ICSE Academy
EUROPEAN WORKSHOP SERIES
Spring 2024

Cluster 1: Tools and approaches to deal with sustainability issues in STEM education

ICSE Academy
International Centre for STEM Education
Co-funded by the European Union
NTNU
Pädagogische Hochschule Freiburg
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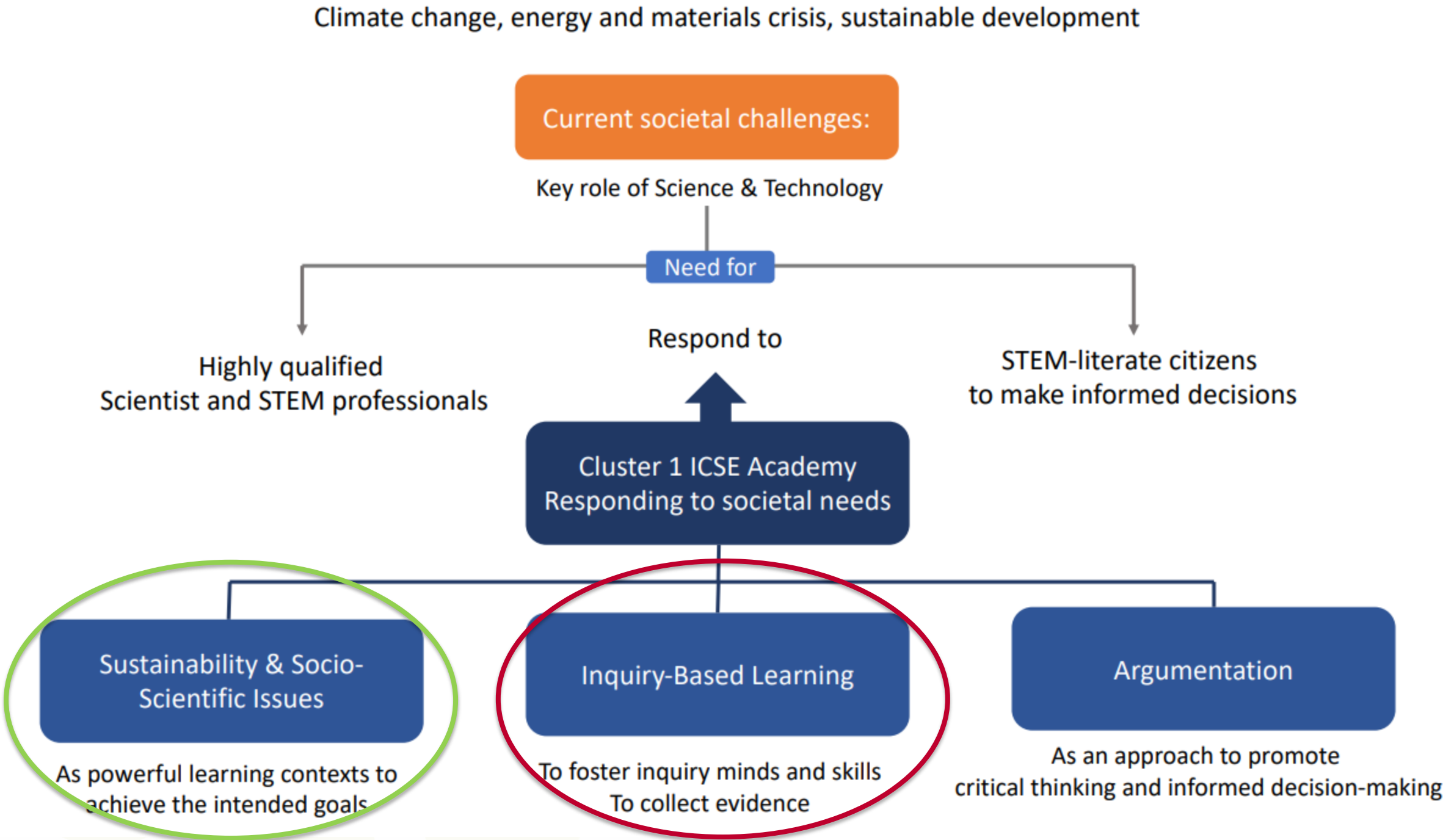
Date	Topic
Cluster 1: Tools and approaches to deal with sustainability issues in STEM education	
March 5 * 16:00 – 18:00	Local introduction to the workshop series
March 12 16:00 – 18:00	1. Sustainability and socio-scientific issues in STEM education
March 19 16:00 – 18:00	2. Inquiry-based STEM learning
April 9 16:00 – 18:00	3. Argumentation and decision making in STEM education
Cluster 2: Diversity and inclusion in STEM	
April 16 16:00 – 18:00	1. Introduction to diversity and inclusion in STEM education
April 23 16:00 – 18:00	2. Analysing and designing STEM tasks for diversity and inclusion
April 30 16:00 – 18:00	3. Analysing inclusive classroom practices (based upon try-outs)

Cluster 3: STEM in a digital era	
May 7 **16:00 – 18:00**	1. Digital Competencies, Skills and Technology in STEM Fields
May 14 **16:00 – 18:00**	2. Escape Games in STEM Education and VR
May 21 **16:00 – 18:00**	3. Computational Thinking
Cluster 4: Innovative Assessment in STEM education disciplines	
May 28 **16:00 – 18:00**	1. Innovative assessment in STEM disciplines
June 4 **16:00 – 18:00**	2. Preparing innovative assessment practices
June 11 **16:00 – 18:00**	3. Innovative assessment practices and equity


Climate change, energy and materials crisis, sustainable development
Current societal challenges:
Key role of Science & Technology
Need for
Respond to
Highly qualified
Scientist and STEM professionals
STEM-literate citizens
to make informed decisions
Cluster 1 ICSE Academy
Responding to societal needs
Sustainability & Socio-Scientific Issues
As powerful learning contexts to achieve the intended goals
Inquiry-Based Learning
To foster inquiry minds and skills
To collect evidence
Argumentation
As an approach to promote
critical thinking and informed decision-making

Tools and approaches to deal with sustainability issues in STEM education

Sustainability issues (characteristics):

- complex questions
- no given/correct answer
- seen from different perspectives: ecological, economical and societal
- involved parties different views – not easy to solve
- interdisciplinary – requires other approaches than the traditional, teacher led
- require **student led and inquiry-based approaches** (Bjønnes, 2017; Laurie et al., 2016)

- Inquiry-based approaches suitable to practice sustainability competences (Bjønnes, 2017; Espen, 2019)
- Solving complex and authentic tasks through the use of inquiry-based approaches gives students a **deeper understanding**, and it enables students to develop **higher-order cognitive abilities** (see Teig et al., 2021)

SESSION 2: INQUIRY-BASED STEM LEARNING

19th March 2024

Coordinators: Ragnhild Lyngved Staberg and Jardar Cyvin,
Norwegian university of science and technology (NTNU), Norway

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OUTLINE, SESSION 2

- Sum up, homework (Animal footprints)
- Plenary introduction to Inquiry-based learning (IBL)
- Group work: Discuss best practices from your countries
- Plenary sharing

- BREAK

- Plenary introduction to five types of IBL
- Group work: Discuss an open task (pros and cons)
- Plenary sharing
- Reminder of homework (assignment)

Sum-up of prework - Animal Footprint

Some input from you:

- not common in my country/context
- requires a “brave teacher”
- fine for the active ones
- more problematic for the passive ones
- connect scientific concepts with real-world observations
- positive for interdisciplinary work (science, math, language, art, social studies)
- encourages critical thinking and creativity, which are essential skills across various subjects
- encourages collaborative learning and differentiation

https://s.ntnu.no/animal-footprint

INTRODUCTION TO IBL

INQUIRY-BASED WORK: “Dear child has many names… ”

American - I

English - E

- *Inquire (Enquire) (verb):* «to put a question, seek for information by questioning, to make an investigation»
- *Inquiry (Enquiry) (noun):* «a request for information, a systematic investigation, examination into facts or principles».

- IBL – Inquiry Based Learning
  IBT – Inquiry Based Teaching
  IBE – Inquiry Based Education
  IBST – Inquriy Based Science Teaching
  IBSE – Inquiry Based Science Education

«Inquiry»: different meanings in different contexts…

- The three most important meanings within science education:

«scientific inquiry» refers to the various ways in which scientists study the natural world and suggest explanations based on evidence derived from their work

«inquiry learning» refers to a learning process in which children actively acquire knowledge of science concepts and learn about nature of science

«inquiry teaching» is defined as a pedagogy by which teachers engage students in inquiry.

Different terms used to describe inquiry sometimes refer to

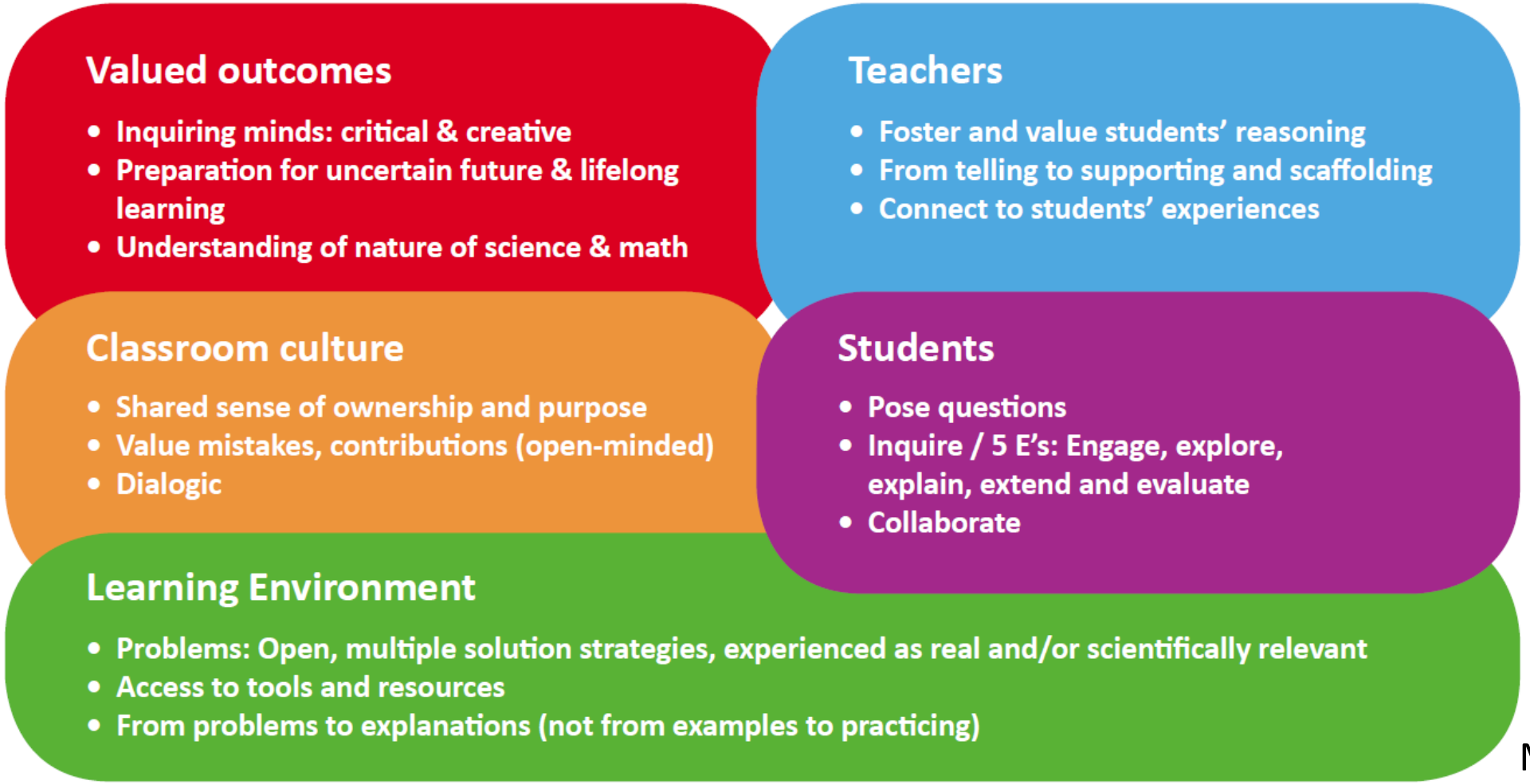
1) the amount of guidance provided by the teacher (e.g., Guided inquiry)
2) the cognitive activities of the student (e.g., Model-based inquiry)

Anderson, 2002
Duschl, 2008

HOW DOES AN INQUIRY CLASSROOM LOOK LIKE?

Stockpicture Microsoft 365

Multifaceted understanding of IBL



Maass, 2013

10 Characteristics of the Inquiry Classroom

@Trev_Mackenzie @sylviaduckworth

1. Nurture student passions & talents

2. Empower student voice & honour student choice

3. Increase motification and engagement

10. Solve the problems of tomorrow in the classrooms of today

Genius Hour
20% Time
Passion Projects

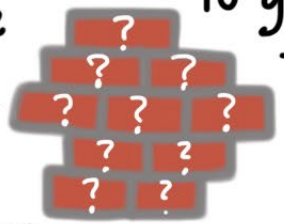
4. Foster curiosity and a love for learning

9. Enable students to take ownership over their own learning and to reach their goals

5. Teach grit, perseverence, growth mindset & self-regulation

7. Deepen understanding to go beyond memorizing facts and content

8. Fortify the importance of asking good questions



6. Make research meaningful & develop strong research skills

https://www.trevormackenzie.com/

CLASSIFICATION OF ACTIVITIES (DEGREES OF FREEDOM, INQUIRY LEVELS)

Stockpicture Microsoft 365

Degrees of freedom

Table 1. Taxonomy of instructional approaches based on the dimensions of question/method/ result that can be either open (O) or given (X)

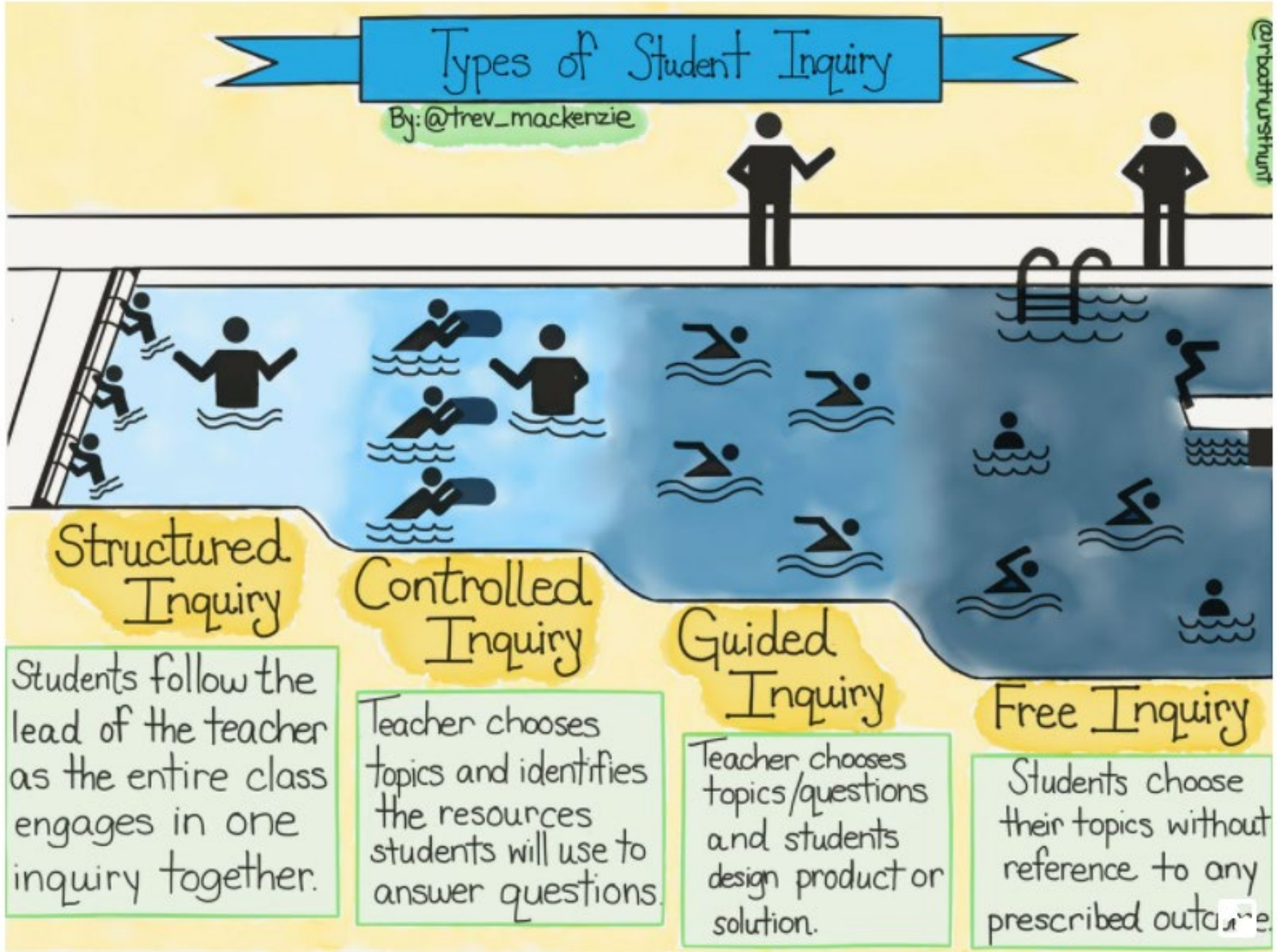
Degrees of freedom	Type of instruction-al approach	Question / Problem	Method	Answer / Result
0	Expository	X	X	X
0	Discovery	X	X	X
1	Problem-Based	X	O	X
1	Guided Inquiry	X	X	O
2	Inquiry	X	O	O
3	Open Inquiry	O	O	O

Gyllenpalm, J., Wickman, P.-O., & Holmgren, S.-O. (2010). Secondary science teachers' selective traditions and examples of inquiry-oriented approaches. Nordina : Nordic studies in science education, 6(1), 44–60 (16s). https://doi.org/10.5617/nordina.269.

Inquiry level in IBL lessons

Fradd et al. (2002), inquiry level in IBL lessons							
Inquiry Level	**Questioning**	**Planning**	**Implementing**	**Concluding**		**Reporting**	**Applying**
			Carrying out plan	**Analyse Data**	**Draw Conclusions**		
0	Teacher	Teacher	Teacher	Teacher	Teacher	Teacher	Teacher
1	Teacher	Teacher	Students /Teacher	Teacher	Teacher	Students	Teacher
2	Teacher	Teacher	Students	Students/ Teacher	Students/ Teacher	Students	Teacher
3	Teacher	Students /Teacher	Students	Students	Students	Students	Students
4	Students/ Teacher	Students	Students	Students	Students	Students	Students
5	Students	Students	Students	Students	Students	Students	Students

Fradd et al. (2002) Promoting science literacy with English language learners through ... Bilingual Research Journal, Social Science Premium Collection, 25 (4)-479-501.



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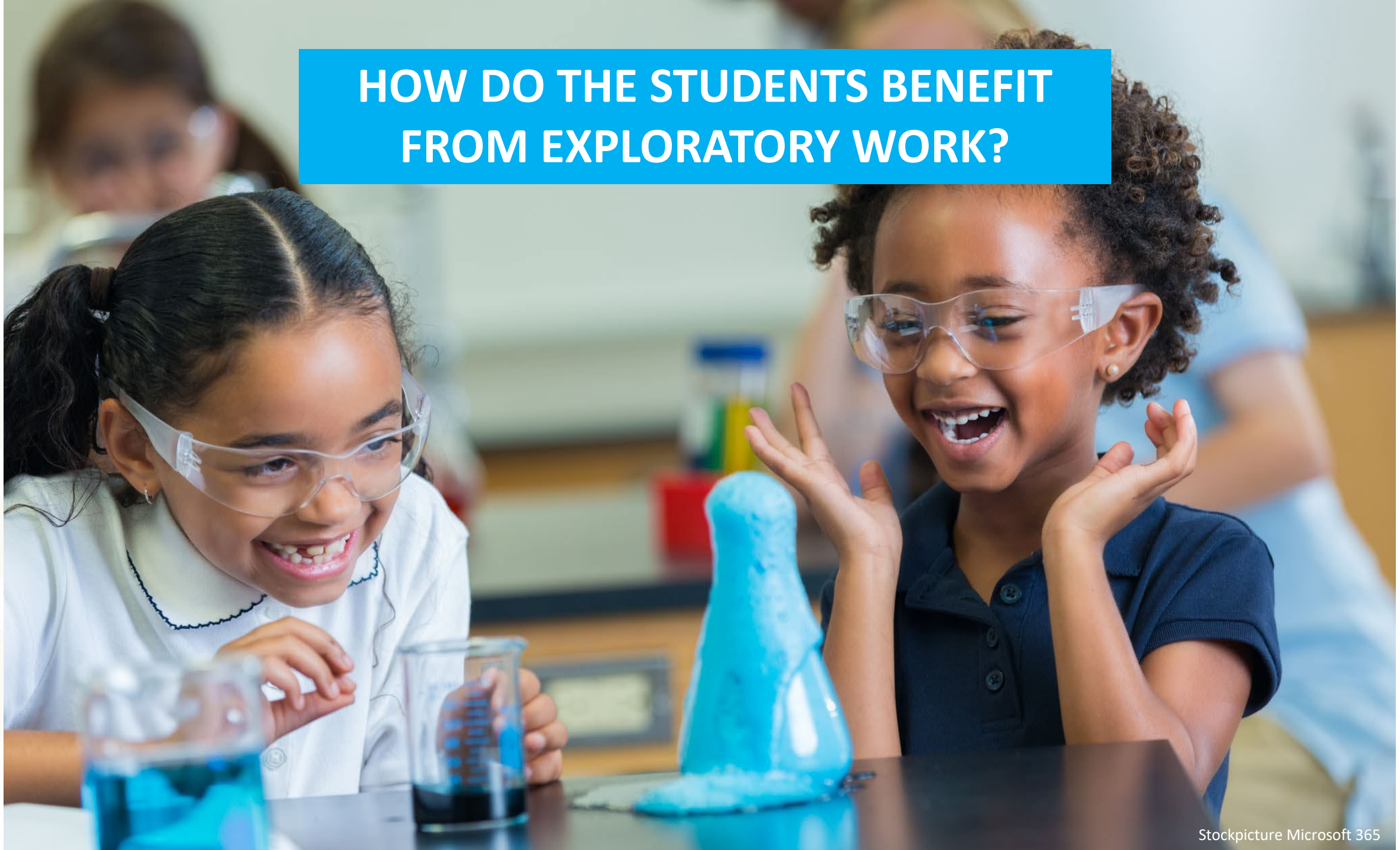
HOW DO THE STUDENTS BENEFIT FROM EXPLORATORY WORK?



Stockpicture Microsoft 365

Why Inquiry Based Science Education (IBSE)?

Why is this a central concept?

Gives possibilities to be creative

Is motivating…

Gives practice in basic skills like writing, reading, talking, calculation, digital skills.

Gives practice in cooperation with peers

Gives a deeper understanding of scientific concepts and models…

Gives practice and experiences in solving authentic scientific problems

Gives experiences and insights in scientific methods researchers use

Can give experiences in argumentation and decision making

(Anne B. Øyehaug, 2014)

What does research say bout IBSE as method to stimulate students' learning and interest?

TIMSS 2015: exploratory learning has a strong and positive connection with pupils' achievements (Bergem et al, 2016, chap. 8.4).

The correlation between the teacher's confidence in using exploratory methods and pupils' performance was also significant and high (0.59).

Several studies document that traditional teaching leads to superficial learning (Pellegrino & Hilton, 2012; Frøyland et al., 2016).

TIMSS 2019: strong positive correlation between IBL and motivation. Moderately strong correlation between IBL and academic achievements (Norwegian 9th graders) (Teig et al. 2021)

Trend in research about IBSE as methods for stimulating students' learning and interest:

Learning:
IBSE, with scaffolding, improve learning of both process and product dimensions of the sciences

Motivation:
IBSE motivate students

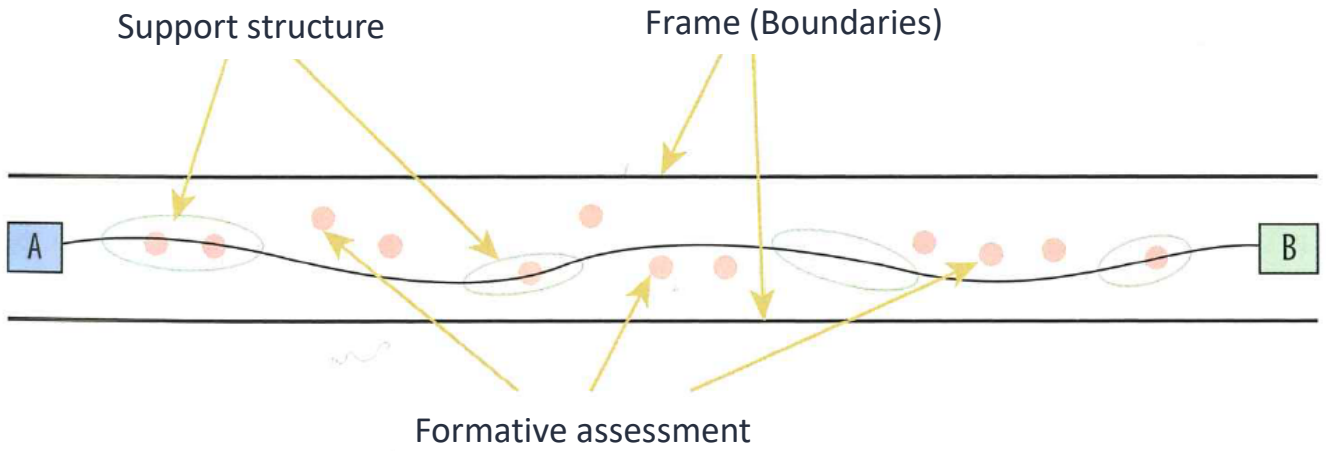
Frames and support structures are essential!

(Anne B. Øyehaug, 2014)

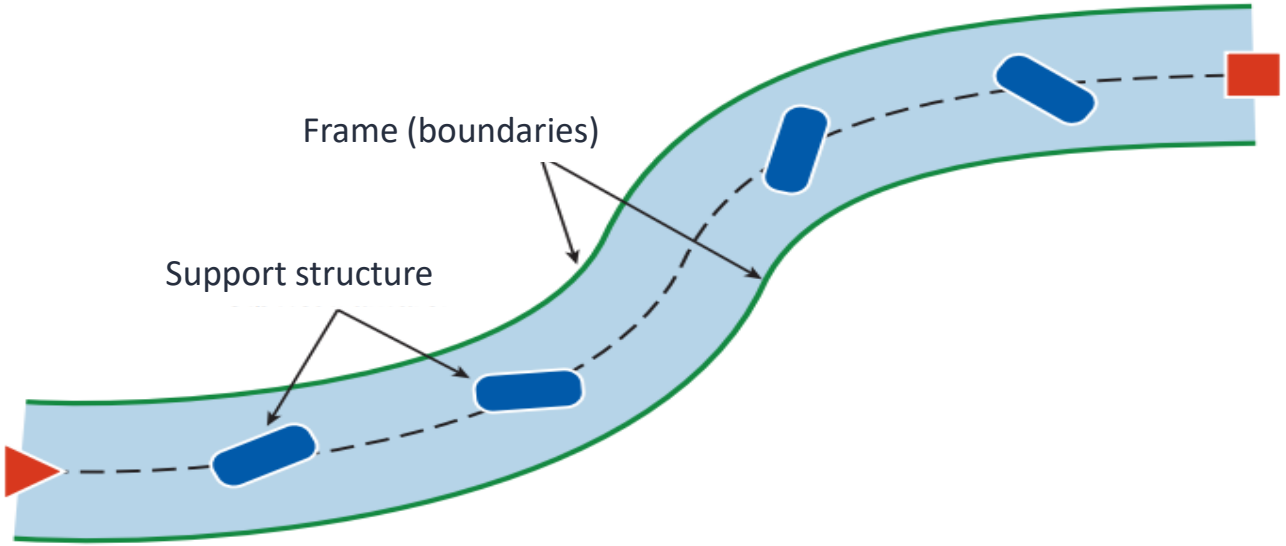
Inquiry teaching approaches does not mean «minimal guidance» or «without guidance»

- «The success of inquiry-based instruction lays in **scaffolding**» (e.g. Hmelo-Silver et al., 2007, Kawalkar & Vijapurkar, 2013).

Illustration of guidance by «frames» and «support structures»



Knain, Bjønnes and Kolstø (2019) i Knain & Kolstø (eds.), Chapter 3 p.71,
Based on among others on Hmelo-Silver, Duncan & Chinn (2007)



Staberg et al. (2020, p. 208) based on Knain, Bjønnes & Kolstø (2019, p.72)

MODELS FOR PLANNING, IMPLEMENTATION AND ASSESSMENT OF INQUIRY-BASED TEACHING

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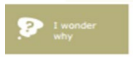
The Nysgjerrigper Method

"Nosy Parker" Method

"Curiosity" Method

Nysgjerrigper's six steps to research



1. I wonder why

2. Why is it like this?

3. Draw up a plan

4. Collect data

5. What we found out

6. Tell everyone else

The Nysgjerrigper method is designed to help children do their own research on things they wonder about. It is a kind of recipe for research. It's the same method that adult researchers use, just a little easier.

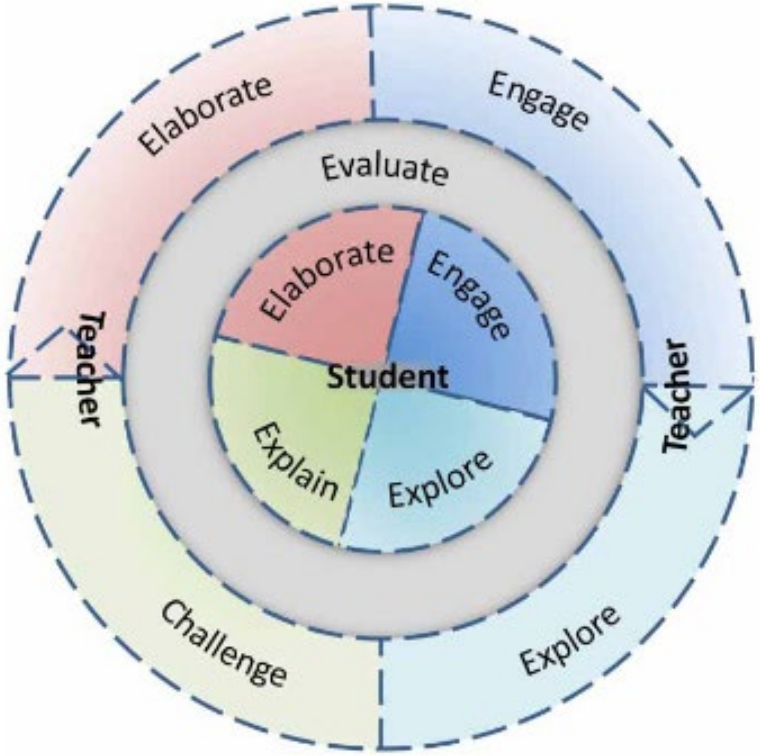
Teachers' guide in English:
https://www.forskningsradet.no/siteassets/publikasjoner/1172688889288.pdf

Nysgjerrigpermetoden.no Nysgjerrigper.no

The 5E model

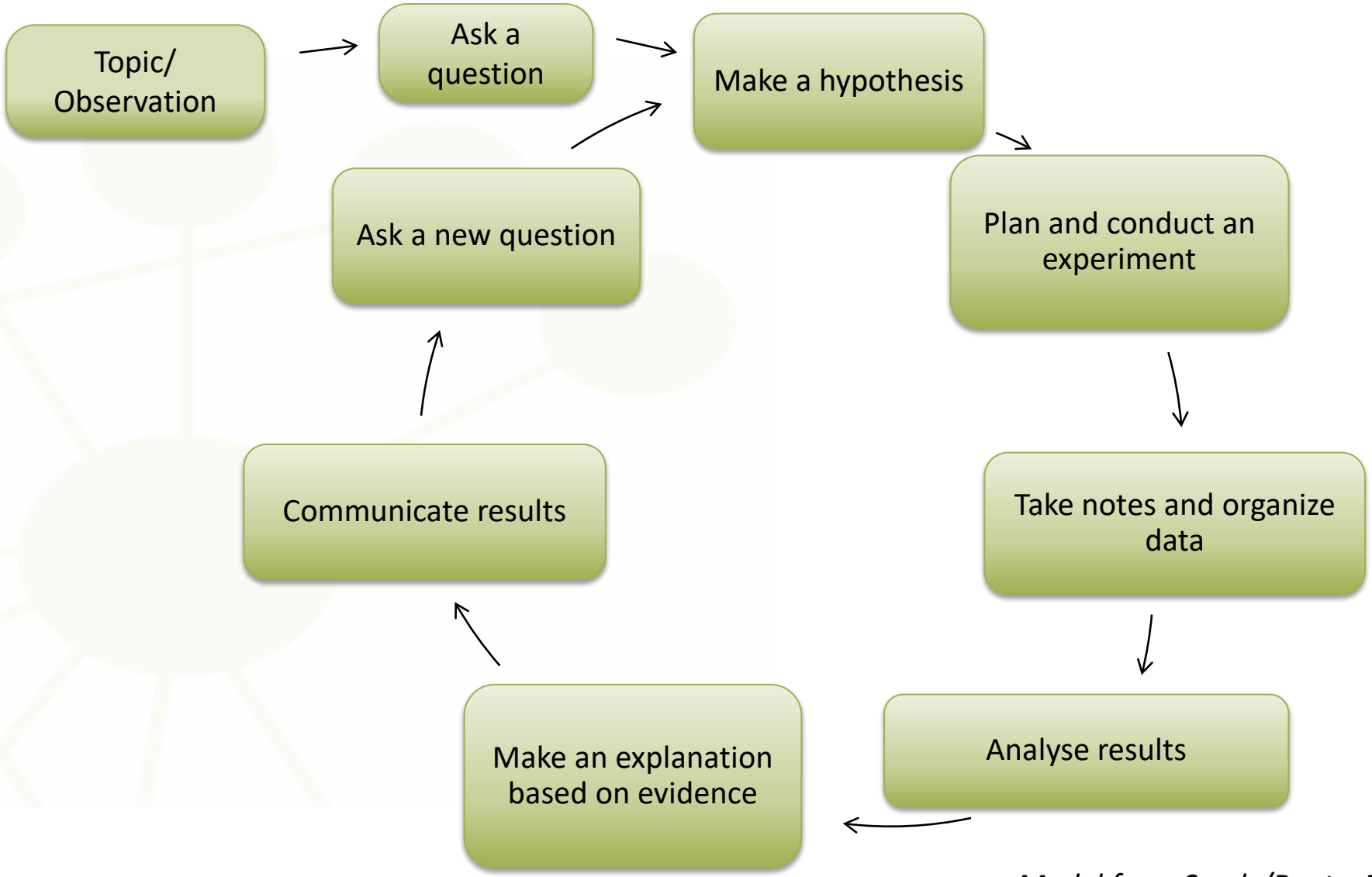
Bybee et.al. (2006). *The BSCS 5E Instructional Model. Origins and Effectiveness. A Report Prepared for the Office of Science Education National Institutes of Health.* http://www.naturfagsenteret.no/SUN.

The revised 5E model



Bodil Svendsen (2015) Mediating Artifact in Teacher ProfessionalDevelopment, International Journal of Science Education, 37:11, 1834-1854, DOI:10.1080/09500693.2015.1053003
(16) (PDF) Mediating Artifact in Teacher Professional Development. Available from: https://www.researchgate.net/publication/279071034_Mediating_Artifact_in_Teacher_Professional_Development [accessed Sep 04 2023].

Inquiry in *Seeds of science/Roots of reading*



Model from Seeds/Roots, Barber (2009)

GROUP WORK

- Discuss best practices from your countries:
  - What kind of tasks or assignments do you use in your classroom practices in STEM education (relate to IBL and the presented models)
  - Choose 1-2 examples, describe them on Taskcard: https://s.ntnu.no/ICSE-IBL-task
  - Share in plenary: why are these tasks inquiry-based

COFFE BREAK

Stockpicture Microsoft 365

Plenary session

- Introduction of 5 approaches to inquiry
- Introduction of groupwork on redesign of tasks

«Soft cake» model - several dimensions of classification

Support structures

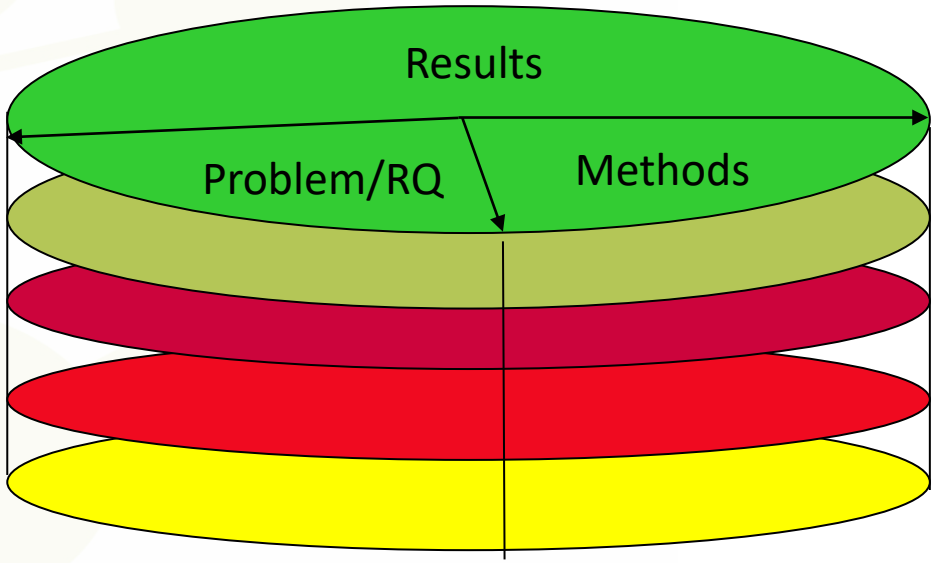
Templates

Templates

Tools

Tools

……..



Frames

Deadlines

Milestones

Frames for products

……..

……..

Degrees of freedom

0-3

Types of IBL

Source: Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

Several types of IBL tasks

Support structures

Templates

Templates

Tools

.....

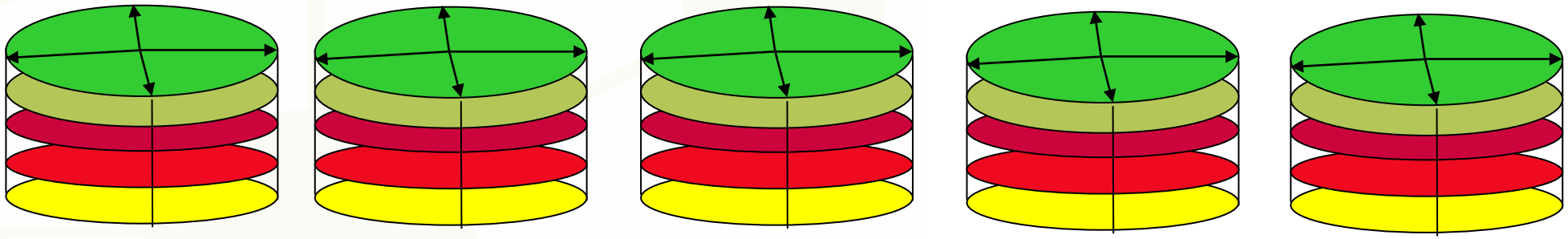
Observing over time

Identifying and classifying

Pattern seeking

Research (incl.literature study)

Fair testing



Frames

Deadlines

Milestones

Frames for products

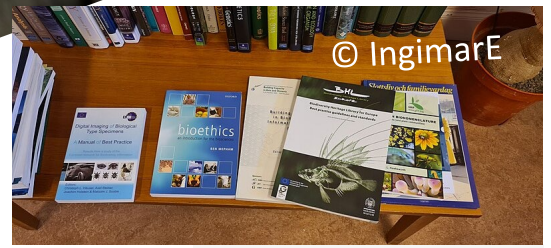
.....

Degrees of freedom, 0-3

Ideas from: Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

«It's not fair» – how to develop student's ideas through primary science inquiry

Type of inquiry based activity	Characteristics of the activity	Example
Observing over time	One or more parameter changes over some time	Moulding bread in a plastic bag
Identify and classify	Group, Sorting based on criteria	Birds – species keys
Pattern seeking	Systematic observation	Weather station
Research (with secondary sources)	Develop questions or find answers by secondary sources	Observe stars: use a star map or an astronomy specialist to find answers
Fair testing	Keep all parameters except one, constant	Measure - How we can hear and measure a sound source, (for example the gym-flute) or the water temperature in ponds



Source: Elaborated from Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

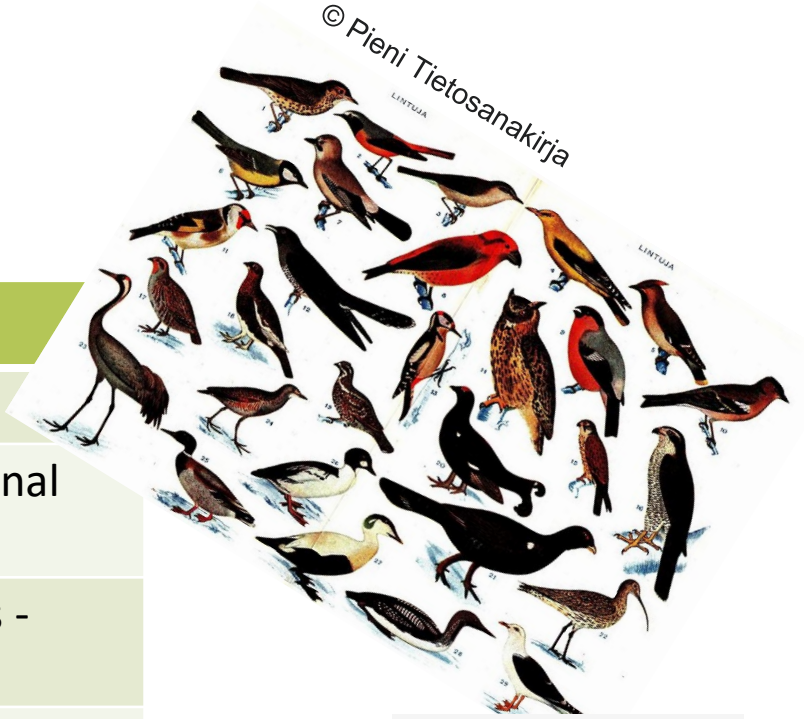
Observing over time

Object of observation	Science parameters	Ideas for math
Growing chicken	Length of feet	Numbers, measure
A puddle changing over time	Depth or area (length/width)	Geometry
Shadow throughout the day	Length, propositions, Extent (area)	Algebra
Hatching of a pupa	Biological development	Statistics. Algebra.
A slice of bread moulding in a plastic bag	Colours, amount of mould (density, spatial spreading)	Statistics. Algebra.
Birds/flowers - Phenology	Arriving date / Date of flowering	Statistics. Algebra

Source: Elaborated from Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

Identify and classify

Object for classification	Science parameters	Ideas for math
Birds – keys	Morphological characters	Quantities, measures
Toys	Colour, material, surface, weight, types of toys	Statistics. (Variables: Ordinal nominal, interval, ration)
Fruit and vegetables	Smell, taste, colours, surface	Hex numbers – hex codes - colour codes
Bathroom products	Smell, colour, phase (liquid, gas, solid), consistency, evaporation	Counting, measuring
Screws and nails	Size, material, form, surface, glance magnetism, brilliance, conductance	Numbers. Counting



ESD

Source: Elaborated from Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

Pattern seeking

Object to observe	Science parameters	Ideas for math
Wildflowers for flower wreaths (Dandelion/horse's hoof/red clover)	System in distribution (maps), regrowth after cutting, classifying of species (taxonomy)	Coordinates.
Our body – systems and pattern	Body length, temperature, pulse, hair growth, nail growth, different parts of the body (their length, and shape) (BE AWARE OF ETHICAL ASPECTS!)	Statistics. Algebra.
Weather pattern	Weather station: Rain, wind direction, wind speed, air pressure, air moisture	Algebra. Units. Measures. Scientific notation.

Source: Elaborated from Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

Research (with secondary sources)

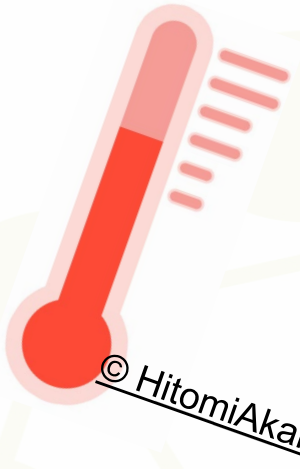
Projects	Sciences - examples of what to study	Ideas for math
Make a product	Chocolade, toy car	Quantify the receipt. Numbers, units.
Observe on the sky	Planets, moon, stars	Measure, huge numbers, scientific notation. Geometry.
Study sport arrangements or an athlete	Anatomy/physiology, physical parameters (distance, velocity, time, forces, mass) health/ways of living	Algebra. Statistics.

ESD

Sources: To develop questions or to find answers
Books
Newspapers
Journals
Internet
Family/Friends/Neighbors
Scientists/Teachers/Specialist/Craftsmen/Researchers
National and global statistics

Source: Elaborated from Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

Fair testing
- keep all parameters except one, constant



Test-experiment	Science parameters for testing	Ideas for math
Measure how we hear a sound source (for example the gym flute)	Blow the flute: Register who hears the sound (frequence) and how long away (distance)	Algebra, numbers
Measure temperature in local ponds. Keep other factors constant (no rain, same day, same depth, same distance form land)	Temperature (degrees Celsius)	Scale ESD
Consumer testing of toothpaste	Testing: taste, "cleaning" effect, ingredients	Statistics
Growing potatoes	Testing: the production related to several factors: Growing place, soil, sun, nutrients, variety of seed potatoes	Statistics ESD

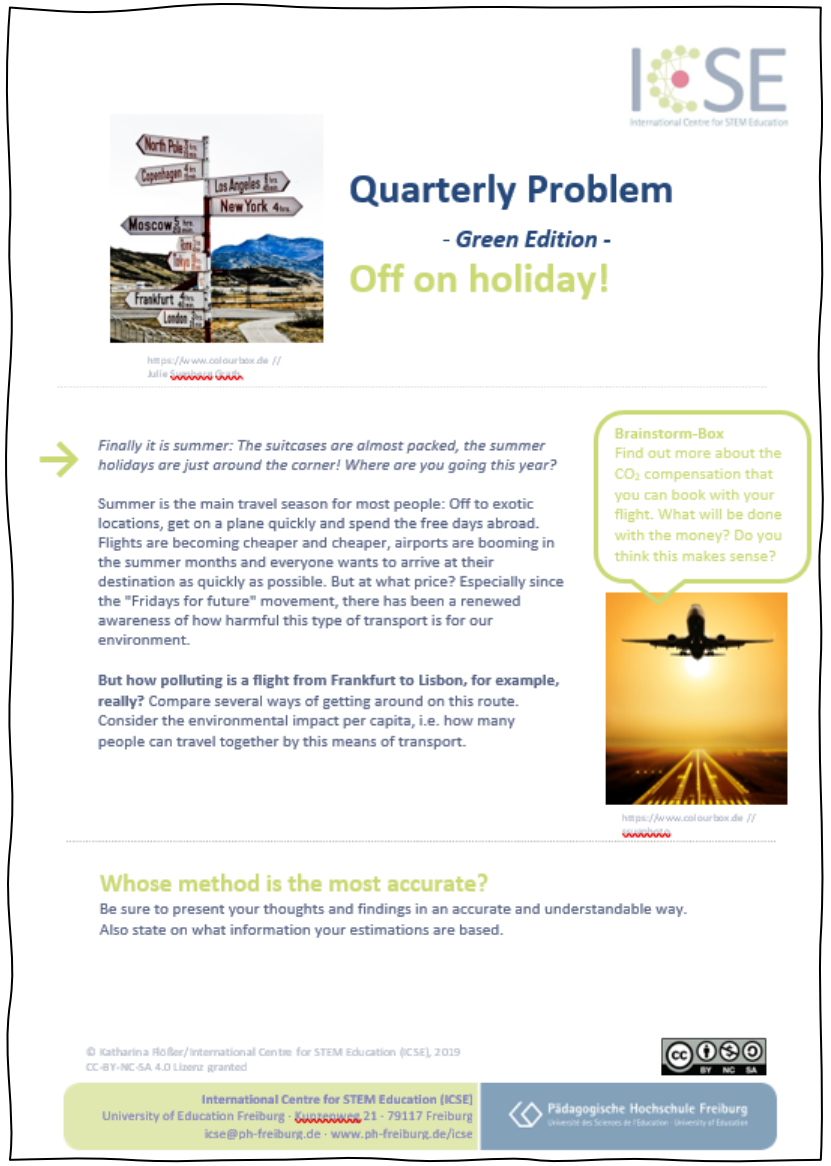
Source: Elaborated from Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). It's not fair. Millgate House Education Ltd.

GROUP WORK: Discuss the Quarterly Problem
Off on holiday!

TASK: Discuss pre and cons for this kind of task.
Write some short bullet points in the TaskCard:

https://s.ntnu.no/ICSE-IBL-TASK-TWO

Download the task from our Moodle or
from the ICSE website:
https://icse.eu/materials/quarterly-problems/



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Quarterly Problem

- Green Edition -

Off on holiday!

Finally it is summer: The suitcases are almost packed, the summer holidays are just around the corner! Where are you going this year?

Summer is the main travel season for most people: Off to exotic locations, get on a plane quickly and spend the free days abroad. Flights are becoming cheaper and cheaper, airports are booming in the summer months and everyone wants to arrive at their destination as quickly as possible. But at what price? Especially since the "Fridays for future" movement, there has been a renewed awareness of how harmful this type of transport is for our environment.

But how polluting is a flight from Frankfurt to Lisbon, for example, really? Compare several ways of getting around on this route. Consider the environmental impact per capita, i.e. how many people can travel together by this means of transport.

Brainstorm-Box
Find out more about the CO_2 compensation that you can book with your flight. What will be done with the money? Do you think this makes sense?

https://www.colourbox.de //

Whose method is the most accurate?
Be sure to present your thoughts and findings in an accurate and understandable way.
Also state on what information your estimations are based.

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Pädagogische Hochschule Freiburg

IF TIME, THINK ABOUT REDESIGN: Reflect upon how this task could be more closed or more open (related to different phases of inquiry-based learning)

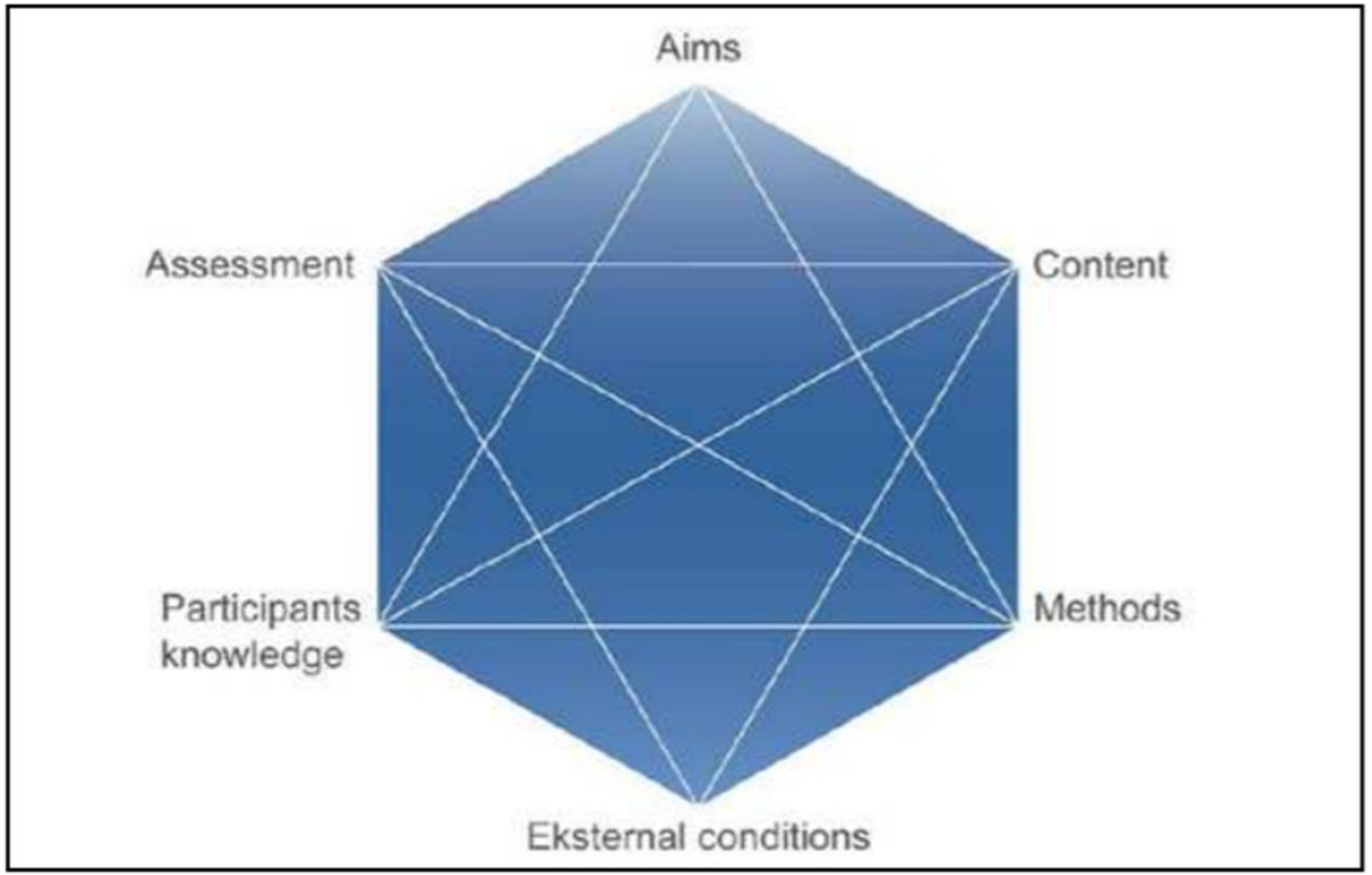
ASSIGNMENT – Cluster 1

TASK:

Prepare an outline for a **STEM lesson** for your local curricula. Chose a topic that you would feel comfortable implementing with your students. The lesson should use an **SSI as a context** and **focus on argumentation and inquiry-based learning (IBL).** In the outline include the following information: level of students, duration of the lesson, participants' prior knowledge, methods to be applied, content, assessment methods, STEM theme, learning objectives, and description of the learning activities.

We encourage you to use the **didactical diamond** or the **curricular spider web** in your planning (see next slides). The task will be graded as passed/not passed.

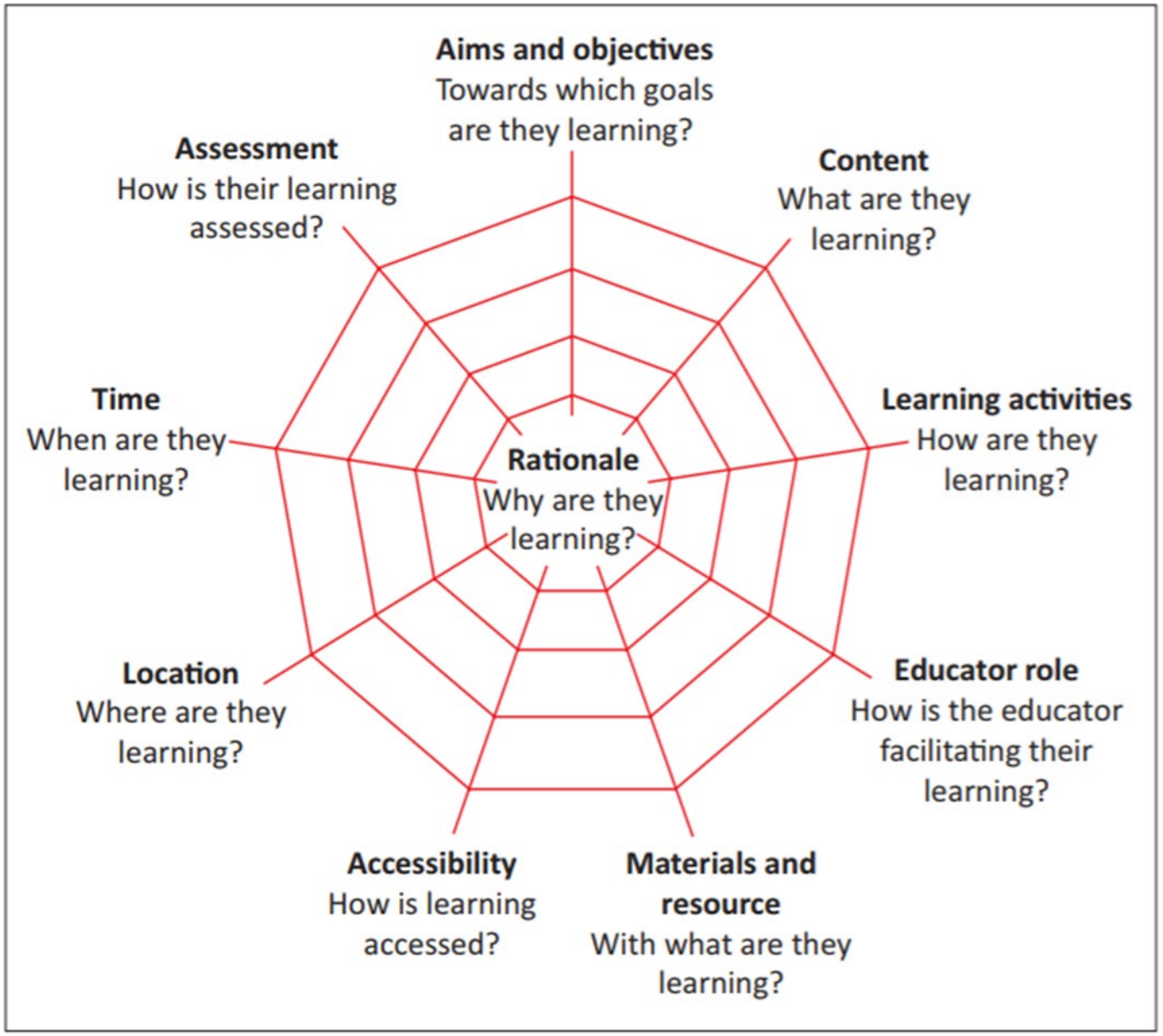
Didactical diamond (Norwegian diamond)



Source: Hole et al., 2010

Curricular Spider Web

Source: Macumane & Ngcobo, 2021,; in Van den Akker, J., 2003, 'Curriculum perspectives: An introduction', in J. Van den Akker, W. Kuiper & U. Hameyer (eds.), Curriculum landscapes and trends, pp. 1–10, Kluwer Academic Publishers, Dordrecht.



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