use common materials

KG1 SCIENCE STANDARDS

Scientific Enquiry

1 Use methods of scientific investigation

1.1 Ask questions about objects, living things and the environment

1.2 Use all their senses to develop intuitive ideas about the properties of materials and objects in their environment

1.3 Sort objects into groups according to common characteristics

2 Process and communicate information

2.1 Communicate observations orally and by drawing

FAMILY RESEMBLANCE APPROACH TO NOS

- There are various ways of thinking about NOS
- Visual images can help inform pedagogical and instructional content about **NOS**

Family Resemblance Approach to NOS

Main concept = *family resemblance*

FAMILY RESEMBLANCE

These are photographs of families.

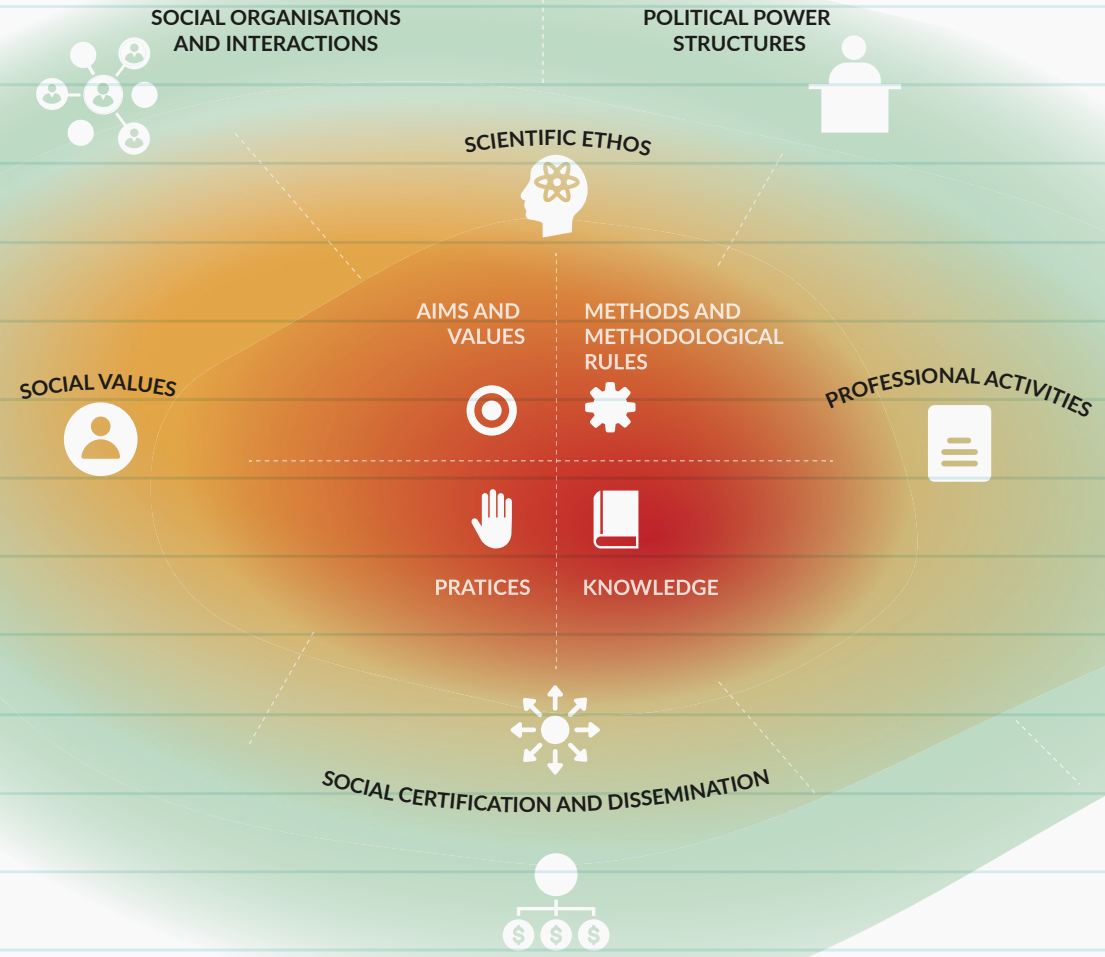
Can you think of what makes a "family"?

- What characteristics do members of a family have?
- What is a biological family?
  Are these biological families? Why?
- Are there other kinds of families?

FAMILY RESEMBLANCE IN SCIENCE

- Think of different branches of science and how/why they are grouped together
- Do they share certain characteristics such as aims and values, methods, practices, knowledge forms and social-institutional contexts?

FAMILY RESEMBLANCE APPROACH



Science as a Cognitive-Epistemicand Social-Institutional System
(Adapted from Erduran & Dagher, 2014, p.28.)

- **Justification of why a domain is considered 'science'**
- **Similar aims and values**
- **Similar practices and methods etc.**
- **Domain-general and domain-specific features**
- **Evidence in chemistry vs astronomy**

Erduran, S. & Dagher, Z. (2014). *Reconceptualizing the nature of science in science education: scientific knowledge, practices and other family categories.* Dordrecht: Springer.

FAMILY RESEMBLANCE APPROACH

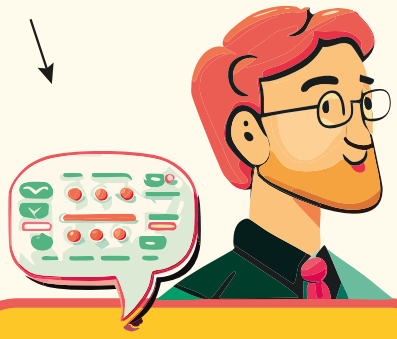
METHOD

PRACTICES

KNOWLEDGE

NATURE OF SCIENCE

AIMS AND VALUES



SOCIAL ASPECTS

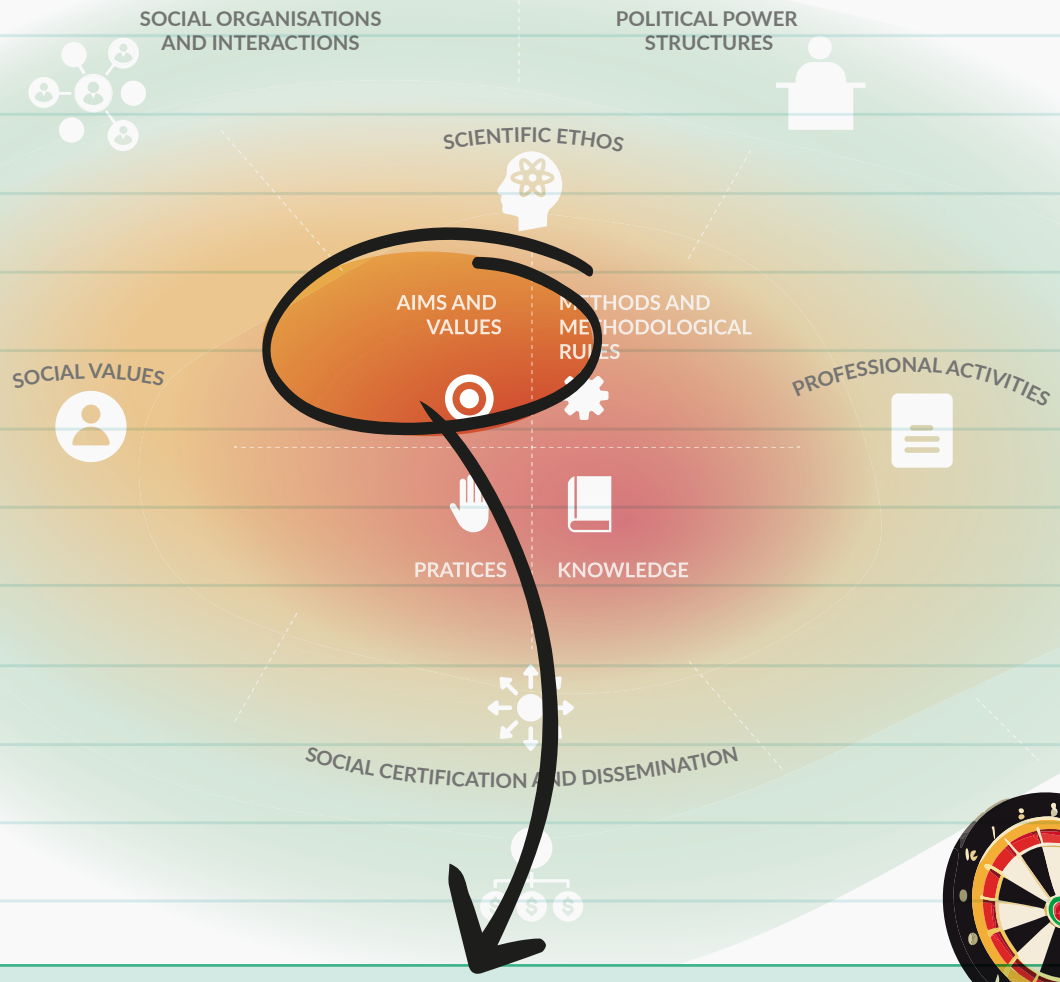
FAMILY RESEMBLANCE APPROACH

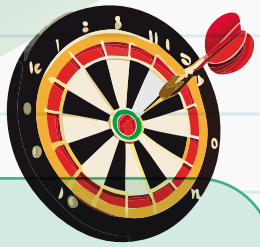
CATEGORY	DESCRIPTION
Aims and values	Cognitive and epistemic objectives of science, such as accuracy and objectivity
Methods	Manipulative as well as non-manipulative techniques that underpin scientific investigations
Practices	Set of epistemic and cognitive practices that lead to scientific knowledge through social certification
Knowledge	Theories, laws and explanations that underpin the outcomes of the scientific inquiry
Social certification and dissemination	Social mechanism through which scientists review, evaluate and validate scientific knowledge for instance through peer review system of journalism
Scientific ethos	Norms that scientists employ in their work as well as in interaction with colleagues
Social values	Values such as freedom, respect for the environment, and social utility
Professional activities	How scientists engage in professional settings such as attending conferences and doing publication reviews
Social organisations and interactions	How science is arranged in institutional settings such as universities and research institutes
Financial systems	Underlying financial dimensions of science including the funding mechanisms
Political power	Dynamics of power that exist between scientists and within structures

SESSION 2:

AIMS, VALUES AND SOCIAL ASPECTS OF SCIENCE

AIMS AND VALUES (BREAKOUT ROOMS)





AIMS AND VALUES (BREAKOUT ROOMS)

1. **In your breakout room, please turn on your camera and microphone and present yourself to the team**

2. **Discuss the following:**

- *Do you think that scientists' values can influence their research? If so, in which way?*
- *How could this be addressed?*
- *Should scientists change their minds when they realize that their ideas are not supported by evidence?*
- *Can you think of other examples of biases and prejudices that can influence scientific findings?*

BIAS AND SUBJECTIVE PREJUDICES

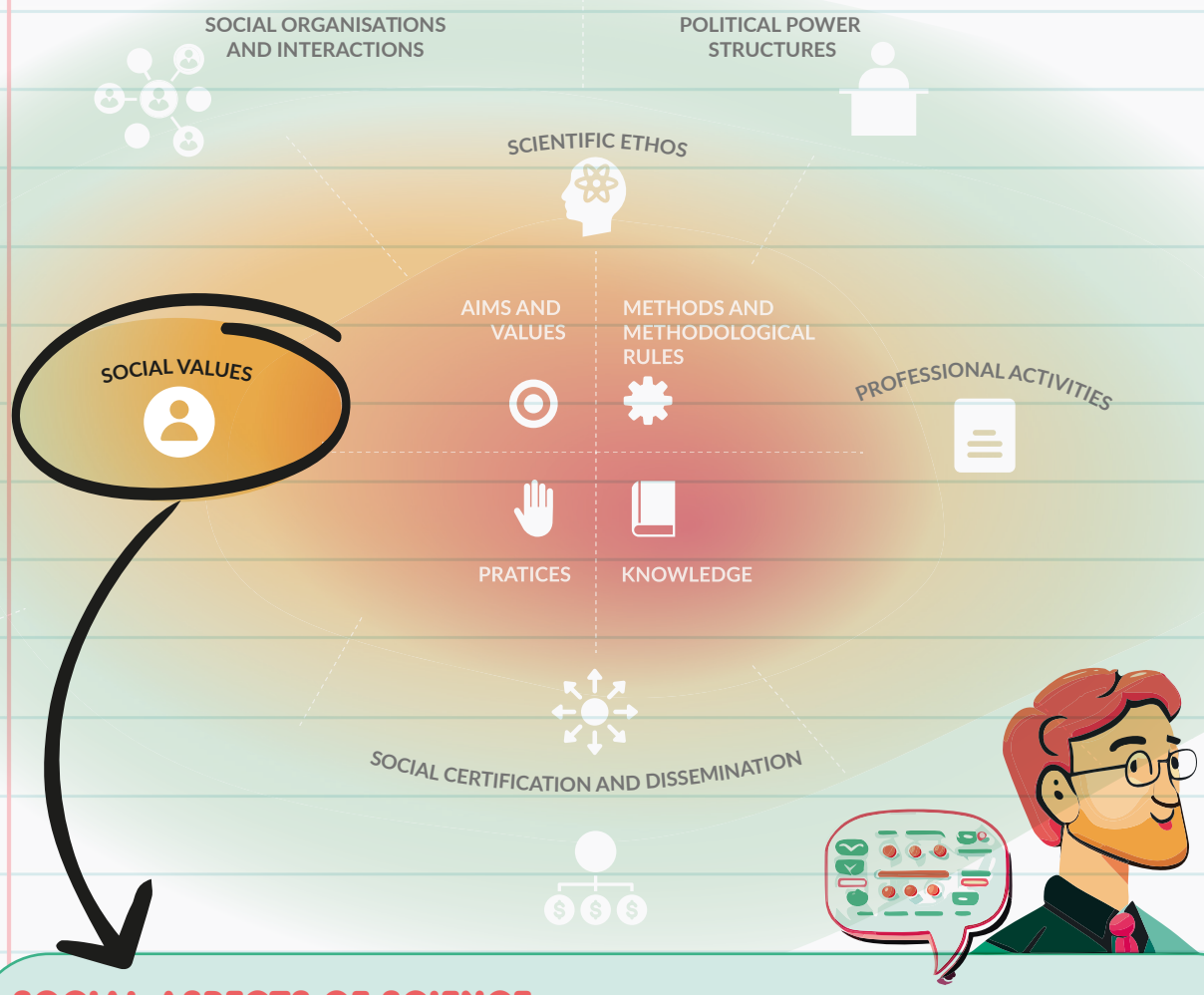
Example:

Andrew Wakefield's 1998 study linked the MMR vaccine to autism. It was retracted from the British Medical Journal in 2010 after evidence that Wakefield manipulated and ignored much of his data. Wakefield's confirmation bias fueled his desire to establish a link to regressive autism – a disproven claim that still affects the medical community today.

HOW DOES SCIENCE WORK?

- **Which of the following photos do you find representative of how science works? Why?**
- **Can you imagine some reasons that might raise some tensions between scientists?**

AIMS AND VALUES (BREAKOUT ROOMS)



SOCIAL ASPECTS OF SCIENCE

- Scientists work in groups and social institutions (e.g. universities)
- They discuss their methods and findings
- They share their findings with other groups and stakeholders (e.g. in conferences)
- Differences in perspectives , values and roles can cause tensions between scientists.

OTHER SOCIAL ASPECTS OF SCIENCE

- Research is funded by funding bodies
- Political decisions may affect research funding and dissemination

ACTIVITY:

CATEGORISE CURRICULUM ACTIVITIES BASED ON THE FAMILY RESEMBLANCE APPROACH

HAVE A LOOK AT THE KG1 AND KG2 STATEMENTS FROM THE UAE SCIENCE STANDARDS.

Using the FRA categories, put the statements into different groups. For example, if you think that a statement is about the aims and values of science, put it under “Aims and Values” category of FRA.

Now think about the following questions:

1. Do you see any patterns in how the standards cover nature of science?

2. Are there any missing categories?

3. Are some categories covered to a greater extent than others? Which ones?

KG1 SCIENCE STANDARDS

Scientific Enquiry	**1. Use methods of scientific investigation.** 1.1 Ask Questions about objects, living things and the environment 1.2 Use all their senses to develop intuitive ideas about the properties of materials and objects in their environment 1.3 Sort objects into groups according to common characteristics. **2 Process and communicate information.** 2.1 Communicate observations orally and by drawing.
Life science	**3. Recognize some common animals and plants** 3.1 Know that different types of organism differ in body shape, form and size and have different names 3.2 Identify basic needs of plants and animals. 3.3 Recognize that plants and animals grow and change. 3.4 Identify animal's body covering and movements 3.5 Recognize the difference between living and non-living things. **4. Know the external parts of their bodies** 4.1 Know the names of the external parts of their bodies 4.2 Identify and describe the five sense and their corresponding body parts. 4.3 Identify the important people that consider as member of their family. 4.4 Identify different emotions 4.5 Identify people are different eg skin/eye color, tall, short **5 Know that keeping clean is important to good health** 5.1 Understand that regular washing is important way to help keep healthy
Earth Science	**6. Recognizing our world** 6.1 Identify components of the natural environment. 6.2 Describe features of day and night. 6.3 Describe how every day human activities generate waste. 6.4 Demonstrate responsible use of technology and equipment. 6.5 Identify/describe seasons that correspond with observable conditions and identify how weather affects daily life. 6.6 Identify the characteristics of the seasons in the UAE.
Physical Processes	**7. Use their senses to make observations** 7.1 Know that we make observations using all our senses and that we can use inventions to assist us.
Materials	**6. Use common materials** 6.1 Use common materials to make and test structures 6.2 Know that objects can be described in terms of the materials that are made from, such as plastic, clay, paper, cloth 6.3 Know that objects can be described in terms of their physical properties, such as colour, size, shape, weight, texture, flexibility, floating, sinking.

KG2 SCIENCE STANDARDS

A look into science	1.1 Use methods of scientific investigation. 1.2 Sort objects into groups according to common characteristics. 1.3 Communicate observations orally and by drawing. 2.1 Use all their senses to develop intuitive ideas about the properties of materials and objects in their environment. 2.2 Identify the important people that consider as member of their family. 2.3 Know the names of the external parts of their bodies. 2.4 Identify and describe the five sense and their corresponding body parts. 2.5 Understand that regular washing is important way to help keep healthy. 2.6 Understand that regular eating is important way to help keep healthy.
Life science	3.1 Recognize the difference between living and non-living things. 3.2 Identify basic needs of plants and animals. 3.3 Recognize that plants and animals grow and change. 3.4 Identify animal's body covering and movements.
Earth Science	4.1 Identify components of the natural environment. 4.2 Describe features of day and night. 4.3 Describe how every day human activities generate waste. 4.4 Demonstrate responsible use of technology and equipment. 4.5 Identify seasons that correspond with observable conditions and identify how weather affects daily life. 4.6 Identify the characteristics of the seasons in the UAE. 4.7 Describe features of weather.
Physical Processes	5.1 Know that different types of organism differ in body shape, form and size and have different names. 5.2 Know that objects can be described in terms of the materials that are made from, such as plastic, clay, paper, cloth 5.3 Know that objects can be described in terms of their physical properties, such as color, size, shape, weight, texture, flexibility, floating, sinking 5.4 Know that materials can change in different conditions
Our Surroundings	6.1 Identify community workers through their uniforms and equipments. 6.2 Name types of transportations.

مدرسة الباهية الخاصة
AL BAHYA
PRIVATE SCHOOL

TEACHING APPROACHES TO NOS IN EARLY YEARS

FRA categories:

1. **Aims and Values**
2. **Social Aspects of Science**

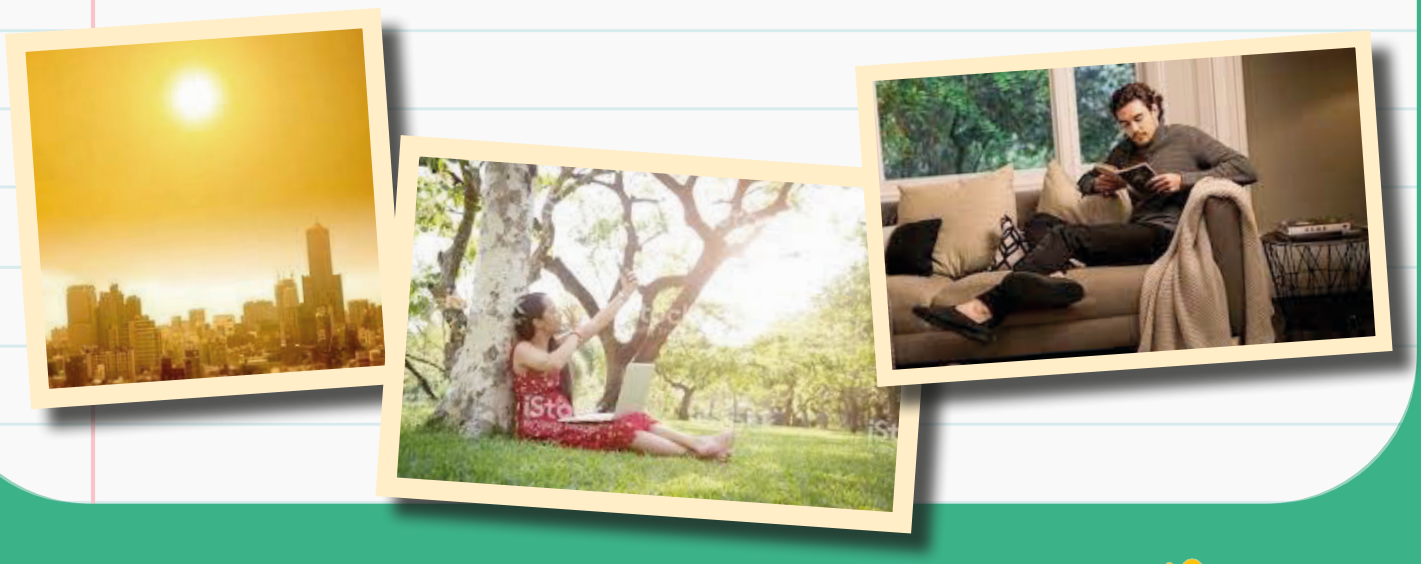
Teaching Approaches:

- Teaching **perspective-taking** and **subjectivity**
- Topic: Explain how to prepare for weather conditions

The activity uses an everyday example to teach students about aims, values and social aspects in a familiar context. Once they recognise these elements, you may want to extend the activity to ask what values and aims scientists have and how their social environment may impact their work.

SCENARIO AS TEACHING ACTIVITY:

On a hot and sunny day you decide to call your friend to say hello. When your friend picks up the phone you realise that he is wearing winter clothes. What would you think?



NATURE OF SCIENCE: SUMMARY

SESSION 3:

WHAT IS SCIENTIFIC KNOWLEDGE?

LEARNING GOALS

- Introduce knowledge in science
- Discuss the ideas of hypotheses, theories, laws and models
- Explore possible ways of introducing theories, laws and models to early years students

WOULD YOU AGREE WITH THE FOLLOWING STATEMENT?

School science is simply a collection and grouping of facts and concepts

- Examples of content knowledge from curriculum
- Children are often curious to know "how do we know what we know"
- They often formulate hypotheses based on their observations

For example:

Babies are smaller in size than toddlers.

↓

Age correlates with size

Grandma is smaller than dad. Does this mean that grandma is younger than dad? No, she is older

↓

Age does not always correlate with size

HYPOTHESES, LAWS AND THEORIES

- A hypothesis is a limited explanation of a phenomenon but may lead to either a theory or a law with the accumulation of enough supporting evidence and acceptance in the scientific community.
- A scientific law is the description of an observed phenomenon usually based on maths. It doesn't explain why the phenomenon exists or what causes it.
- The explanation of the phenomenon is called a scientific theory.

It is a misconception that theories turn into laws with enough research.

NATURE OF KNOWLEDGE

- Tentative nature of science knowledge
- Discoveries come along that totally change our view of the world and our knowledge to date
- Can you think of any?

MIASMA VS GERM THEORY

- The **germ theory of disease** is the currently accepted scientific theory for many diseases. It states that microorganisms known as pathogens or "germs" can lead to disease.
- The miasma theory was the predominant theory of disease transmission before the germ theory took hold towards the end of the 19th century, and it is no longer accepted as a scientific theory of disease. It held that diseases such as cholera, chlamydia infection, or the Black Death were caused by a *miasma* , a noxious form of "bad air" emanating from rotting organic matter.

THEORIES, LAWS AND MODELS

Understanding the mechanism of knowledge growth would ensure that students distinguish scientific knowledge as a coherent network of theories, laws and models. Rather than discrete and unrelated pieces of information.

WHAT WE SEE VS WHAT THERE IS

Our observations are usually the best available tool that we have to make predictions

But, sometimes our observations are limited

WHAT IS A MODEL?

A model is a representation of something that is unfamiliar to us with something familiar to us.

For example, an anatomy doll is a representation of the human body

BREAKOUT ROOMS - TIME TO DRAW!

Can you think of any other models that can be used in early years classrooms?

Drawings used as representations are also types of models.
If you asked your *students to draw the heat that the sun generates to Earth*, how would these drawings look like?
Try to recreate student's drawing using the jamboard

MODELS IN EARLY YEARS

SCHOOL SCIENCE

"Although school science is dominated by theories, laws and models, often characterised as "content knowledge", there is little in the way of building students understanding of how various forms of scientific knowledge relate to each other and how they contribute to scientific explanations in a given scientific discipline in a specific topic."

(Erduran and Dagher 2014)

NATURE OF KNOWLEDGE IN POPULAR CULTURE- BREAKOUT ROOMS

1. **Watch the video: https://www.youtube.com/watch?v=nVW9QOIeqQg and discuss:**

   - **the curriculum themes that could be discussed**
   - **the NOS ideas that can be discussed**

2. **Look up for other stories, videos and comics that could be used to teach a session incorporating the NOS ideas discussed earlier**

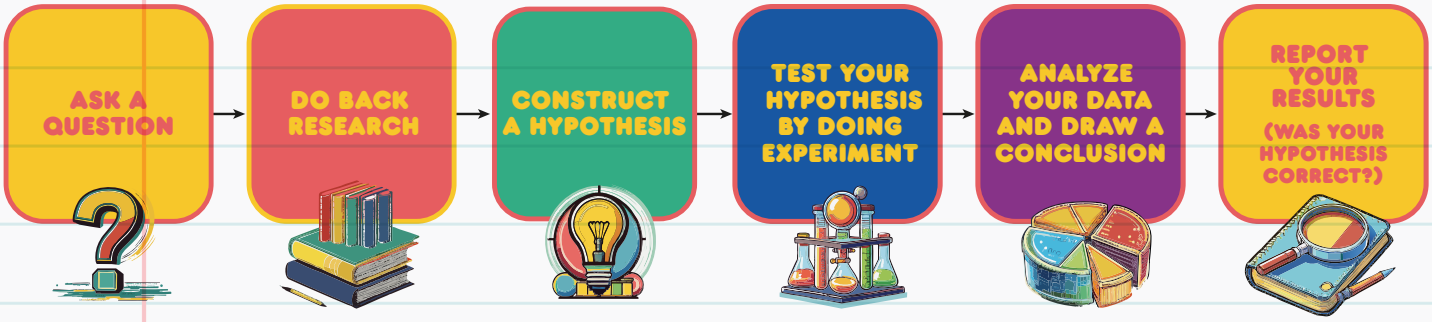
SESSION 4:

TEACHING SCIENTIFIC METHODS AND PRACTICES

METHODS IN SCIENCE

- **What do science investigations begin with?**
  - An observation (Practice)
  - And/or a question (Which comes first?)
  - Decide what method(s) to carry out the investigation
    - Run the investigation
    - Collect data
    - Analysis the data
    - Draw conclusions

THE MYTH OF THE SCIENTIFIC METHOD!



WHY IS THE 'SCIENTIFIC METHOD' CONSIDERED FLAWED?

It implies that there is one universal method shared as much by the theoretical cosmologist in their office as the ecologist working in the field.

It fails to capture the diversity of the methods science uses.

Students should be involved in multiple investigations that expose them to the range of methodological diversity involved in science domain they are studying

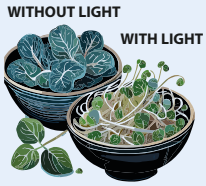
Non-manipulative observation and description and/or measurement (e.g. angle, time)

- **Hypothesis testing**
- If the earth spins, then...
- If the earth doesn't spin, then...

SCIENTIFIC METHODS (BRANDON, 1994, P. 63)

	EXPERIMENT / OBSERVATION	
	MANIPULATE	NOT MANIPULATE
TEST HYPOTHESIS	1	2
MEASURE PARAMETER	3	4

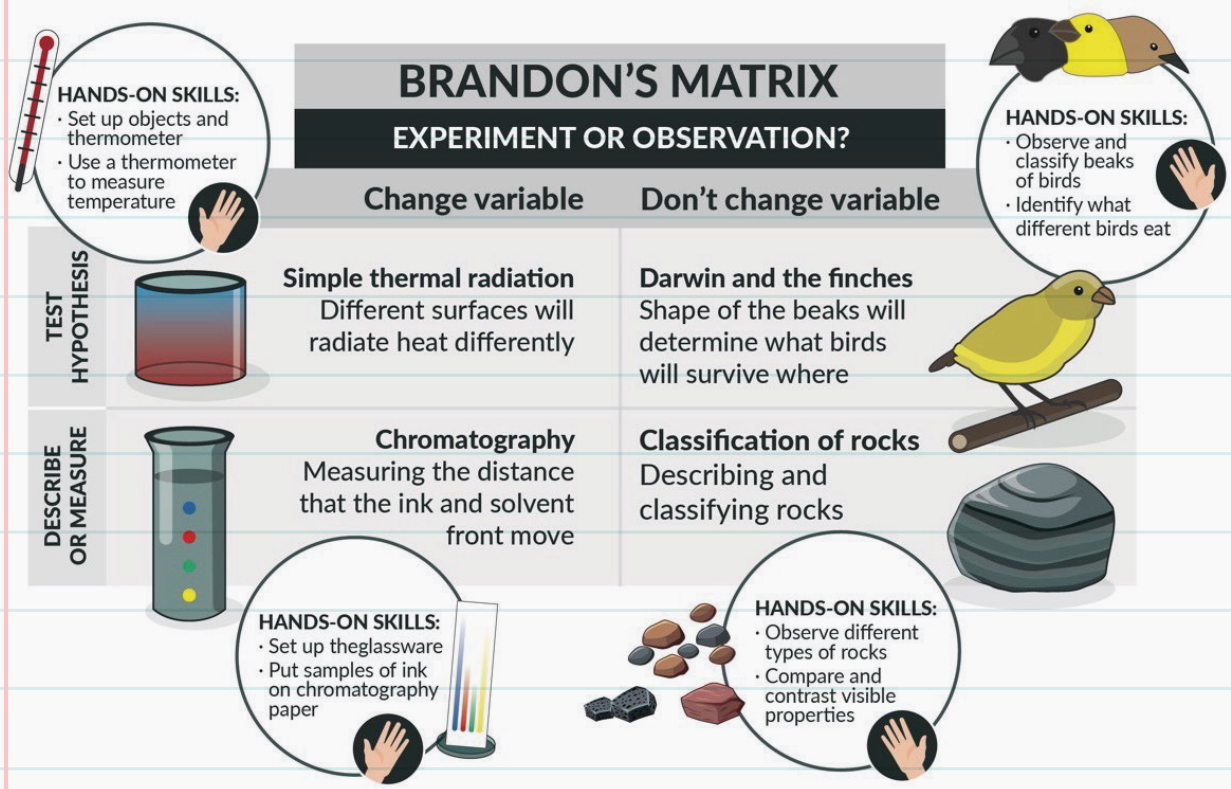
BRANDON'S MATRIX

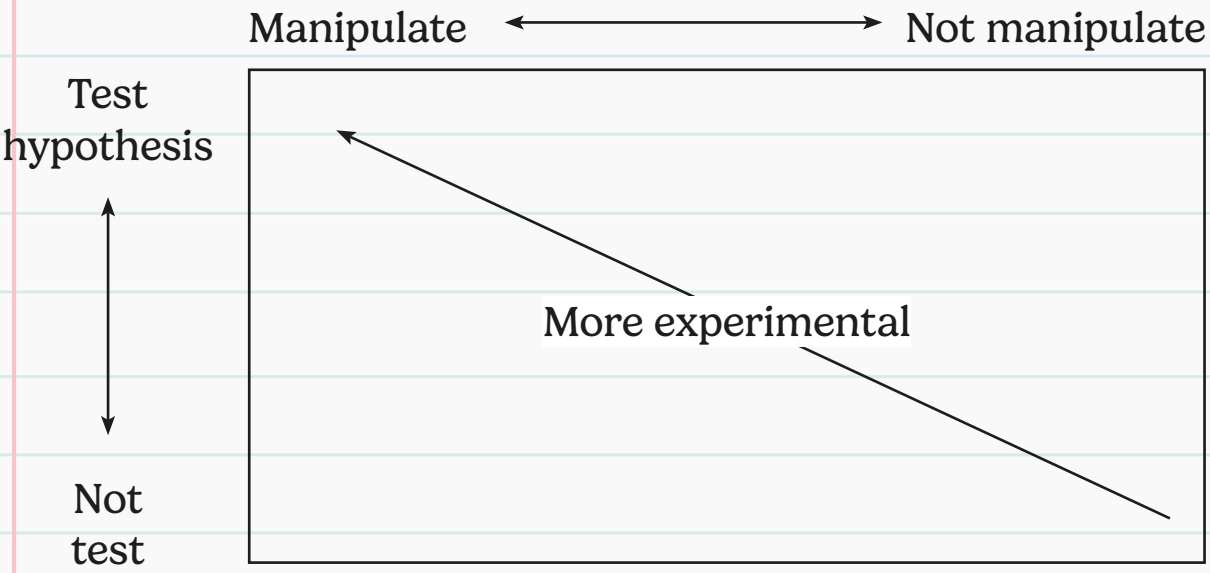
	EXPERIMENT / OBSERVATION	
	MANIPULATE	NOT MANIPULATE
TEST HYPOTHESIS		
MEASURE PARAMETER		

For more resources based on Brandon's Matrix, please visit
https://projectcalibrate.web.ox.ac.uk

SCIENTIFIC METHODS (BRANDON, 1994, P. 63)

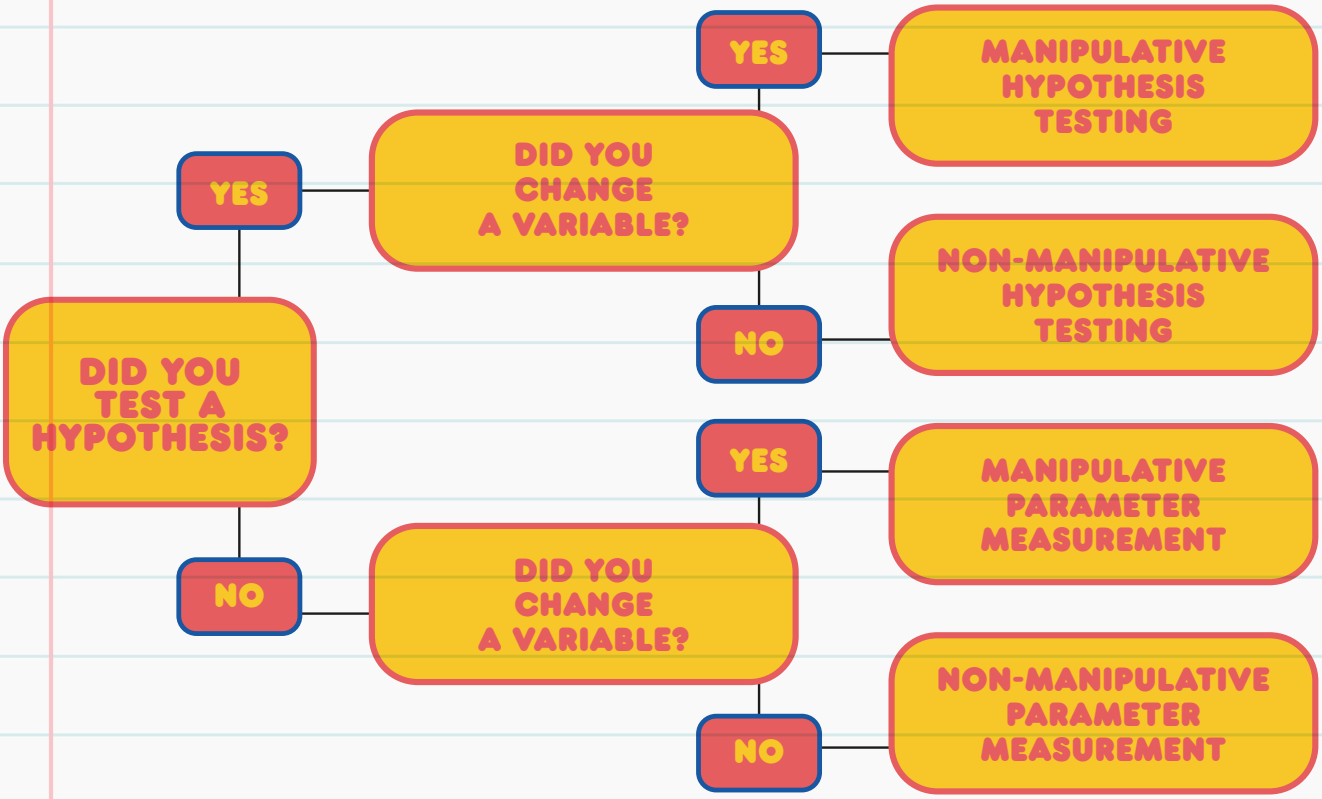
	EXPERIMENT / OBSERVATION	
	MANIPULATE	NOT MANIPULATE
TEST HYPOTHESIS	This scientific approach tests a hypothesis by changing dependent and independent variables.	This scientific approach tests a hypothesis without changing dependent and independent variables.
MEASURE PARAMETER	This scientific approach does not test a hypothesis, but conducts an investigation by changing dependent and independent variables	This scientific approach has no hypothesis; it is an exploratory approach to measure or observe an outcome.


BRANDON'S MATRIX
EXPERIMENT OR OBSERVATION?
Change variable
Don't change variable
TEST HYPOTHESIS
DESCRIBE OR MEASURE
HANDS-ON SKILLS:
· Set up objects and thermometer
· Use a thermometer to measure temperature
Simple thermal radiation
Different surfaces will radiate heat differently
Darwin and the finches
Shape of the beaks will determine what birds will survive where
HANDS-ON SKILLS:
· Observe and classify beaks of birds
· Identify what different birds eat
Chromatography
Measuring the distance that the ink and solvent front move
Classification of rocks
Describing and classifying rocks
HANDS-ON SKILLS:
· Set up theglassware
· Put samples of ink on chromatography paper
HANDS-ON SKILLS:
· Observe different types of rocks
· Compare and contrast visible properties


Manipulate
Not manipulate
Test hypothesis
More experimental
Not test

WHAT METHOD DID I USE?

Answer the questions to find out what method you used




SCIKIDS
PROJECT

LEARNING TO TEACH NATURE OF SCIENCE

in Early Years' Education in the United Arab Emirates

Sibel Erduran, Olga Ioannidou & Rachel Takriti | 2024

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