Experiences from two European IBSE teacher education projects – ESTABLISH and SAILS

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ESTABLISH (2010-2014) - Coordinator
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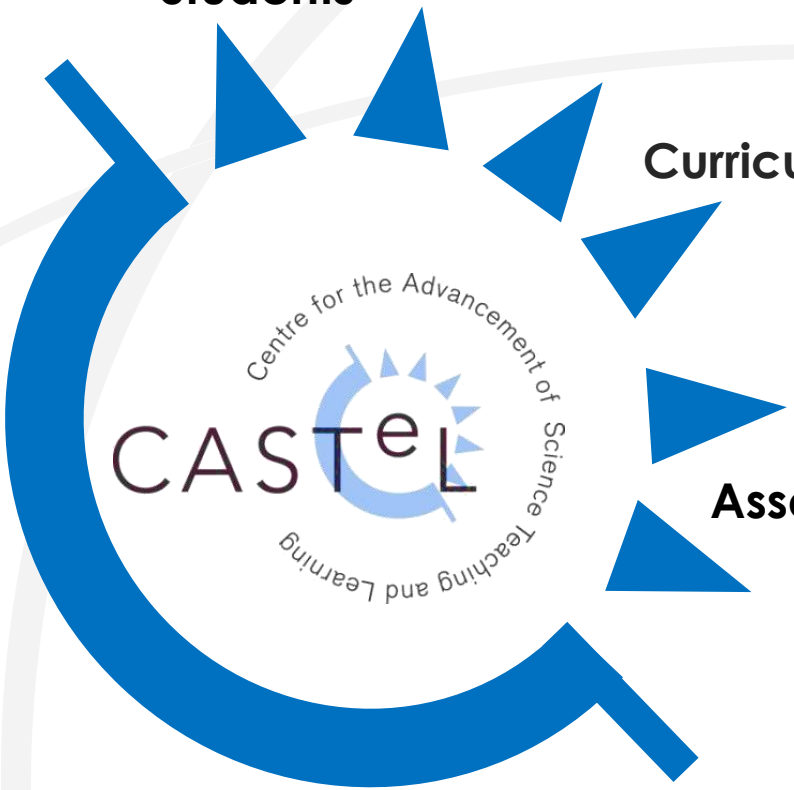
CASTeL undertakes **research to inform and enhance teaching and learning of science and mathematics** at and across all educational levels (i.e. primary through to postgraduate).

Focus incorporates…

Teachers & Students

Curriculum

Assessment



Research activities in…

Learner-centred approaches, e.g. using Inquiry based learning

pre-service & in-service teacher education

learner-centred supports for learning

Overview

- FP7 ESTABLISH Project (2010-2014)
  - to extend the use of inquiry-based science education (IBSE) in second level schools across Europe.
- FP7 SAILS Project (2012-2015)
  - to support the assessment of inquiry-based science education (IBSE) in second level schools across Europe.
- Getting Involved

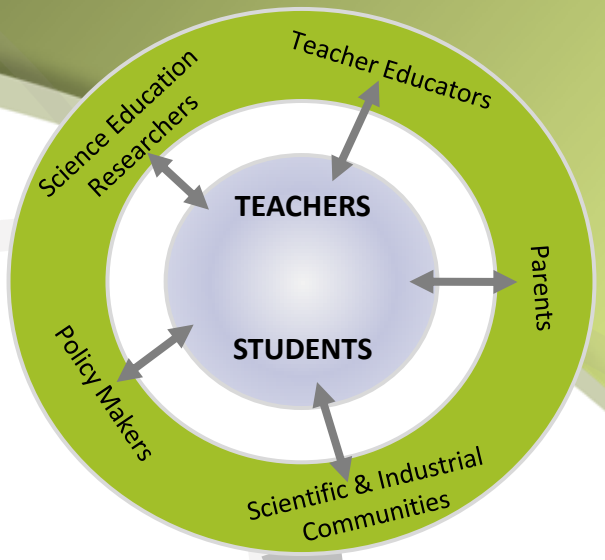
Background, framework and purpose

- Shift in educational systems within Europe towards the implementation of Inquiry based science education (IBSE).
- Explosion of knowledge and the growing demands of the workplace.
- Skills and competencies that can be used in different situations, not only in science lessons.
- EU Seventh framework programme funded 20+ projects (10-25 partners) in Science for Society – Science Education.

ESTABLISH

14 institutions in **11 European countries**

- extend the use of inquiry-based science education (IBSE) in second level schools across Europe
- work with teachers to develop and implement IBSE
- engage with stakeholders in STEM education



http://www.establish-fp7.eu/

Establish

European Science and Technology in Action:
Building Links with Industry, Schools and Home

Characterisation of Inquiry/IBSE

Inquiry is the “intentional process of

(1) diagnosing problems,
(2) critiquing experiments,
(3) distinguishing alternatives,
(4) planning investigations,
(5) researching conjectures,
(6) searching for information,
(7) constructing models,
(8) debating with peers, and
(9) forming coherent arguments.”

(Linn, Davis and Eylon, 2004)

ESTABLISH Units

- 18 Scientific Topics
- Teacher & Classroom Materials
- Physics, Chemistry & Biology
- activities to engage teachers
- applicable for pre-service and in-service teachers
- representative of IBSE
- suggested learning paths for IBSE
- share benefits of IBSE in practice
- inspiration to generate own materials

The ESTABLISH project has received funding from the

ESTABLISH IBSE Teaching & Learning Units

www.establish-fp7.eu

- Sound
- Light
- Designing a Low Energy Home
- DC Electricity

- Disability
- Blood Donation
- Eco-biology
- Water in the Life of Man

- Renewable Energy
- Forensic Science
- Medical Imaging

- Exploring Holes
- Chitosan – Fatmagnet?
- Cosmetics
- Photochemistry
- Chemical Care
- Photosynthesis
- Polymers around us

Appropriate to teachers more experienced with Inquiry based teaching and learning and would like to deepen and extend their experience with additional activities and content.

Units- Sound, Subunit 1, Inquiry

Through the activities in this subunit students develop basic abilities to do and understand scientific inquiry.

- Asking and answering questions.
- Planning and conducting simple investigations.
- Employing tools to gather data.
- Using data to construct reasonable explanations.
- Communicating investigations and explanations.
- Understanding that scientists use different kinds of investigations and tools to develop explanations using evidence and knowledge.

Some activities are ICT activities in which a computer with sound sensor is used to record sound waveforms.

Units- Sound, Subunit 1, concepts & ideas

- Sounds are produced by vibrating objects and vibrating columns of air.
- Pitch and loudness are two characteristics of sound.
- Changing the way an object vibrates can change the pitch or volume of the sound produced
- Pitch is determined by the frequency and loudness by the amplitude of vibrations.
- Sound is produced by human vocal folds as air moves through the tightened folds.
- Sound requires a medium (for example, air, glass, metal, wood) to travel through.
- Speed of sound is less than the speed of light.
- The human ear has a membrane that vibrates when sound reaches it; the ear and the brain translate these vibrations into sensation of sound. Exposure to very loud sounds can cause damage to hearing.

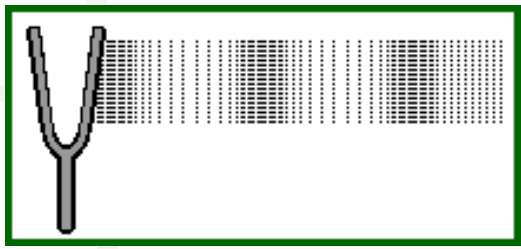
Sound Worksheet – How sound travels?

QUESTIONS

How does sound energy travel from the sound source to you ear?

Do you have a theory that might explain this process?

What evidence do you have for your theory?



INVESTIGATIONS

•Can you explain how the sound from outside gets to your ears?

•Can you hear through walls?

•Knock at one end of a table while your classmate listens with an ear against the other end of the table. Can your classmate hear you knocking? Why?

•If all air in the classroom were replaced with water, could you still hear?

•Units- Sound, Subunit 2

The main IBSE approach in this subunit are **guided discovery** and **open inquiry.**

Inquiry based skills developed in this unit are amongst others:

•Performing experiments.

•Analyzing results obtained with experiments (or presented by the teacher).

•Communicating results with the use of graphs.

•Using results from one experiment (double bass) to analyze the results of another experiment (frets of a guitar).

•Using knowledge from one field of acoustics (strings) in another field of acoustics (air columns).

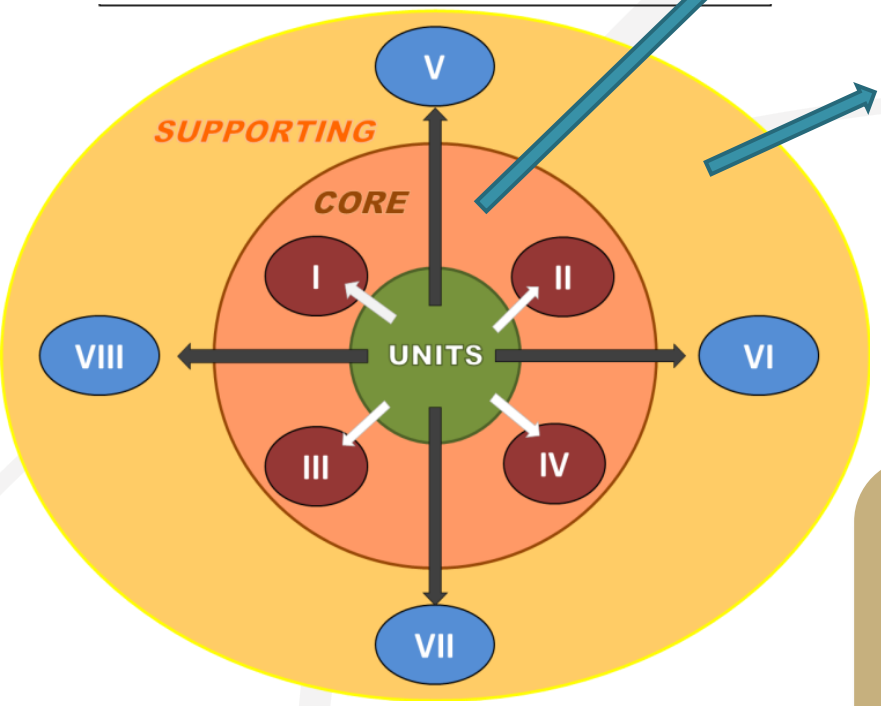
In some activities the computer is used to record sound and to analyse the data.

•Teacher Education Workshops

The ESTABLISH project has received funding from the

ESTABLISH Teacher Education Programmes #=2,090

I	Establish view of IBSE
II	Industrial Content Knowledge
III	Science teacher as Implementer
IV	Science teacher as Developer



V	ICT
VI	Argumentation in the classroom
VII	Research and design projects
VIII	Assessment of IBSE

Appropriate to those new to Inquiry based teaching and learning where there is information, suggestions and activities to broaden and develop your inquiry teaching skills.

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ESTABLISH Impact on Teachers

Quantitative Evaluation – Pre and Post TEP

- Understanding of inquiry
- Attitude towards inquiry
- Industrial importance/links
- Practice in the inquiry classroom
- Personal Skills in relation to inquiry

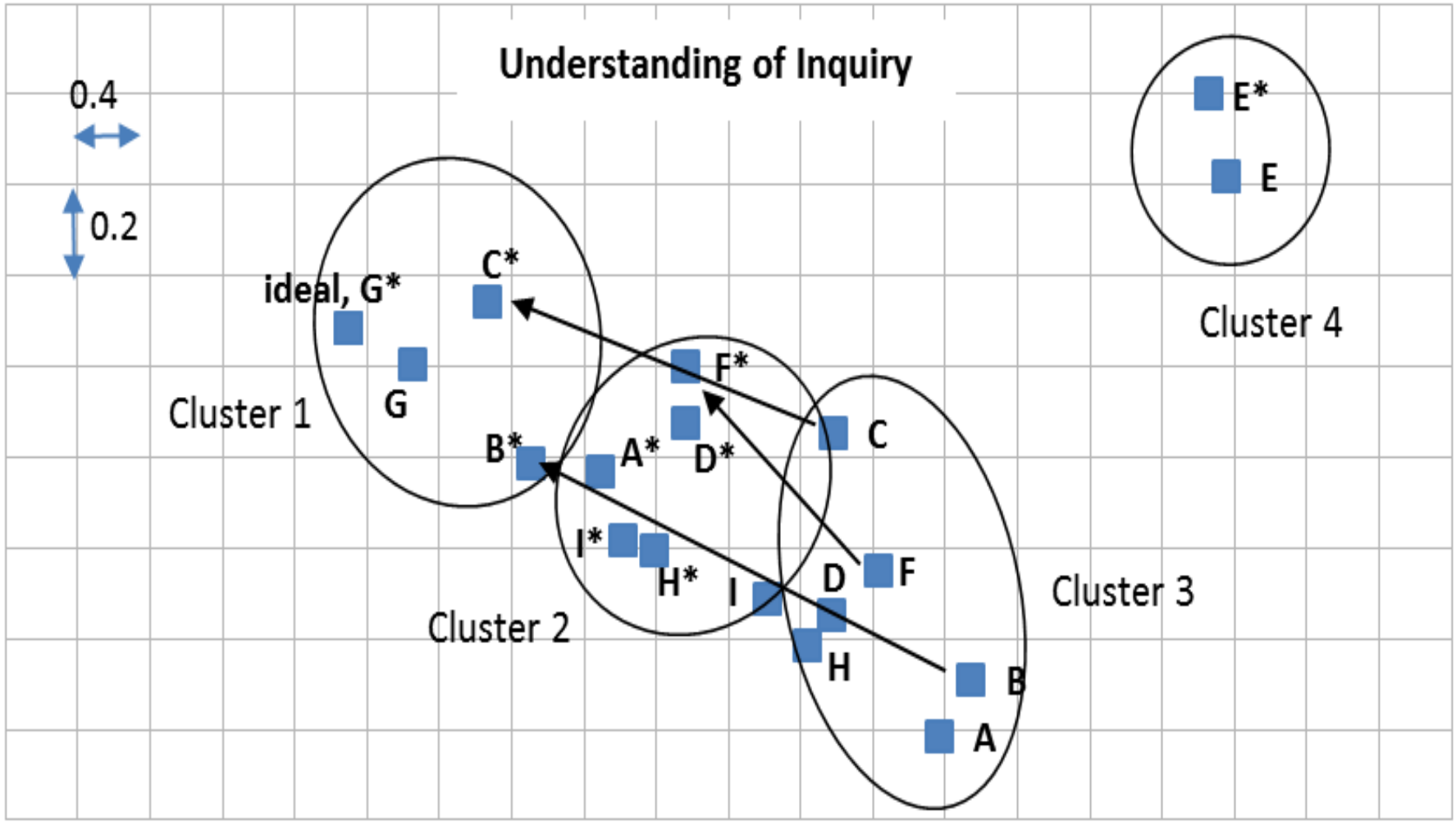
ESTABLISH - Impact on Teachers

- **Understanding of inquiry**
  - I don't fully understand inquiry based science education
  - I don't fully understand my role as a teacher in an inquiry classroom
  - I don't fully understand the role of the students in an inquiry classroom

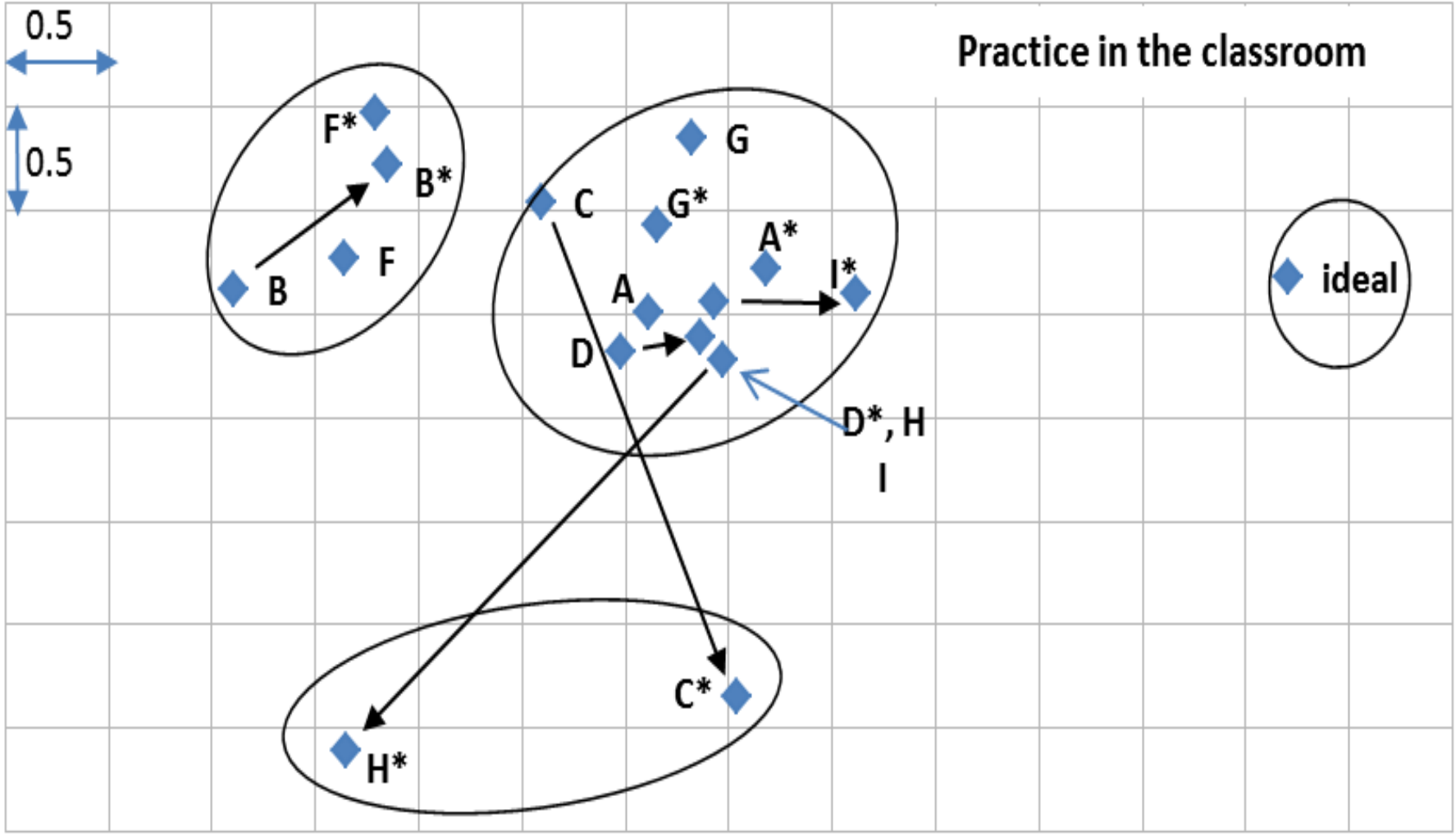
- **Practice in the classroom**

•If a student investigation leads to an unexpected result I always tell the students the right answer/result;
•I am unsure how to ask students higher order questions that promotes thinking;
•I have sufficient knowledge of science to implement an inquiry lesson effectively.

Results - Understanding of inquiry, #=233



Results – Practice in the classroom, #233



•ESTABLISH – Project Outcomes

• increased use of IBSE methodologies by teachers;

• greater understanding, attitude and ability to use IBSE in their teaching;

• increased student's motivation and communication during science lessons;

• greater student attitude towards science and taking up careers in science or technology;

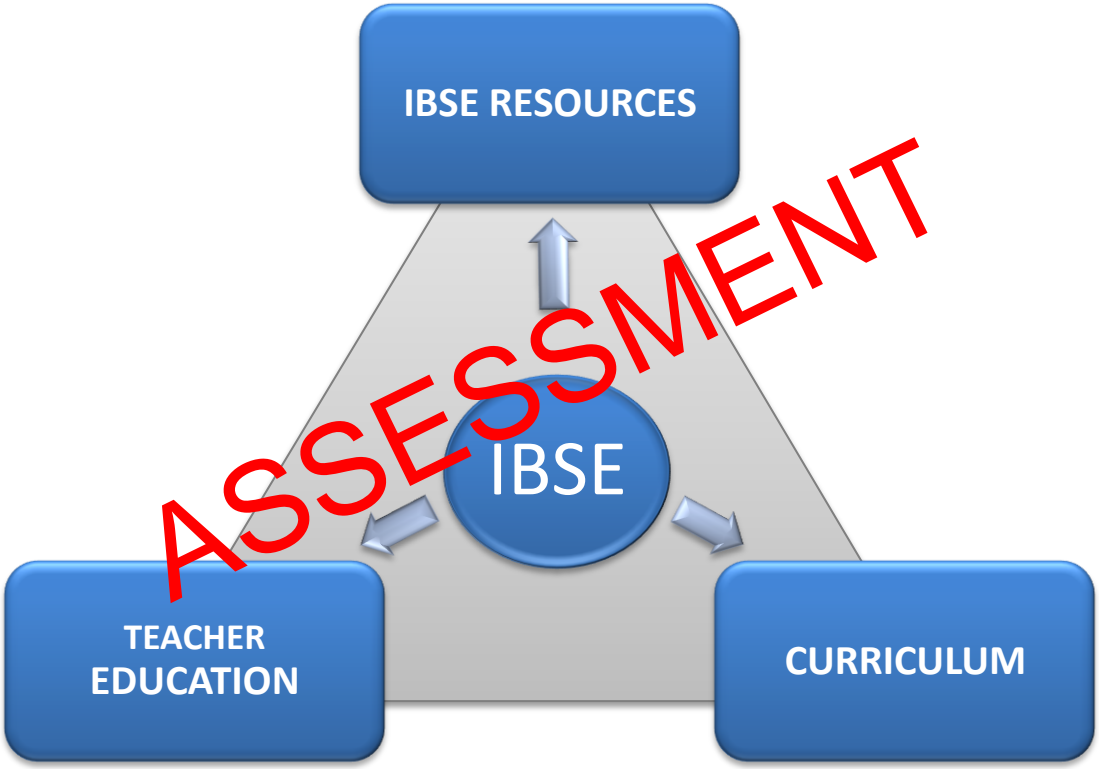
• increased interaction between those teaching and learning about science and those using science.

SAILS partners

14 institutions in **12 European countries**

Sustainable model for IBSE

Unified approach of implementing all the necessary components for transforming classroom practice - sustainable model for IBSE.



Inquiry Skills and Competencies

Inquiry is the “intentional process of

(1) diagnosing problems,
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(6) searching for information,
(7) constructing models,
(8) debating with peers, and
(9) forming coherent arguments.”

(Linn, Davis and Eylon, 2004)

Curriculum and Assessment – Lower Secondary

	Diagnose problem	Critique experiments	Distinguish alternatives	Plan Investigation	Researching conjectures	Search for information	Construct models	Debate with peers	Form coherent arguments
Belgium	Curriculum and Assessment		Curriculum Only	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment			
Denmark	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only		Curriculum Only	Curriculum Only
Germany	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment
Greece		Curriculum Only							
Hungary	Curriculum Only			Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only	
Ireland		Curriculum Only		Curriculum and Assessment		Curriculum Only		Curriculum Only	Curriculum and Assessment
Poland	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only		Curriculum Only	Curriculum Only
Portugal	Curriculum and Assessment		Curriculum and Assessment	Curriculum and Assessment		Curriculum and Assessment	Curriculum Only	Curriculum and Assessment	
Slovakia	Curriculum Only	Curriculum Only	Curriculum and Assessment	Curriculum Only	Curriculum Only	Curriculum and Assessment	Curriculum and Assessment	Curriculum Only	Curriculum and Assessment
Sweden	Curriculum Only	Curriculum and Assessment	Curriculum Only	Curriculum and Assessment	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum Only	Curriculum and Assessment
Turkey	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment
UK	Curriculum and Assessment	Curriculum Only	Curriculum Only	Curriculum and Assessment	Curriculum and Assessment	Curriculum and Assessment			Curriculum and Assessment

Curriculum Only

Curriculum and Assessment

Curriculum and Assessment – Upper Secondary

	Diagnose problem	Critique experiment	Distinguish alternatives	Plan Investigation	Researching conjectures	Search for information	Construct models	Debate with peers	Form coherent arguments
Belgium									
Denmark									
Germany									
Greece									
Hungary									
Ireland									
Poland									
Portugal									
Slovakia									
Sweden									
Turkey									
UK									

Curriculum Only

Curriculum and Assessment

The main purposes for assessment

- ***Summative assessment:*** Assessment of current individual level of knowledge and competence (in order to monitor educational progress and to compare student learning to the standards of performance or to their peers).

- ***Formative assessment:*** Assessment to assist learning (trough providing teachers and students with feedback – for the teachers to revise their teaching and for students to monitor their own learning)

- ***Accountability assessment (evaluation):*** Assessment to evaluate educational programs (national performance, school performance, etc.) (in order to drive changes in practice and policy)

The terms describe the purposes for which the assessment is done, not the task itself – all assessment tasks can be used summatively as well as formatively!

An assessment research project

Students divided into 4 groups:

A: got marks for their assignments

B: got written comments (and no marks) to their assignments

C: got both marks and comments

D: got no feedback (control group)

A: Same improvement as the control group

B: 30% better than the control group

C: same as A and control group (Judith Butler 1988)

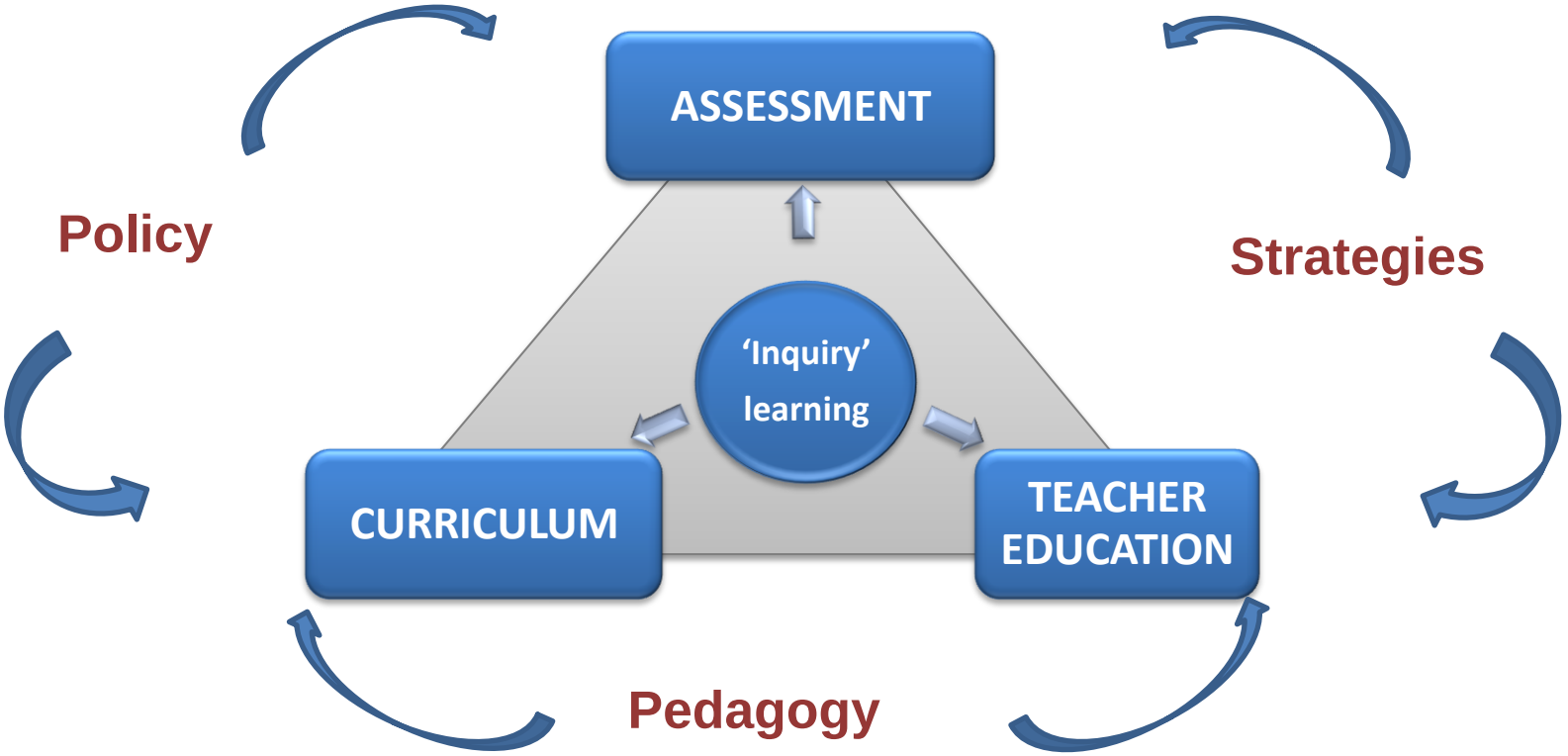
Point: Summative assessment does not enhance learning!

Time spent on summative assessment and evaluation is taken from time spent on learning.

SAILS
Strategies for Assessment of Inquiry Learning in Science

AIM OF PROJECT

"SAILS aims to prepare teachers not only to be able to teach through IBSE, but also to be confident and competent in the assessment of their students' learning through inquiry."



SAILS
Strategies for Assessment of Inquiry Learning in Science

Objective 1

Enhance existing IBSE teaching and learning materials

by incorporating inquiry assessment strategies and frameworks

SAILS
Strategies for Assessment of Inquiry Learning in Science

Objective 2

Partner with teachers to identify and implement assessment strategies and frameworks to evaluate key IBSE skills and competences in the classroom

SAILS
Strategies for Assessment of Inquiry Learning in Science

Objective 3

Provide Teacher Education workshops in IBSE and CoP

in 12 European countries

Communities of Practice CoPs

Facilities available to International CoP members:

- Discussions:
  - Lists discussions taking place in the CoP
  - Allows users to post comments and add new discussions
- Calendar:
  - Shows planned events in a calendar format
  - Allows users to add an event
- Resources:
  - Contains materials/units/case studies shared by members (e.g. documents, images, videos, web links, etc.)
- Members: CoP members and their contact details

SAILS
Strategies for Assessment of Inquiry Learning in Science

The **SAILS** project has received funding from the European Union's Seventh Framework Programme [**FP7/2007-2013] under grant agreement n° 289085**

CAPACITIES

SAILS
Strategies for Assessment of Inquiry Learning in Science

Objective 4

Promote the use and dissemination of inquiry approaches to teaching, learning and assessment

with national and international stakeholders.

SAILS Motivation

School leavers need to:

- Be prepared for work/future study/life
- Become independent learners
- Have 21st century skills such as described in the next slides

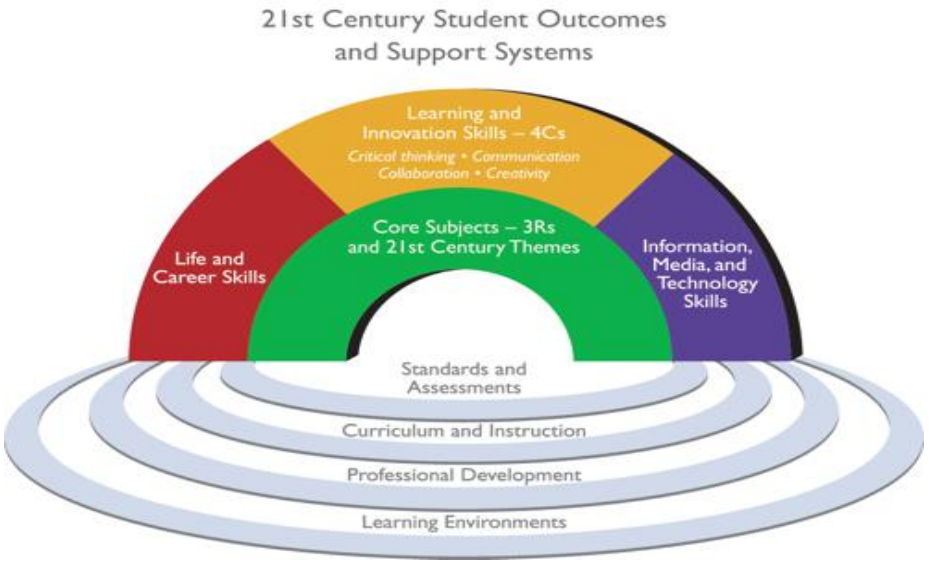
Partnership for 21st Century Skills
(2011)

Core Subjects and 21st Century Themes

Learning and Innovation Skills
- Creativity and Innovation
- Critical Thinking and Problem Solving
- Communication and Collaboration

Information, Media and Technology Skills
- Information Literacy
- Media Literacy
- ICT Literacy

Life and Career Skills
- Flexibility and Adaptability
- Initiative and Self-Direction
- Social and Cross-Cultural Skills
- Productivity and Accountability
- Leadership and Responsibility



Mapping IBSE with 21st Century Skills (1)

Creativity and Innovation

Framework for 21st Century Learning	Teaching science so students	In IBSE, students engage in
think creatively	question conclusion	diagnosing problems critiquing experiments distinguishing alternatives researching conjectures
work creatively with others	communication	discussion with peers forming coherent arguments searching for information
implement innovations	design data	planning investigations constructing models

Mapping IBSE with 21st Century Skills (2)

Critical Thinking and Problem Solving

Framework for 21st Century Learning	Teaching science so students	In IBSE, students engage in
Reason Effectively	question	diagnosing problems critiquing experiments
Use System Thinking	design	constructing models
Make Judgments and Decisions	predict conclusion	distinguishing alternatives planning investigations
Solve Problems	data	researching conjectures

Mapping IBSE with 21st Century Skills (3)

Communication and Collaboration

Framework for 21st Century Learning	Teaching science so students	In IBSE, students engage in
Communicate Clearly	question design data conclusion communication	distinguishing alternatives debating with peers forming coherent arguments
Collaborate with Others		

Topics of SAILS Units

Plant nutrition
Living conditions of wood lice
Tooth decay
Natural selection
Speed
Electricity
UV radiation
Speed of reaction
Galvanic cell
Plastics
Water pollution (impact of detergents)
Which is the best fuel?

SAILS Unit format

Topic

Key concepts and ideas

Inquiry skills

Reasoning skills

Scientific literacy

Suggested learning sequence

Suggested assessment items

Case study

Learning sequence
Inquiry skills
Evidence
Criteria

Case study

Case study

Case study

Example

Student dialogue

Written/ video

Diagnostic

CRITERIA

Part A

Part B

Example of a unit: Collision of an egg

Content	Collision of an egg from free fall in case of different surfaces
Course **Level (target age)**	Science, Physics for 15-16 yrs. age group
Goals	The identification of effects on the forces during collision, planing an experiment.
Time (lessons)	90min (2)
Equipment, materials	Materials: one box of eggs per group, flour, water, semolina, sand, baloon and materials advised by the students Equipment: tape measure, digital balance, bucket, deep bowl, stopwatch

Collision of an egg

2. Content

The task is to solve an unstructured problem. The theme of the task is that of mechanics, the connection between force and momentum, with some reference to traffic safety.

3. Inquiry skills:

- Developing a hypothesis
- Planning investigations

Collision of an egg - Supportive questions

- What physical variables effect the forces generated on objects?
- How does the change in momentum effect force?
- What does momentum depend on?
- How can an object's momentum be changed?
- What does impact speed depend on?
- How do you calculate the speed of an object in free fall?
- Which variable can be taken as constant?
- How do you find connections between the variables?
- How does the drop height effect the egg's collision?
- How does the surface effect the collision?
- Why does the egg remain intact in flour and semolina?

Case studies (Teacher Stories)

Case studies will provide a narrative on how teachers:

- have implemented or adapted the learning sequence (differentiation/age level),
- what skills did they assess and how,
- what evidence did they collect on student learning
- and how they judged this assessment data (criteria and explanation/justification)

Example of criteria:

Developing a hypothesis			
Helpful questions: • What do you expect to happen? • Why does the occurance happen? • Can you explain you hypothesis from what you have learnt?	The student formulates presupposition, but is unable to explain the hypothesis	The student formulates the presupposition and is able to explain the hypothesis with the helpful question	The student explains the hypothesis and supports it with scientific facts
Planning the investigation			
Helpful questions: • How can the experiment be implemented? • Which physical variable should be studied? • How can connection be found between variables? • What can you do in order to accurately fix the measurements? • More exact questions in teacher support.	The student gives recomendations on how the experiment should be carried out, but is unable to proceed and does not understand the process.	The student gives recomendations on how the experiment should be carried out and understands the process, but is unable to proceed.	The student gives recomendations on how the experiment should be carried out and understands the process, can proceed with the planing of the experiment.

Case study on Wood lice:

Skill: Developing hypothesis, Level 1

Choosing your variable:

Variables: There are many variables that could affect the life of a woodlouse.
Suggested variables for you to investigate are:

- Intensity of light
- Amount of moisture
- Food preferences

Discuss these variables in your group and decide which one you would like to investigate. Write your choice below.

Which variable have you decided to investigate?

Intensity of Light

Formulating your hypothesis:

Now you have decided which variable you would like to investigate, use the space below to explain the *question(s) you are trying to answer* (or *the problem(s) you are trying to solve*).

Questions to be answered:

Dark
Room Light
Intense Light

Predictions: Use any **scientific knowledge** you already have, answer the following questions. Try and be as clear as you can in your answers.

***What* do you think will happen?**

they will all run away from the Intense Light and go to the Complete darkness

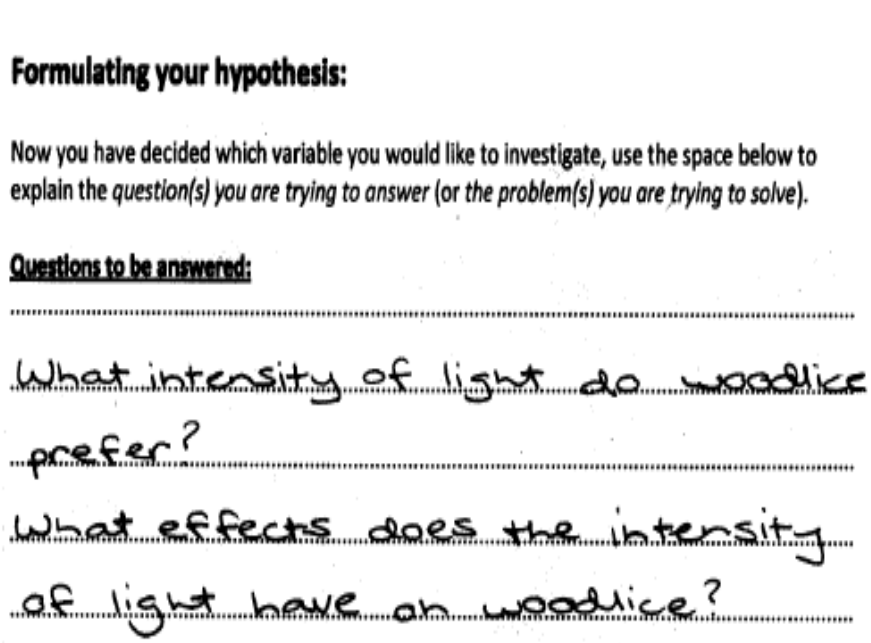
***Why* do you think this will happen?**

because they arn't an Inteligent life form

The student formulated a prediction about what would happen within their light intensity experiment. However, when they attempted to explain why they thought this would happen, their answer showed no relevant connection to their prediction.

Case study on Wood lice

Skill: Developing hypothesis, Level 2



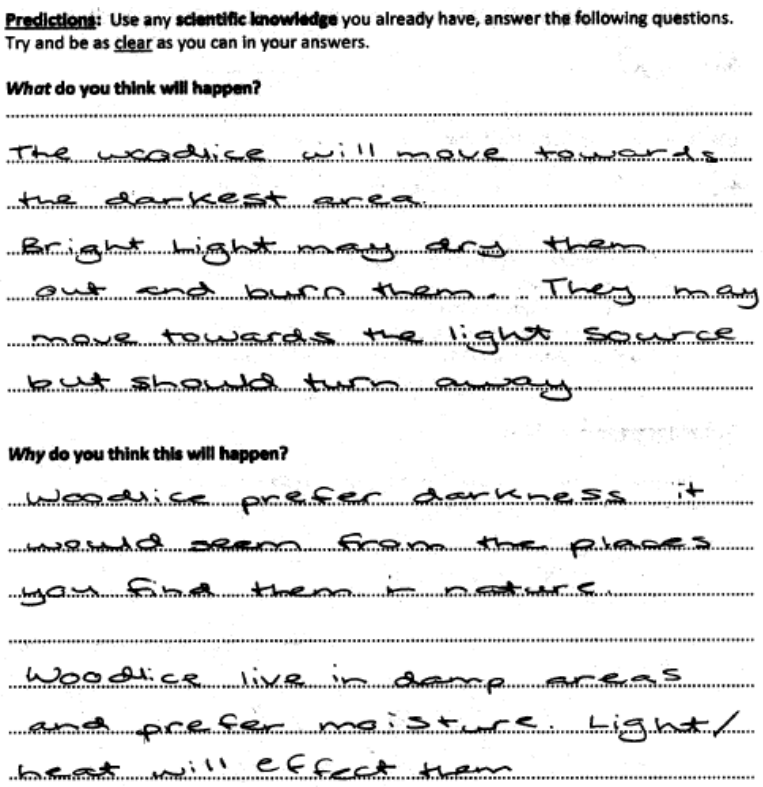
Formulating your hypothesis:

Now you have decided which variable you would like to investigate, use the space below to explain the *question(s) you are trying to answer* (or *the problem(s) you are trying to solve*).

Questions to be answered:

What intensity of light do woodlice prefer?

What effects does the intensity of light have on woodlice?



Predictions: Use any **scientific knowledge** you already have, answer the following questions. Try and be as clear as you can in your answers.

***What* do you think will happen?**

The woodlice will move towards the darkest area. Bright light may dry them out and burn them. They may move towards the light source but should turn away.

***Why* do you think this will happen?**

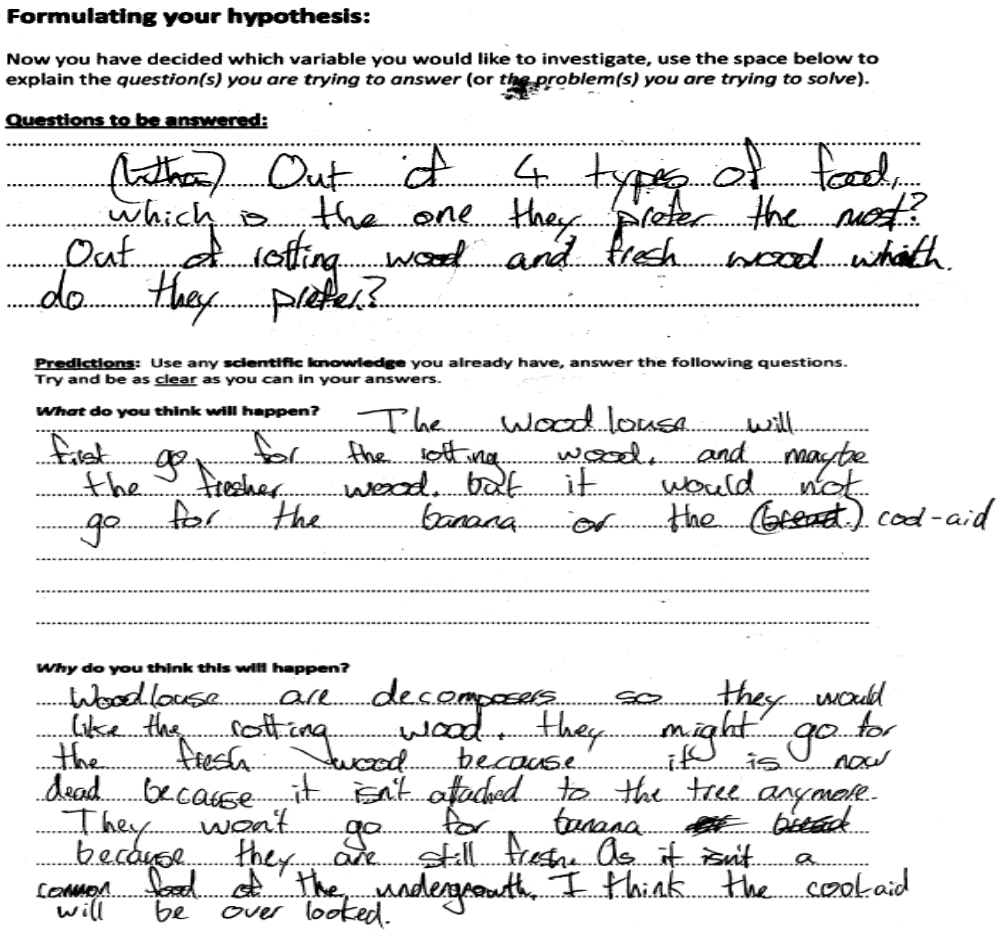
Woodlice prefer darkness it would seem from the places you find them in nature.

Woodlice live in damp areas and prefer moisture. Light/heat will effect them

The student made their prediction about what would happen during the experiment, and explained why they believed this would happen based on their experiences with woodlice.

Case study on Wood lice,

Skill: Developing hypothesis, Level 3



Formulating your hypothesis:

Now you have decided which variable you would like to investigate, use the space below to explain the *question(s) you are trying to answer* (or *the problem(s) you are trying to solve*).

Questions to be answered:

(within) Out of 4 types of food, which is the one they prefer the most? Out of rotting wood and fresh wood which do they prefer?

Predictions: Use any **scientific knowledge** you already have, answer the following questions. Try and be as clear as you can in your answers.

***What* do you think will happen?** The woodlouse will first go for the rotting wood, and maybe the fresher wood. but it would not go for the banana or the (bread) cool-aid

***Why* do you think this will happen?**

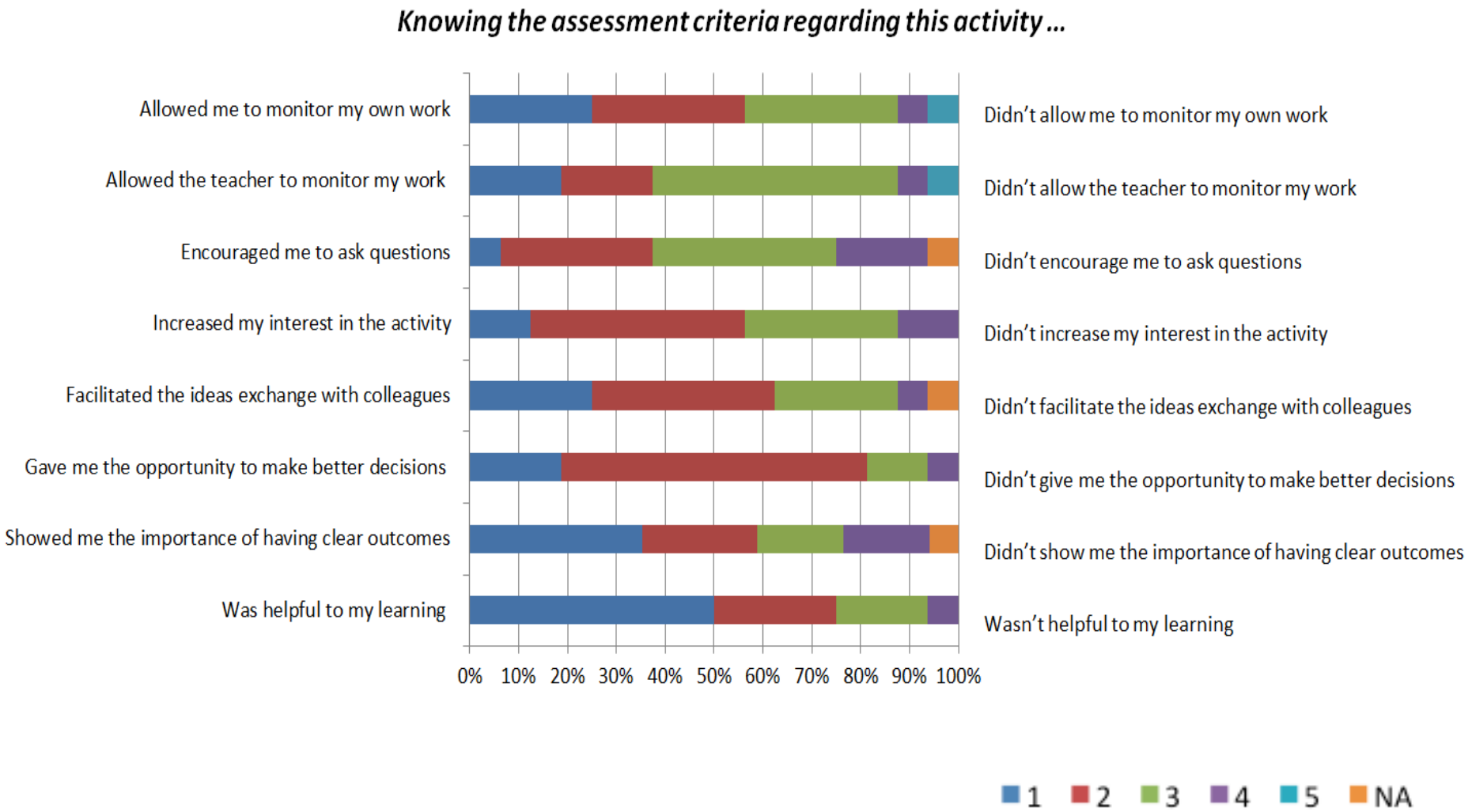
Woodlouse are decomposers so they would like the rotting wood. they might go for the fresh wood because it is now dead because it isn't attached to the tree anymore. They won't go for banana ~~or~~ bread because they are still fresh. As it isn't a common food of the undergrowth. I think the cool-aid will be over looked.

This student made a detailed prediction and explained why they believed this would happen using their scientific content knowledge (indicating differences in different types of wood, and that woodlice are decomposers.

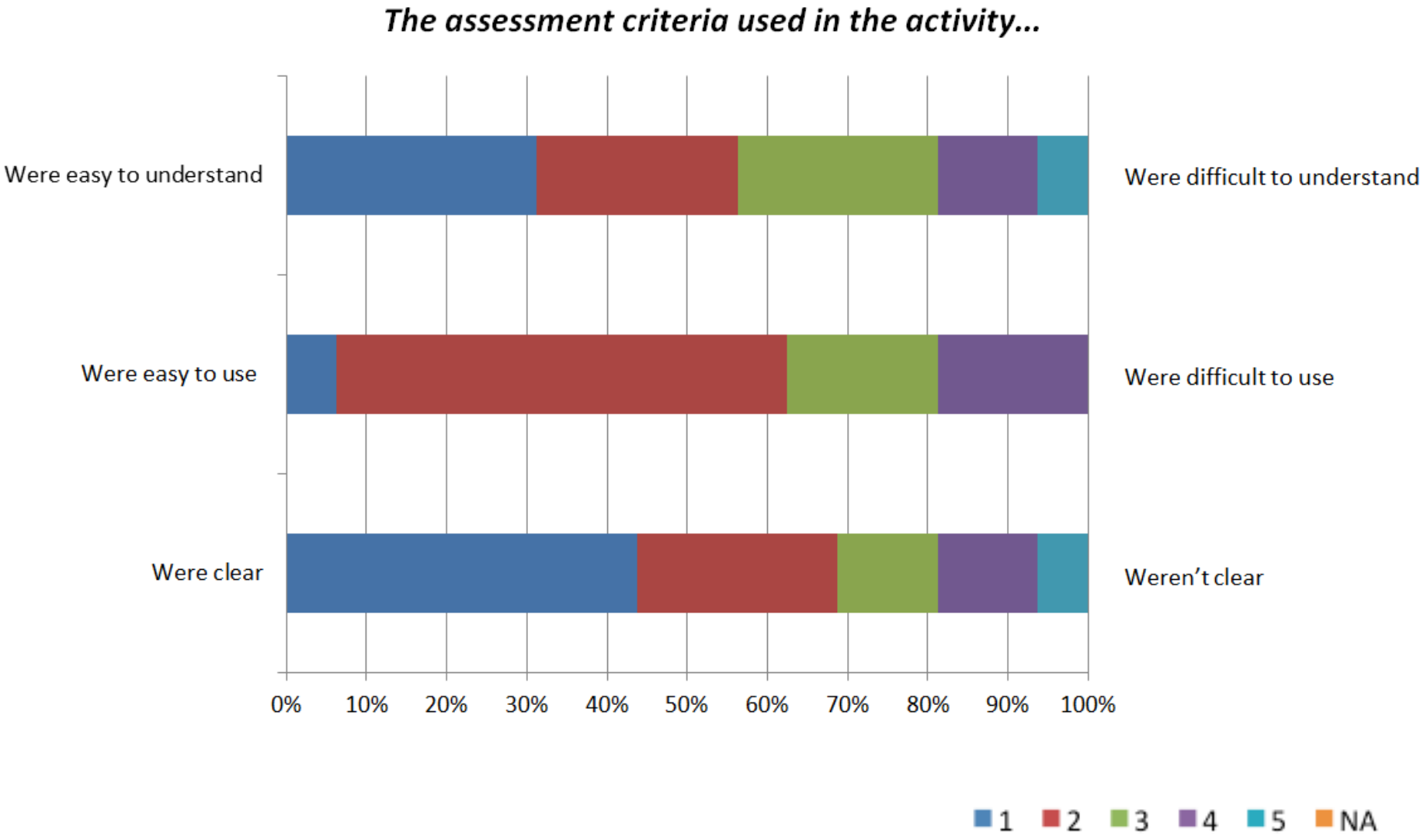
Forms of evidence

- Student worksheets/reports
- Student dialogue
- Teacher observations
- Classroom videos
- Diagnostic questioning
- Student presentations
- …
- …

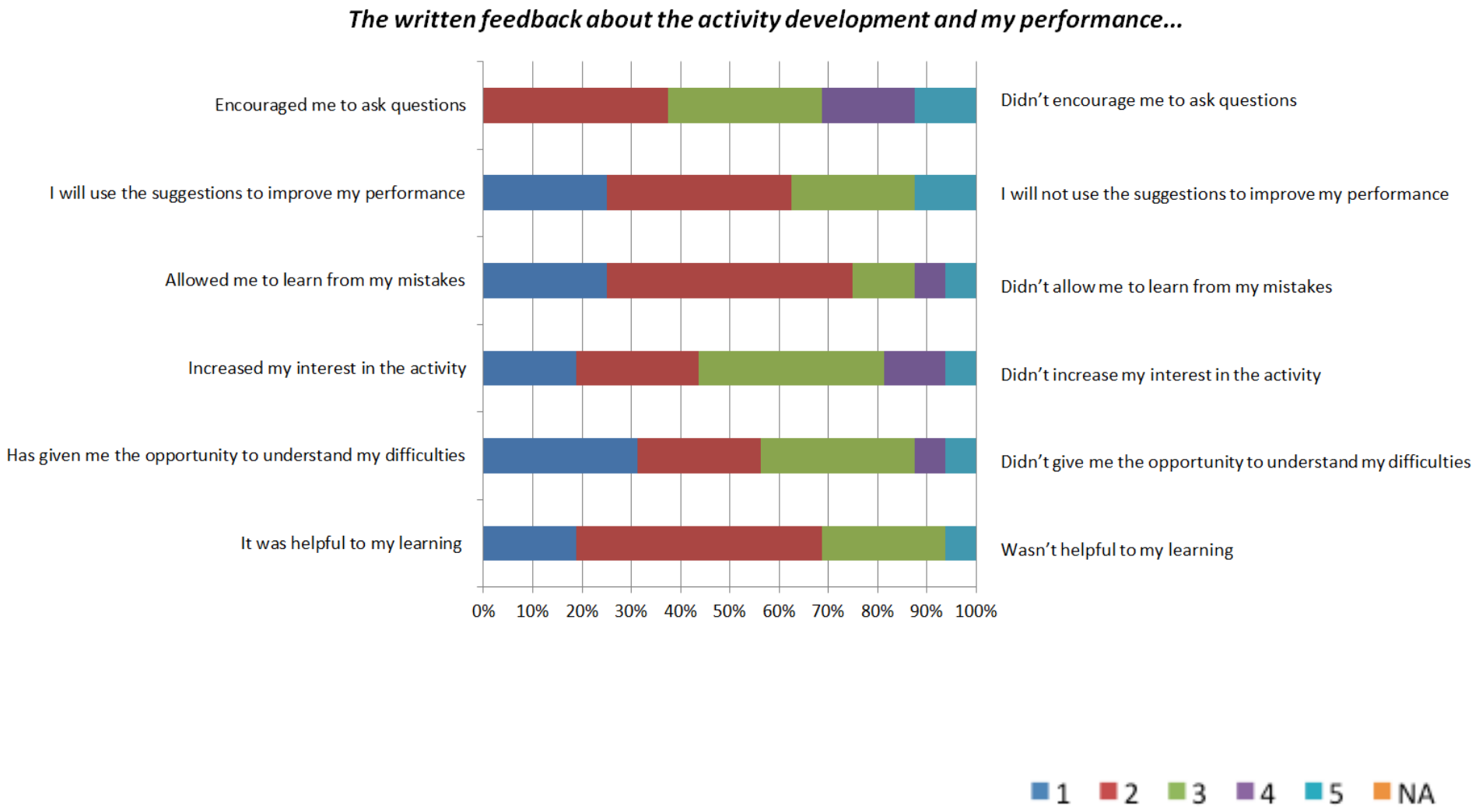
Students Opinions regarding assessment process (1)



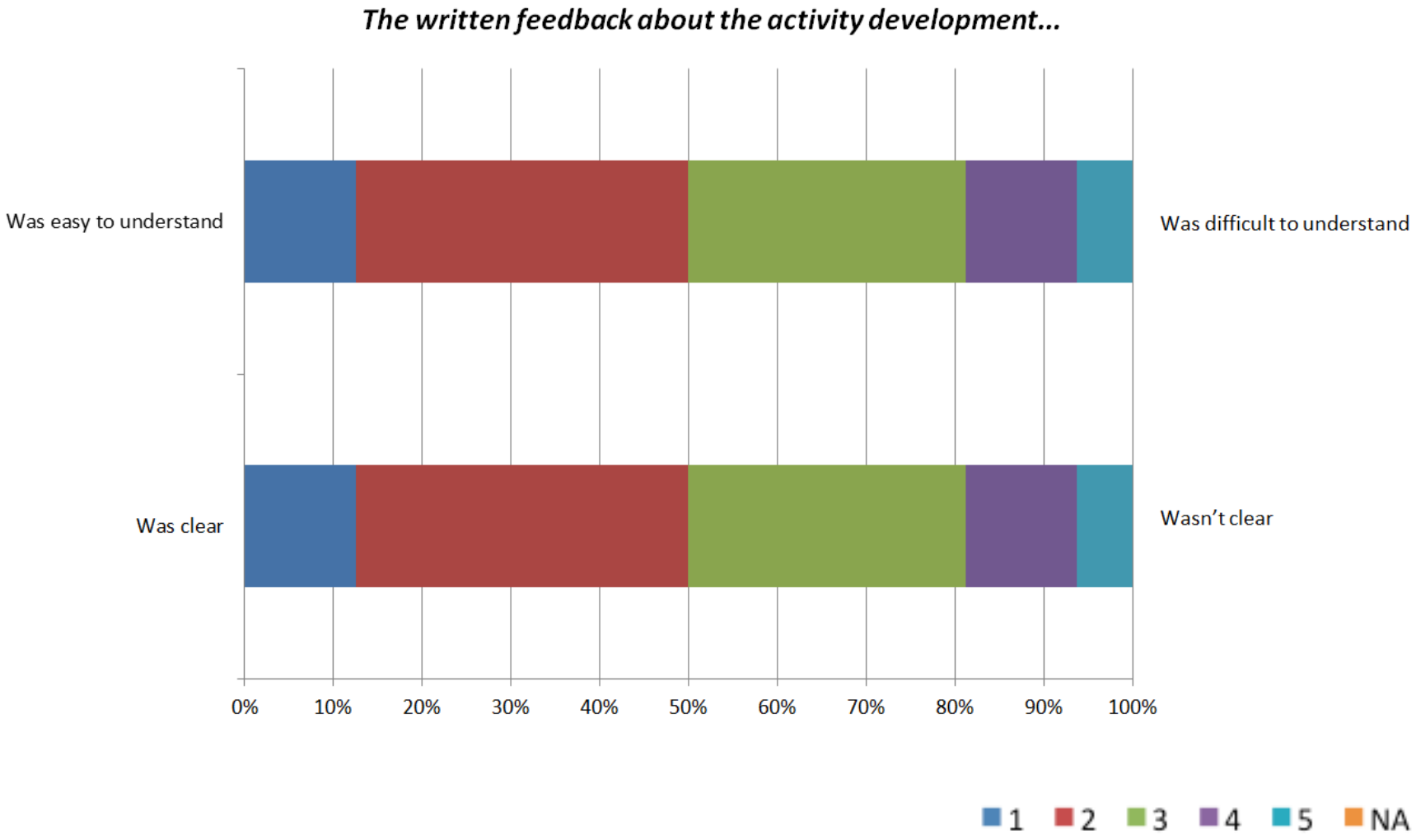
Students Opinions regarding assessment process (2)



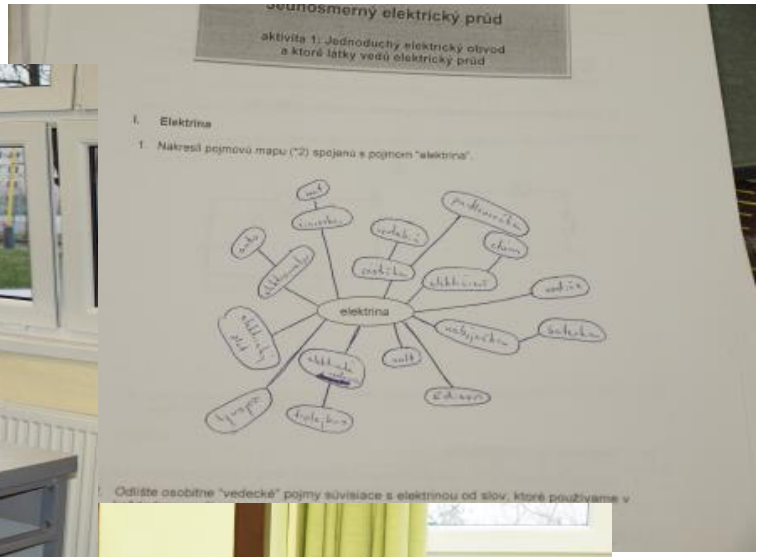
Students Opinions regarding assessment process (3)



Students Opinions regarding assessment process (4)



e.g. Unit - Electricity



Teacher feedback - electricity unit

- Dorota, lower secondary school:

  "I was inspired by this unit and assessment tools designed for this activity. It was quite new for pupils who are not used for this kind of activities and assessment. I think they need more training in this field."

- Vierka, lower secondary school:

- *"The proposed assessment tools evaluate pupils´ abilities in different aspects of inquiry well and it helped me to reveal problematic areas of pupils abilities like to plan and express the investigation procedure, interpretation skills, on the other hand I was surprised by the activity and creativity of some pupils that have usually poor results."*

- *"I was really amazed by this activity and so were the pupils and I would like to have more activities like this with detail description - materials for teachers and pupils available."*

SAILS Teacher Education Programmes

- **Experience inquiry themselves**
- Implement-trial in classroom
- Develop inquiry lessons
- Evaluate resources
- **Experience assessment in action**
- Assess student work
- Develop assessment criteria
- Techniques for classroom management
- Variety of assessment practices

Conclusions- Success in IBSE

The **success** of the **education reform** movement requires many elements to be taken into account, such like improvements in:

- curricula and student assessment,
- in-service and pre-service teacher training,
- appropriate instructional materials for teachers,
- positive atmosphere towards these trends at school, etc.

(Roschelle et col., 2000)

Getting Involved

- **SAILS Community of Practice (CoP)** – connecting practitioners in assessing inquiry.

  sails-project.eu/portal/cop

- **SAILS/SMEC Conference,** 24th-25th June 2014, Dublin City University – bringing together teachers, educators, researchers and policy makers –

  "*Thinking Assessment in STEM Education*"

  www.dcu.ie/smec

SAILS

Strategies for Assessment of Inquiry Learning in Science

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CAPACITIES

European Research Area