Aras Rafanavičius, Neringa Barauskaitė-Šarkinienė

DEVELOPING COGNITIVE COMPETENCE IN PHYSICS CLASSES

Kaunas Jurgis Dobkevičius progymnasium

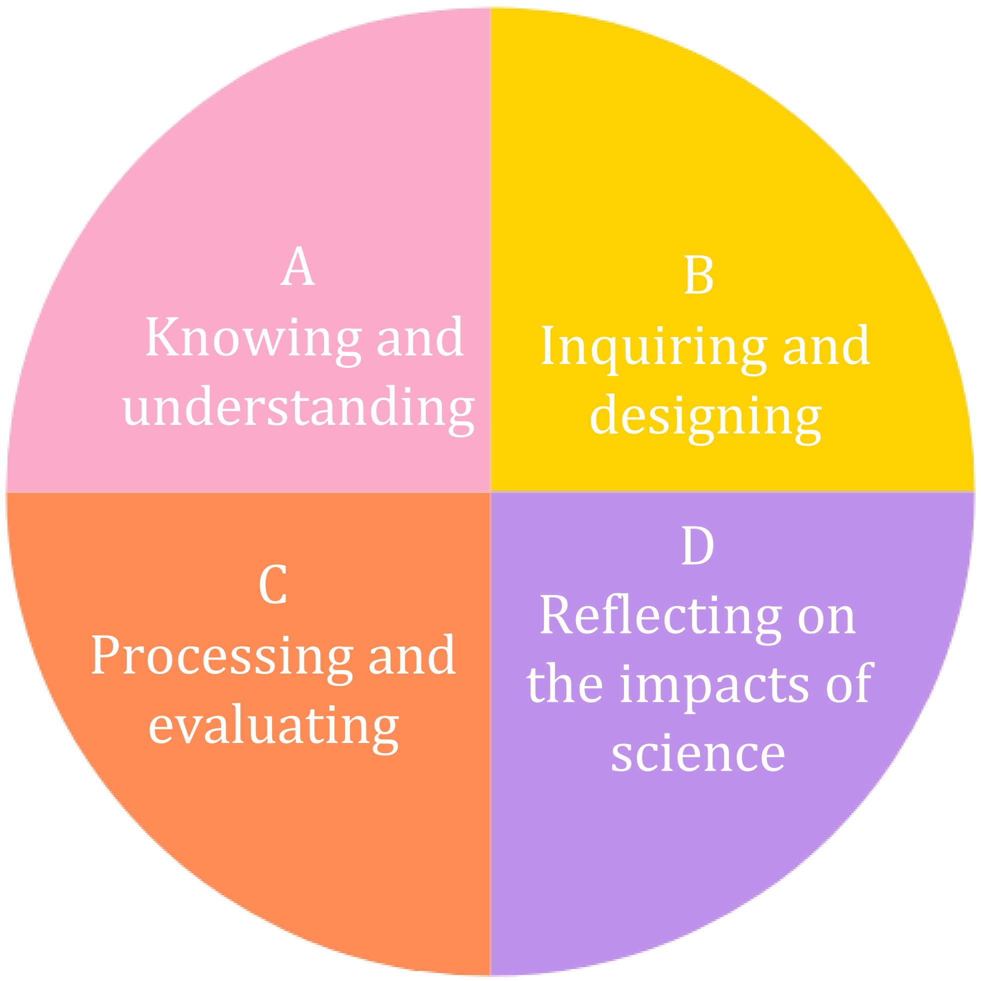
Kaunas, 2025

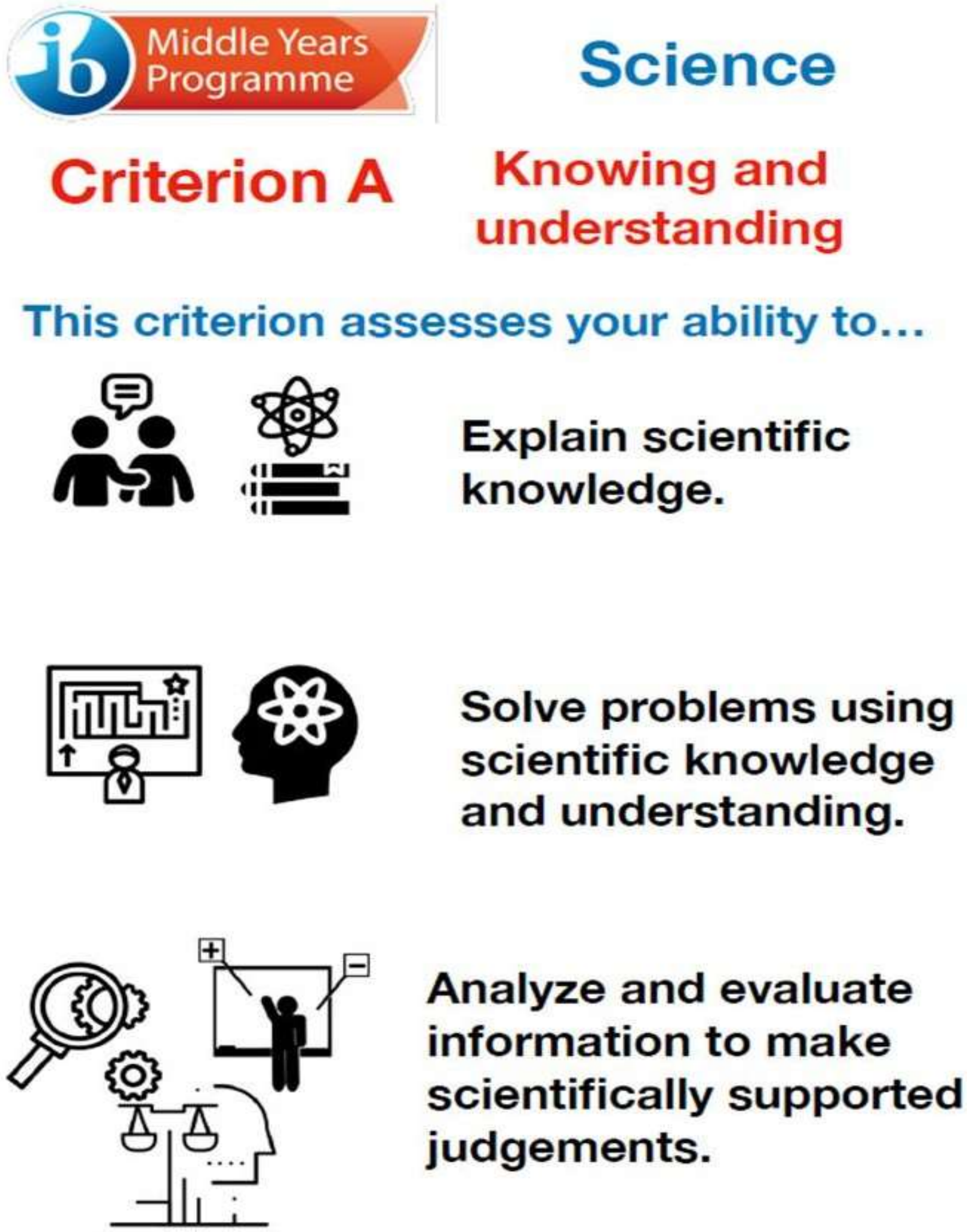
Co-funded by the European Union

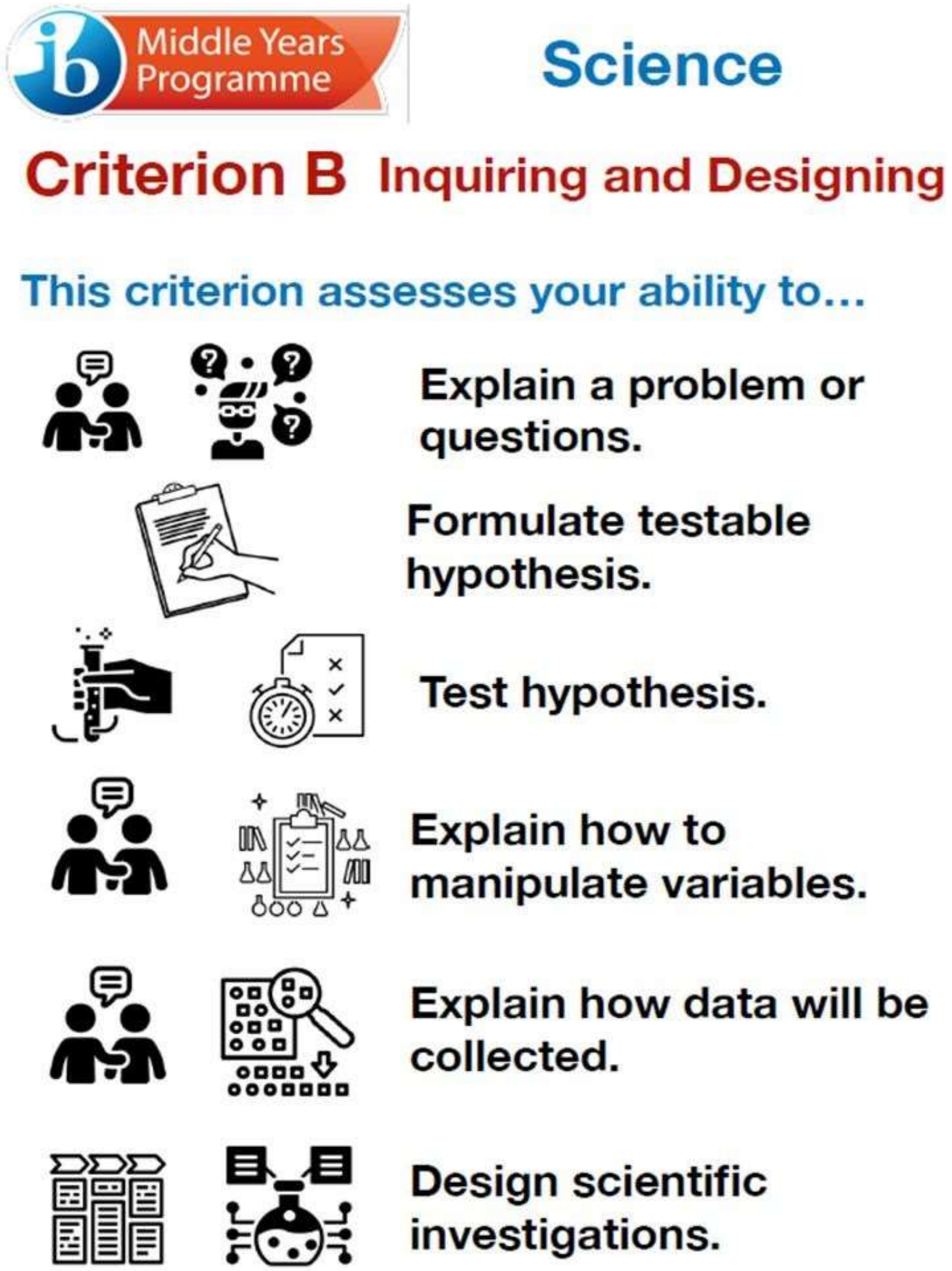
COMPASS COMPETENCE ASSESSMENT

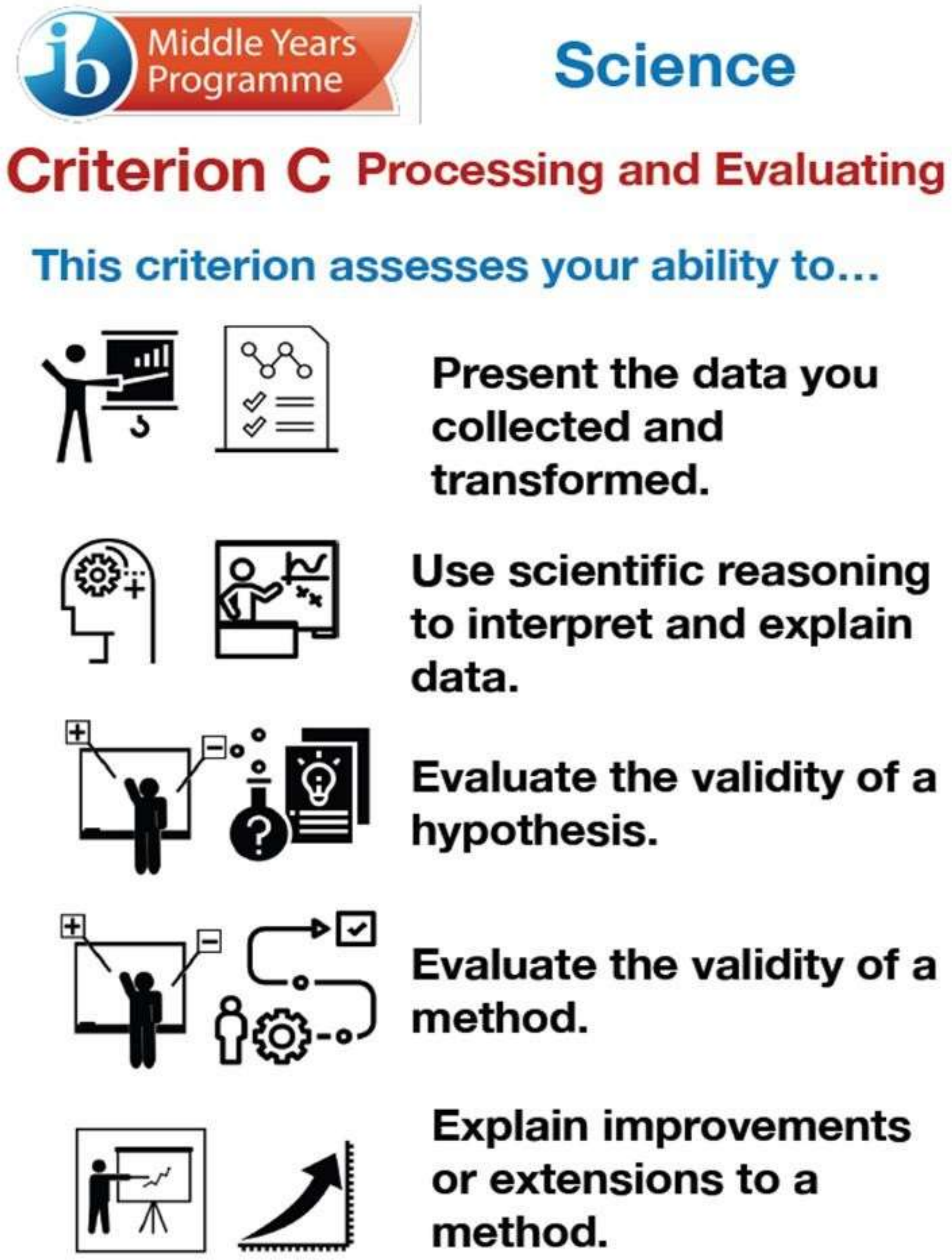
Approaches to Learning (ATL) skills

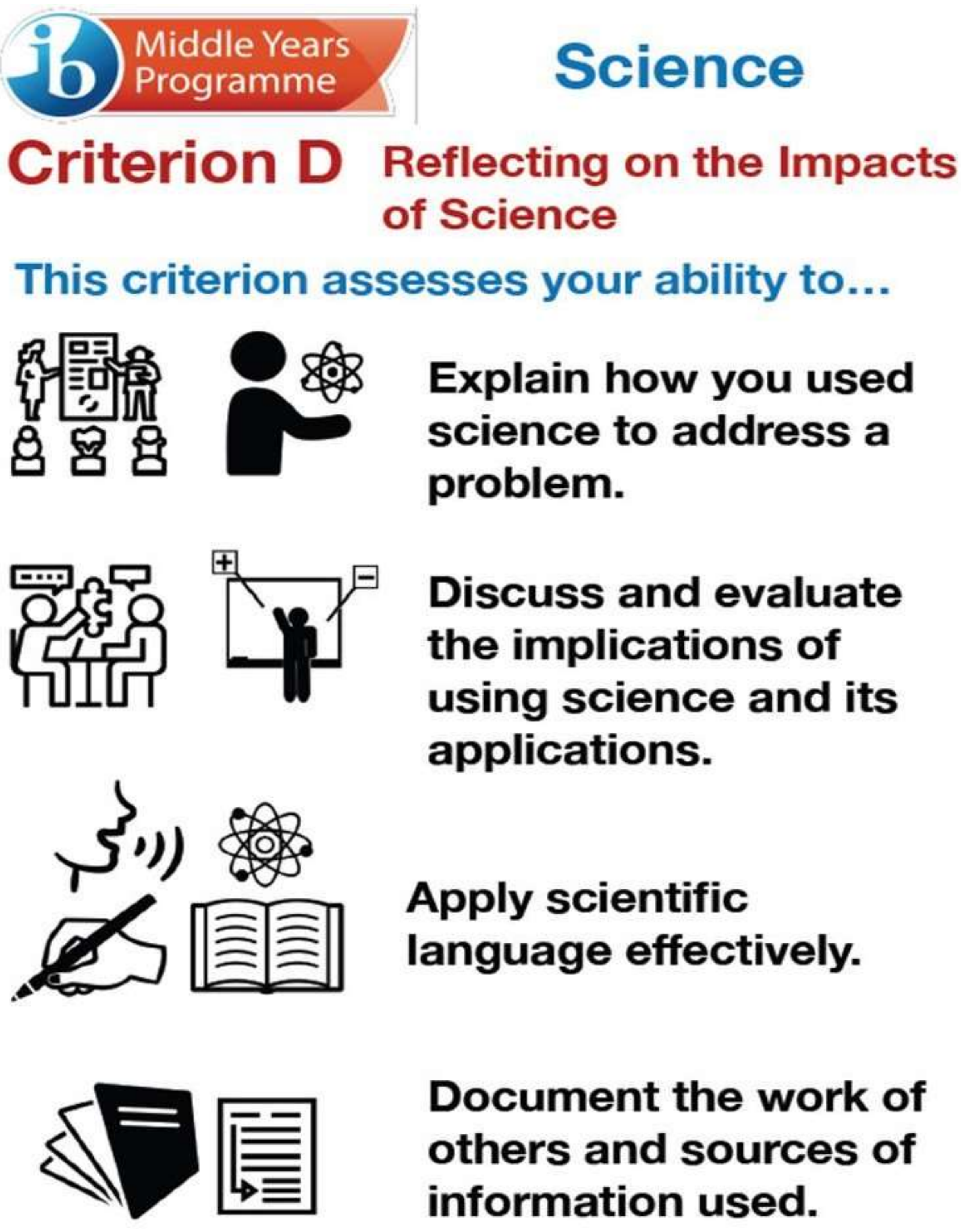
MYP Science criteria




ib Middle Years Programme
Science
Criterion A
Knowing and understanding
This criterion assesses your ability to…
Explain scientific knowledge.
Solve problems using scientific knowledge and understanding.
Analyze and evaluate information to make scientifically supported judgements.


ib Middle Years Programme
Science
Criterion B
Inquiring and Designing
This criterion assesses your ability to…
Explain a problem or questions.
Formulate testable hypothesis.
Test hypothesis.
Explain how to manipulate variables.
Explain how data will be collected.
Design scientific investigations.


Middle Years Programme
Science
Criterion C Processing and Evaluating
This criterion assesses your ability to...
Present the data you collected and transformed.
Use scientific reasoning to interpret and explain data.
Evaluate the validity of a hypothesis.
Evaluate the validity of a method.
Explain improvements or extensions to a method.


Middle Years Programme
Science
Criterion D Reflecting on the Impacts of Science
This criterion assesses your ability to...
Explain how you used science to address a problem.
Discuss and evaluate the implications of using science and its applications.
Apply scientific language effectively.
Document the work of others and sources of information used.

Context (1)

- **21 eighth-grade students** (10 boys and 11 girls, aged 13 to 15) participated in the lesson cycle „Radioactivity“.
- The class is **bilingual**, with some subjects taught in English and others in Lithuanian.
- The class includes students with **varying abilities**. We do not have any students with special educational needs, but some students experience learning difficulties, e.g., they have difficulty concentrating and have weak information analysis and calculation skills.

Context (2)

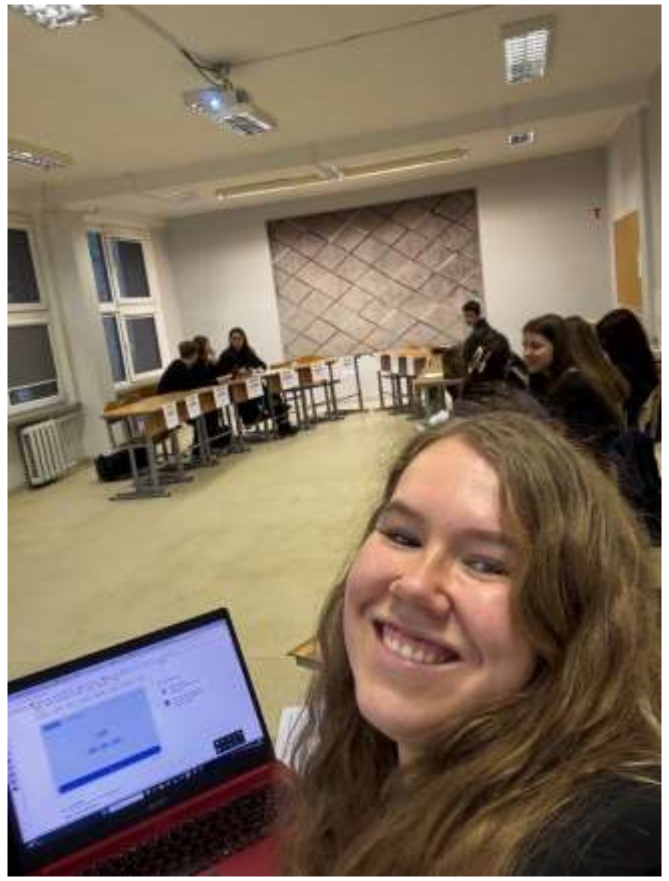
The unit consisted of **18 lessons** and the following tasks were completed:

- Solving problems on the topic of radioactivity during homework and lessons;
- Debates "Nuclear Energy";
- Research and work with articles and online sources (project-practical work "Nuclear Power Plants");
- Virtual visit to Ignalina Nuclear Power Plant (https://virtual.iae.lt/)
- Assessment test.

Virtual Tour

https://virtual.iae.lt

Debates



Context (3)

- We developed a diagnostic assessment tool—a questionnaire—to help students assess their initial level in each competence area. We selected active, inquiry-based activities that encourage student engagement, independence, and reflection.
- We planned formative and summative assessment methods based on IB (International Baccalaureate) criteria (A–D) to monitor progress in all areas of cognitive competence.
- After finishing the unit the same questionnaire was taken by the same students to determine and compare the changes. Additionally, the students were asked to map which of the unit tasks helped develop specific cognitive competence skills.

Cognitive Competence (1)

How we presented Cognitive Competence to students

Cognitive competence is your **desire** and **ability** to be curious, to understand yourself and the world.

Think about it this way:

- You want to **know**: you are interested in how things work, why certain things happen, and who you are. This is **motivation**.

- You know how to find out: you not only want to, but you also know **how to** look for information, learn from books, teachers, experiments, or even mistakes. You use what people have already discovered before. That is **ability**.

Cognitive Competence (2)

How we presented Cognitive Competence to students

What does it mean for you at school and in your life?

- Not just memorizing facts: it's important not only to know formulas or dates, but also to understand why they are they way they are and how they work.
- Think smart: be able to ask "why?", don't believe everything right away, look for evidence **(critical thinking)**
- Solve problems: when something is unclear, know how to look for solutions **(problem solving)**
- Ability to learn: understand what ways of studying are the most effective, learn from mistakes.
- See the bigger picture: understand how different subjects are related and help explain the world at large.

Cognitive Competence means being a curious inquirer who knows how to learn, think and understand both oneself and the world around them.

Cognitive Competence (3)

How Students understand Cognitive Competence

Deeper understanding (12 %)

“Cognitive competence is about expanding knowledge, understanding and growth”

“When you learn new things, think critically and solve problems”

“The ability to understand yourself or what you are learning”

“That while studying the unit, perhaps you also get to know yourself better?”

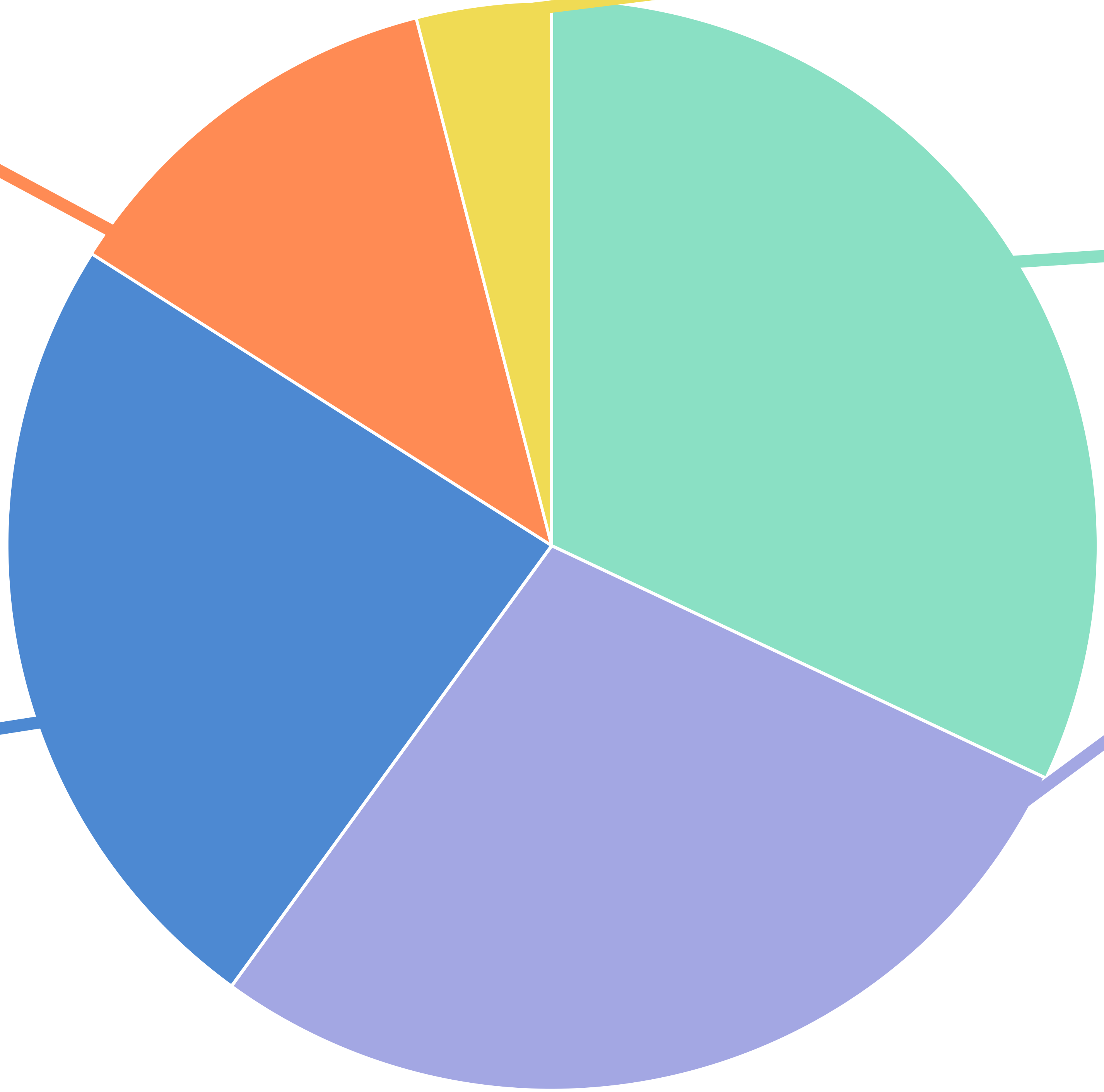
Understanding through learning (24%)

“When you learn to understand new things”

“How well you understand things”

“Ability to learn and discover new and unknown fields”

“Ability to comprehend”



Unclear/Other (4 %)

“I understand well”

Complete lack of understanding (32%)

“I don‘t know”

“I can hardly imagine”

Surface-level understanding (28%)

“How you know something”

“Ways to learn things”

“How many new things I’ve learned”

“How capable am I to learn”

“Selection of knowledge”

Formative assessment

The students learned about their progress and improved abilities through self-evaluation tasks throughout the unit. Assessment was oriented not only to the end-result but to the learning process itself, reflection and self-evaluation of students’ skills.

- ***Repeated assessment of cognitive competence*** and the comparison of answers before and after the unit.
- ***Reflection*** on specific tasks – students were asked to map which tasks helped foster specific skills.
- ***Debates and project work***. During the debates, students had to demonstrate argumentation skills, evaluate information, think critically. Project work required them to actively research information and apply it.
- ***Teacher’s feedback*** – including both the end-result and the thinking processes conveyed by the students, their efforts and approaches to the tasks. This helped the students to name the skills they feel they improved, determine their strengths and weaker spots.

Questionnaire results: Subject knowledge and skills

I understand the types of radioactive decay and their associated properties

I can explain what half-life of a nucleus is and where this is applied

I understand the principles of nuclear fission and nuclear synthesis

I know how nuclear reactors work and what are their uses

BEFORE

- Weakest area – the topics were new and unknown.

AFTER

- Grew significantly.
- Students feel more confident about their knowledge.
- Most improved element of the competence.

Questionnaire results: Critical thinking

I can critically assess information about the benefits and drawbacks of nuclear energy

I can tell the difference between facts and opinion when discussing radioactivity and nuclear energy

I can discuss the safety of nuclear energy and its effect on the environment with reasonable arguments

I understand the ethical questions regarding the use of radioactivity in medicine and other fields

BEFORE

- Students had some pre-existing opinions about the complexity of the topic but lacked the knowledge for a well-reasoned evaluation.

AFTER

- Grew significantly.
- Students feel more confident about their skills in evaluating information and discussing ethical dilemmas.
- Significantly improved the skill to discuss with reasonable arguments – successful implementation of discussions and debates during the lessons.

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Questionnaire results: Problem solving

If can calculate radioactivity of a substance after a certain amount of time, using its half-life

I can provide solutions for treatment of radioactive waste

I can analyse the consequences of a nuclear incident and provide preventative solutions

I can apply my knowledge about radioactivity solving practical exercises

BEFORE

- Weakest confidence in problem-solving skills.
- Average confidence in nuclear incident analysis.

AFTER

- Grew significantly.
- Calculations remain mostly difficult.
- Theoretical problem-solving greatly improved.

Questionnaire results: Ability to learn

I can independently find information on radioactivity and nuclear energy

I can effectively learn new nuclear physics definitions

I can critically assess various sources of information on radioactivity

I can process the knowledge about radioactivity and nuclear energy

BEFORE

- Average confidence in learning skills.
- Students had some general learning skills but were not confident about their application for these topics.

AFTER

- Grew significantly; students maintain relatively high confidence.

Questionnaire results: Mapping the skills to the tasks

CRITICAL THINKING

- 95 % - debates (argumentation and evidence)
- 62 % - unit test (knowledge processing)

PROBLEM SOLVING

- 90 % - debates (research, data analysis, argumentation)
- 57 % - home- and classwork problems and project work “Nuclear power plants”

ABILITY TO LEARN

- 86 % - unit test and preparatory work (knowledge processing and the choice of learning strategies)
- 57 % - home- and classwork problems.

SUBJECT KNOWLEDGE AND SKILLS

- 95 % - debates and virtual tour (active, contextual and critical learning)
- 86 % - unit test (direct application of knowledge)

Closing remarks

- **The concept of "Cognitive competence" is poorly understood** by 8th grade students, they tend to equate it with **individual elements** or parts of learning process rather than perceive cognitive competence as an **integral whole.**
- The concept of cognitive competence has to be presented in **plain terms** and through specific **examples**, emphasising its elements (curiosity, the ability to ask questions, etc.)
- Lessons should be planned to **actively use and develop elements of cognitive competence**. Reflective questions and feedback helps students demonstrate and evaluate their progress.
- **Active, engaging and problem-based tasks** help students remember facts and critically analyse them, solve real problems and consciously and responsibly control their learning process.
- **Self-evaluation questionnaires** help students gauge their improvement and motivate them.

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