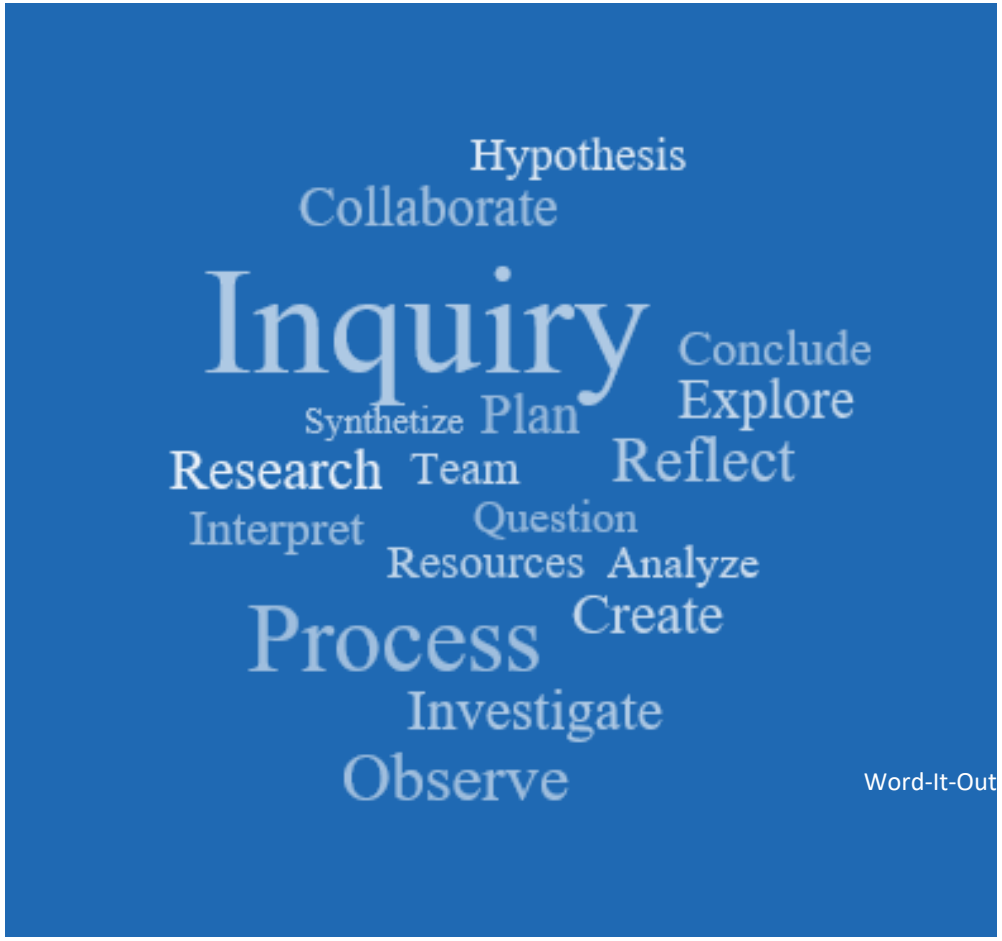
LEARNING THROUGH INQUIRY

DAGMARA SOKOŁOWSKA

JAGIELONIAN UNIVERISTY, KRAKOW

IBL IN SHORT


Hypothesis
Collaborate
Inquiry
Conclude
Explore
Synthetize
Plan
Research
Team
Reflect
Interpret
Question
Resources
Analyze
Create
Process
Investigate
Observe
Word-It-Out

IBL GENESIS

Jean Piaget (1896-1980)

*… **creative, inventive and discoverers, capable of doing new things** who **can be critical and verify**, and not accept, everything they are offered.*

Lev Vygotsky (1896-1934)

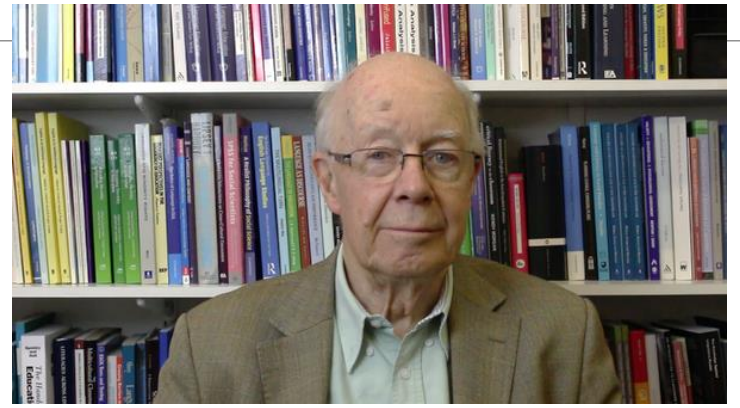
*…value lies not only in its results, not in the product of creation, but **in the process** itself.*

John Dewey (1859-1952)

Give the pupils something to do, not something to learn.

Scientific principles and laws do not lie on the surface of nature. They are hidden, and must be wrested from nature by an active and elaborate technique of inquiry.

Physics by Inquiry
Lilian McDermott

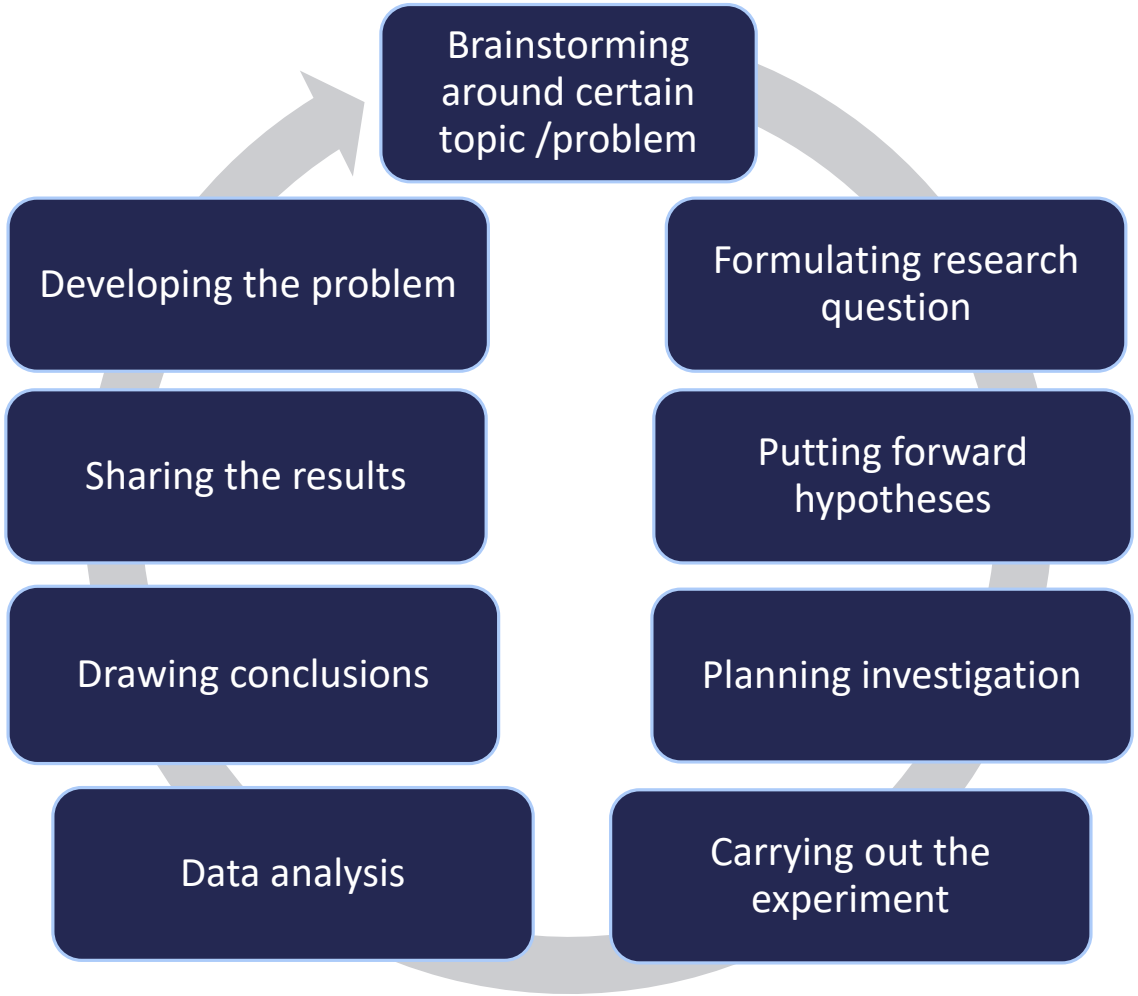


Assessment for Learning in the classroom
Paul Black

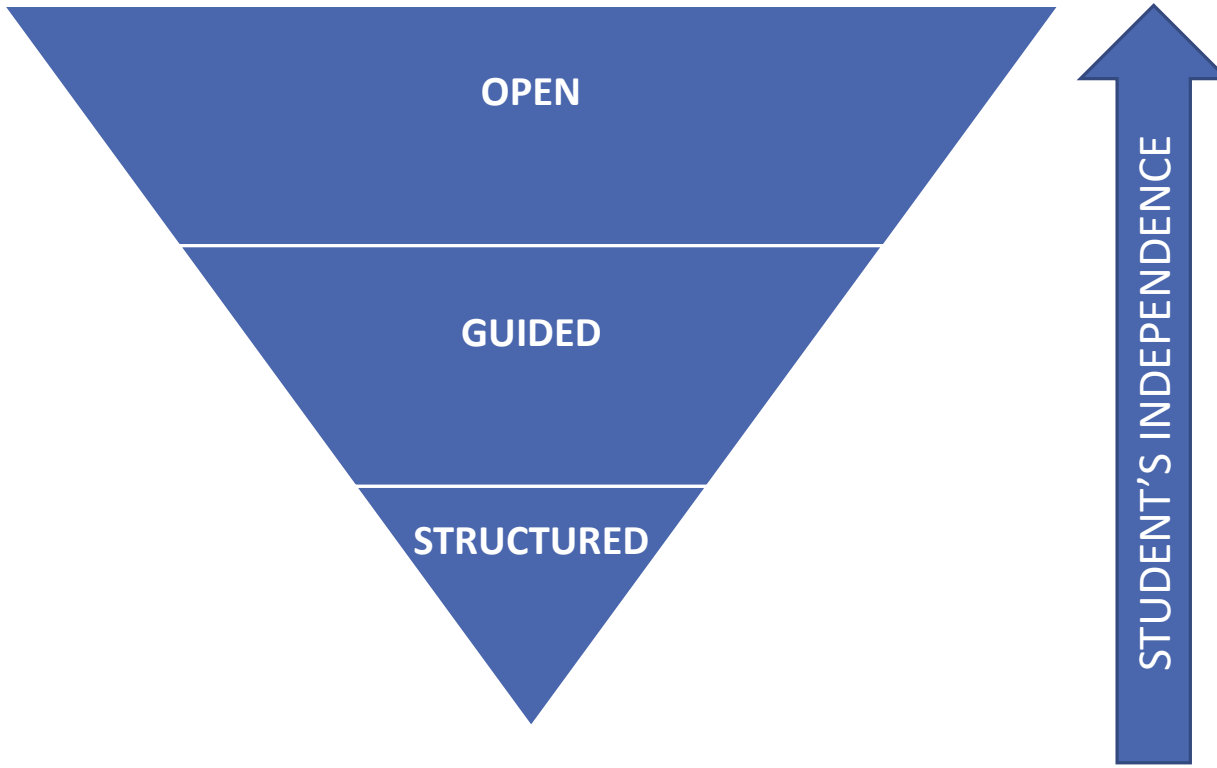
Principles and Big Ideas of Science Education
Wynne Harlen

Focus on Inquiry
Sharon Friesen

INQUIRY-BASED LEARNING (IBL)

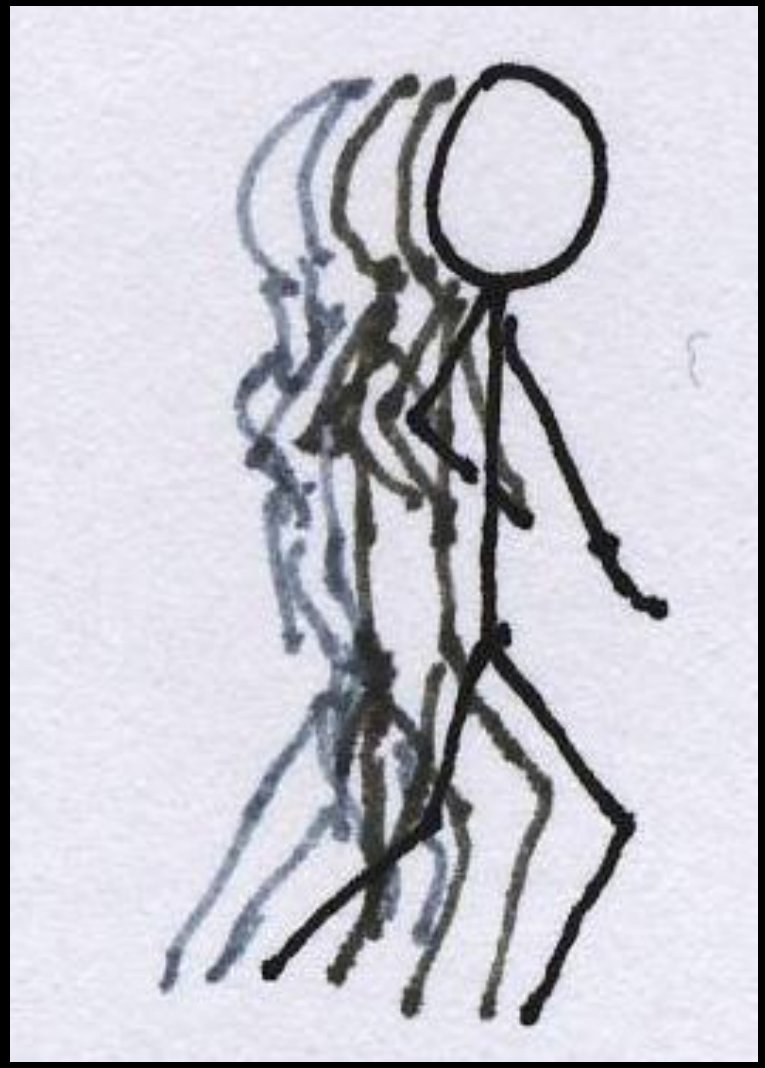


Fibonacci project EU, 2010-2013

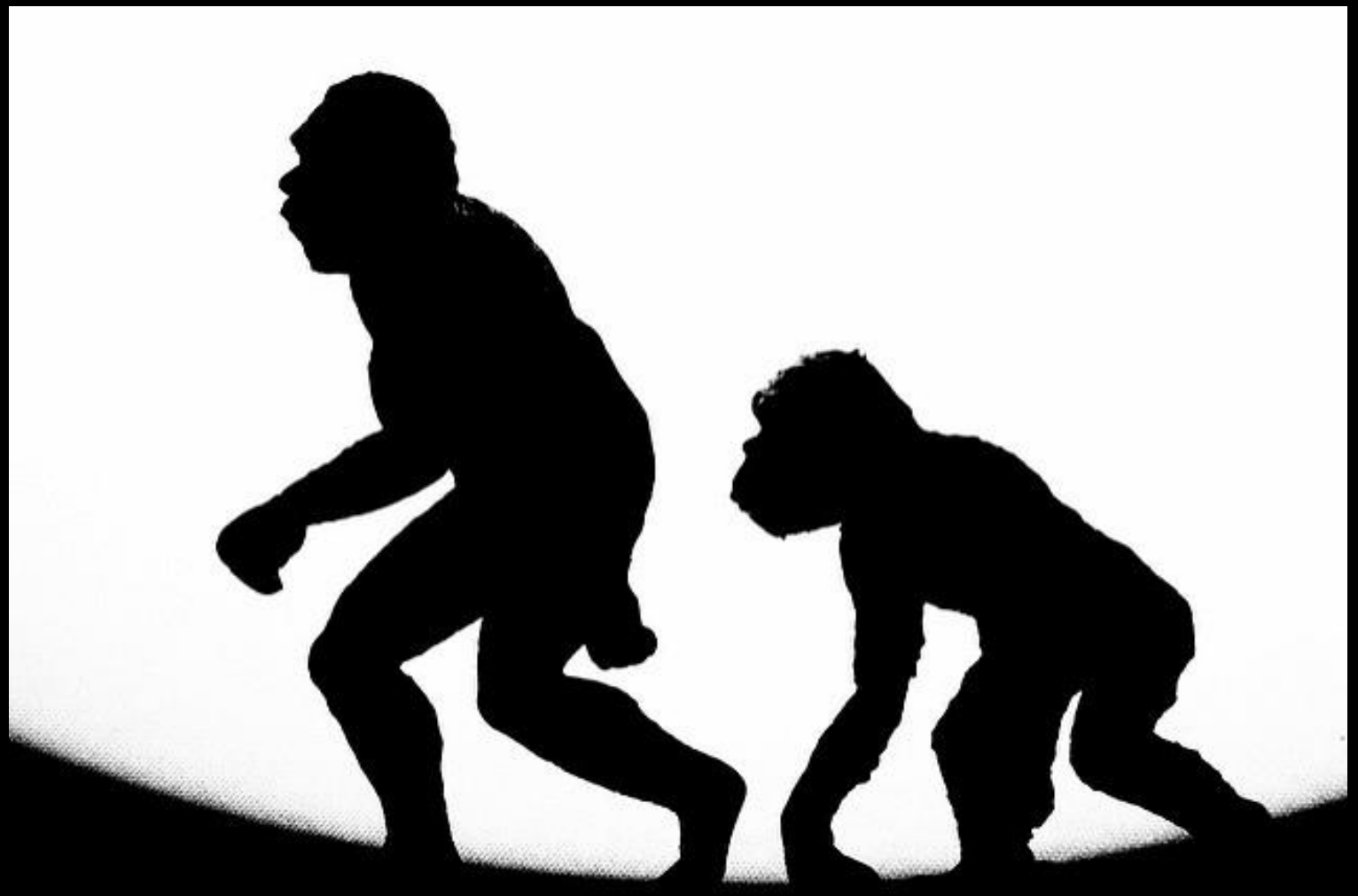


Focus on Inquiry, Sharon Freisen

Phot. by Praveen Kumar



Phot. by Xavier Verges



Phot. by Kevin Dooley

Phot. by Andy

Phot. by Kerry Sanders

3 x H

Head

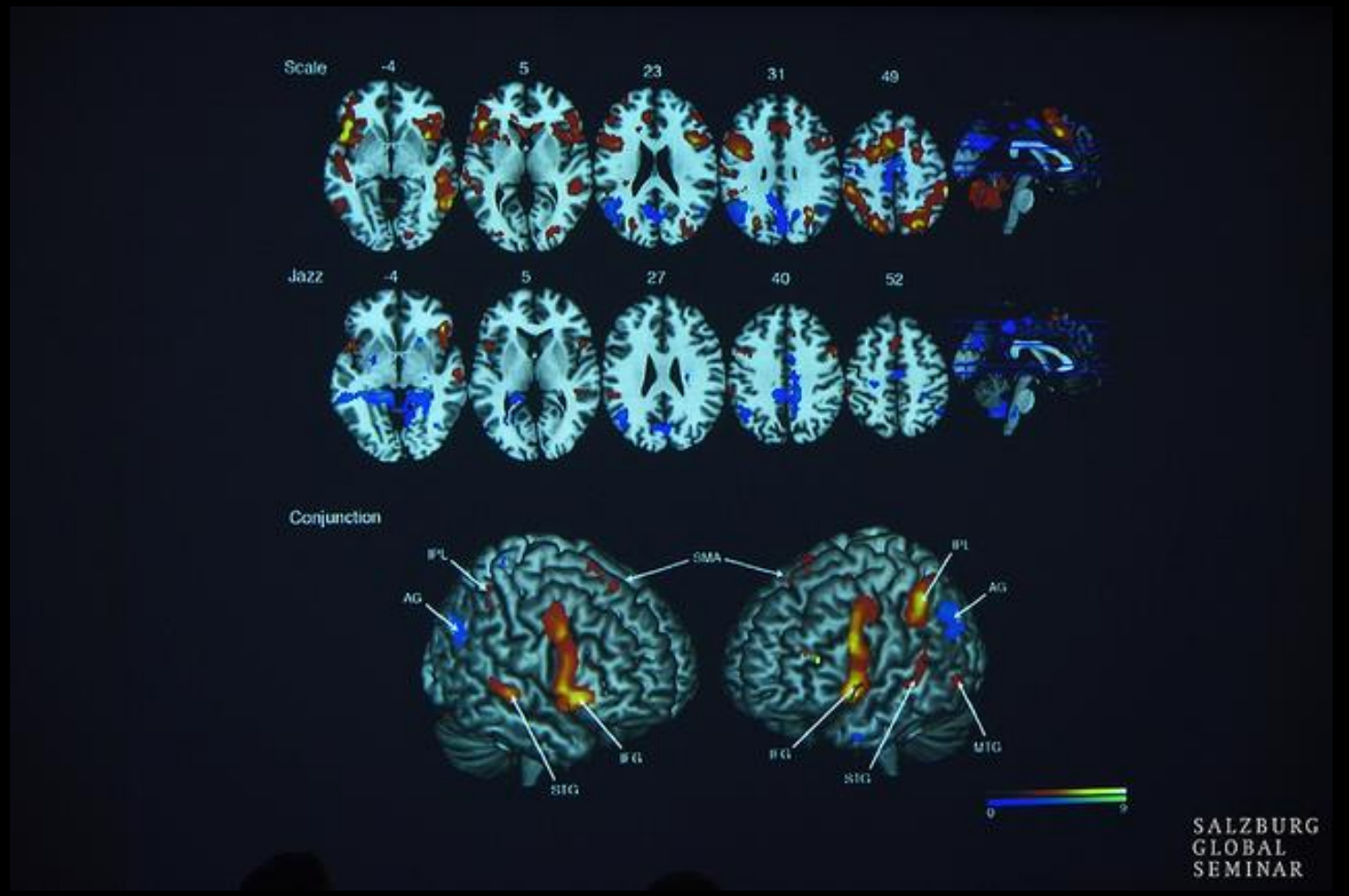
Hand

Heart

From 3 x H to Competences

KNOWLEDGE — SKILLS — ATTITUDES

COMPETENCES



Session: *The Neuroscience of Art.: What are the sources of Creativity and Innovation?*
21-26 Feb 2016

Learning by playing

Taking roles

Learning through interaction with others

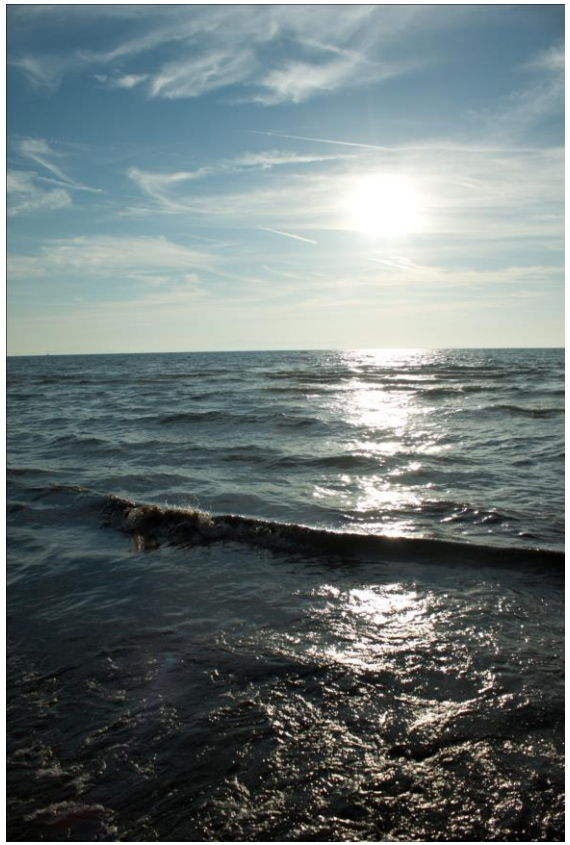
Involving emotions

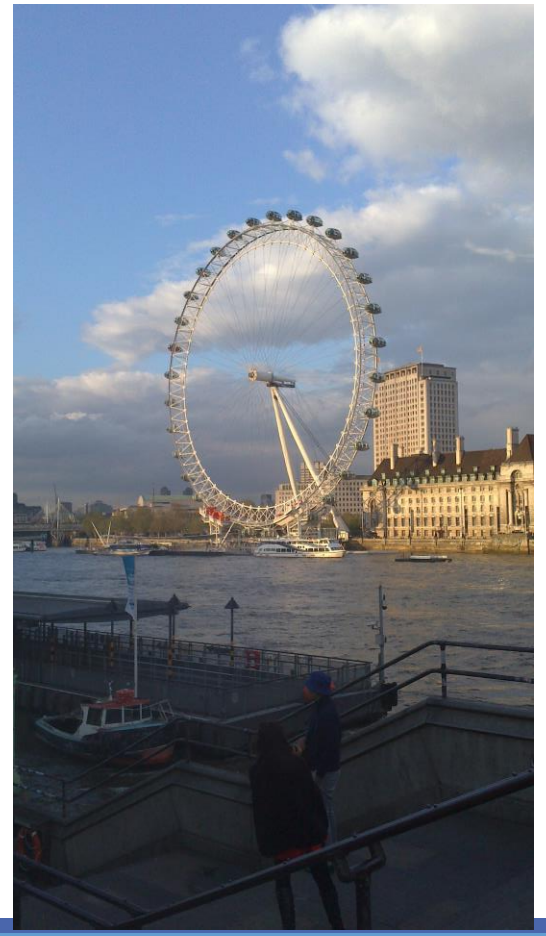
Context learning

Multisensory teaching/learning

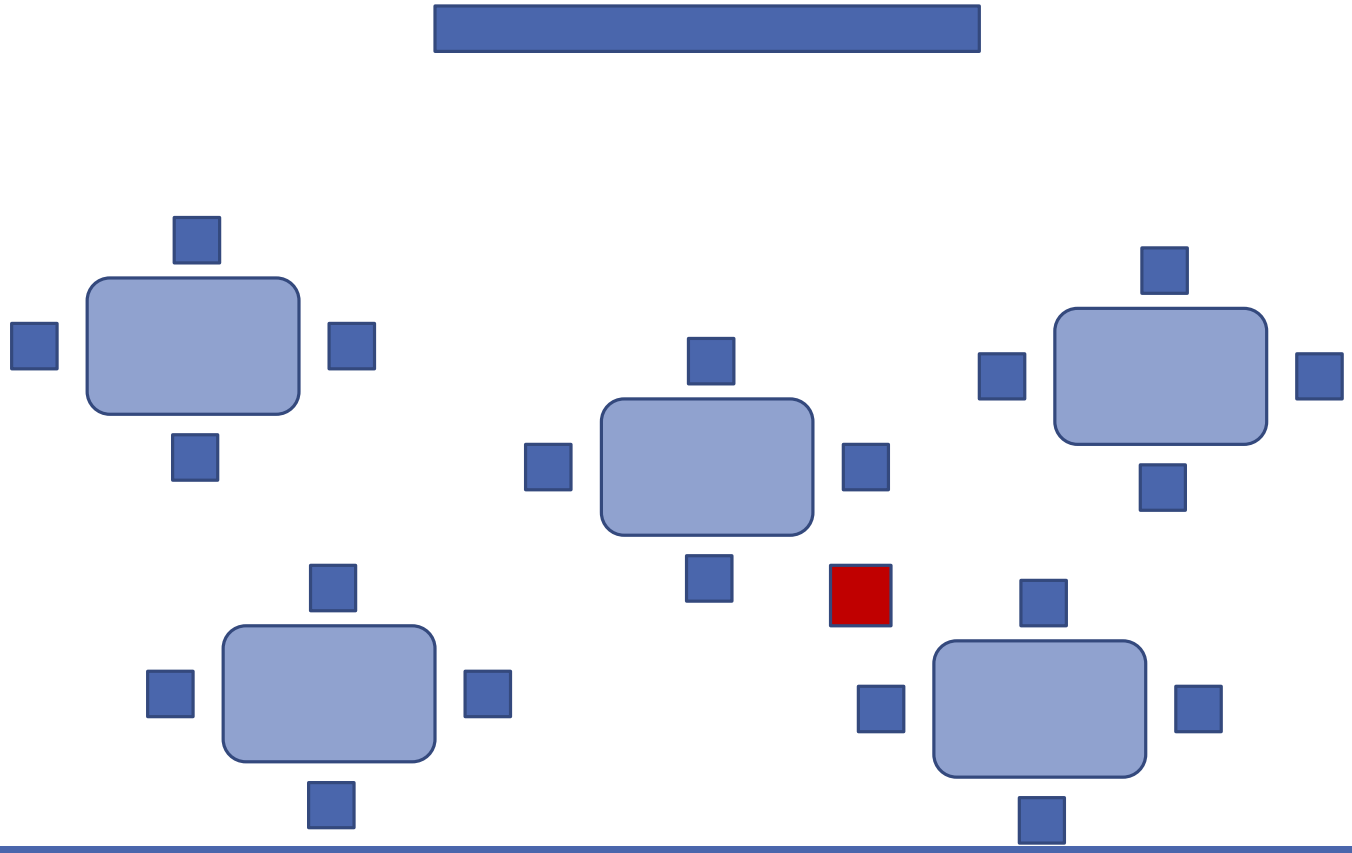
Solving problems

Context

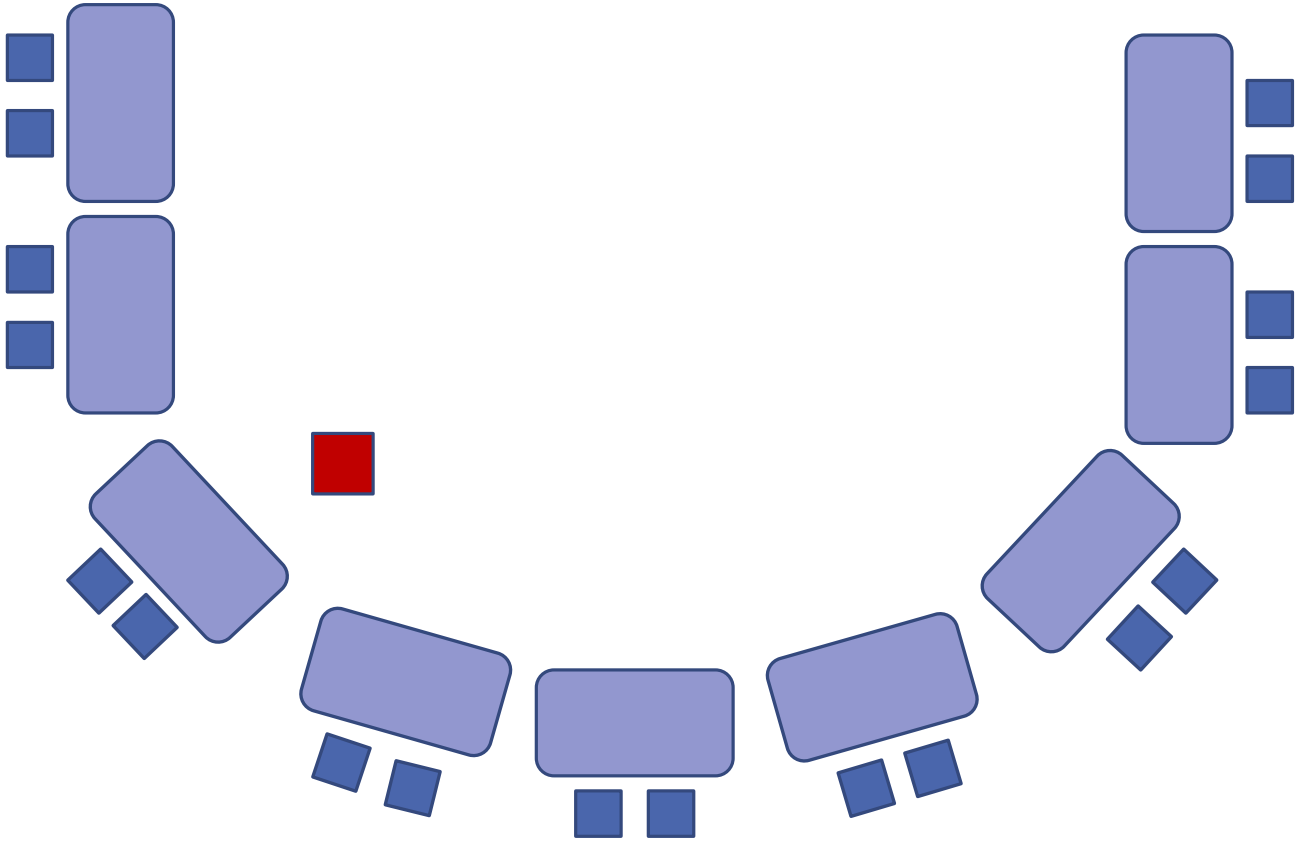




Spatial arrangment



Spatial arrangment



Time and resources

In collaboration with a school:

- physics in groups
- lessons in a row

Without further demands from a school:

- laboratory of everyday materials, devices and tools
- use of smartfones
- internet resources

Embodiment

Źródło: demotywatory.pl

Formative assessment

rubrics

self-assessment

peer-assessment

activity chart

observation

Specially taylored tests

IMPACT OF IBL

Always positive effect on the increase of motivation and interest (widely reported)

Effect on learning outcomes is researched least

Hattie in „Visible learning" (2009):

- Brederman (1983), Shymansky et al. (1990) – medium effects of inquiry teaching on process, low effect on content
- Smith (1996) – large effect from inquiry in critical thinking, medium in skills achievement, low in proces skills

Negative effect

- Cairns & Areepattamannil, Res.Sci.Ed. 2019, 49

No effect

- Pine et al. JRST 2006, 43

Partially positive effect

- Lee et al. JRST 2006, 43
- Song & Kong, Educ. Media Intl. 2014, 51

Big positive effect

- Cervetti et al. JRST 2012, 49
- Cuevas et al. JRST 2005, 42
- Varma, J.Sci.Educ.Tech2014, 23
- Kim et al., Res.Sci. Ed. 2012, 42
- Kukkonen et al., IJSE 2014, 36
- Minner et al. JRST 2009, 46

Effects do not depend on:

- **ability group**
- **gender**

Effect decreases with age

Learning through guided inquiry is the most effective

MOTIVATION

- Lack of consensus about the acquisition of knowledge through inquiry
- Teachers' concern about students' learning outcomes as measured by standard tests (Tan and Caleon 2016)
- Little research on mid-term and long-term retention of learning achievement
- Insight into development of research skills through IBL

ACADEMIC CENTER OF CREATIVITY (2015)

Akademickie Centrum Kreatywności

a research project to test the feasibility and effectiveness of the **IBL** method and accompanying assessment tools

Participants
- 5 primary schools
- 10 classes: grades 4-6 (11-13yo)
- 170 learners
- 5 pre-service science teachers
- 5 in-service science teachers

Teacher training
- 20h training for in-service teachers
- 30h training for pre-service teachers
- in-service teachers paired with pre-service teachers
- pre-service teachers implementing IBL in classes of in-service teachers

Implementation at schools
- 10 lessons in IBL in each class (guided inquiry)
- 2-4 lessons in IBL in each class (open inquiry)





RESEARCH QUESTIONS

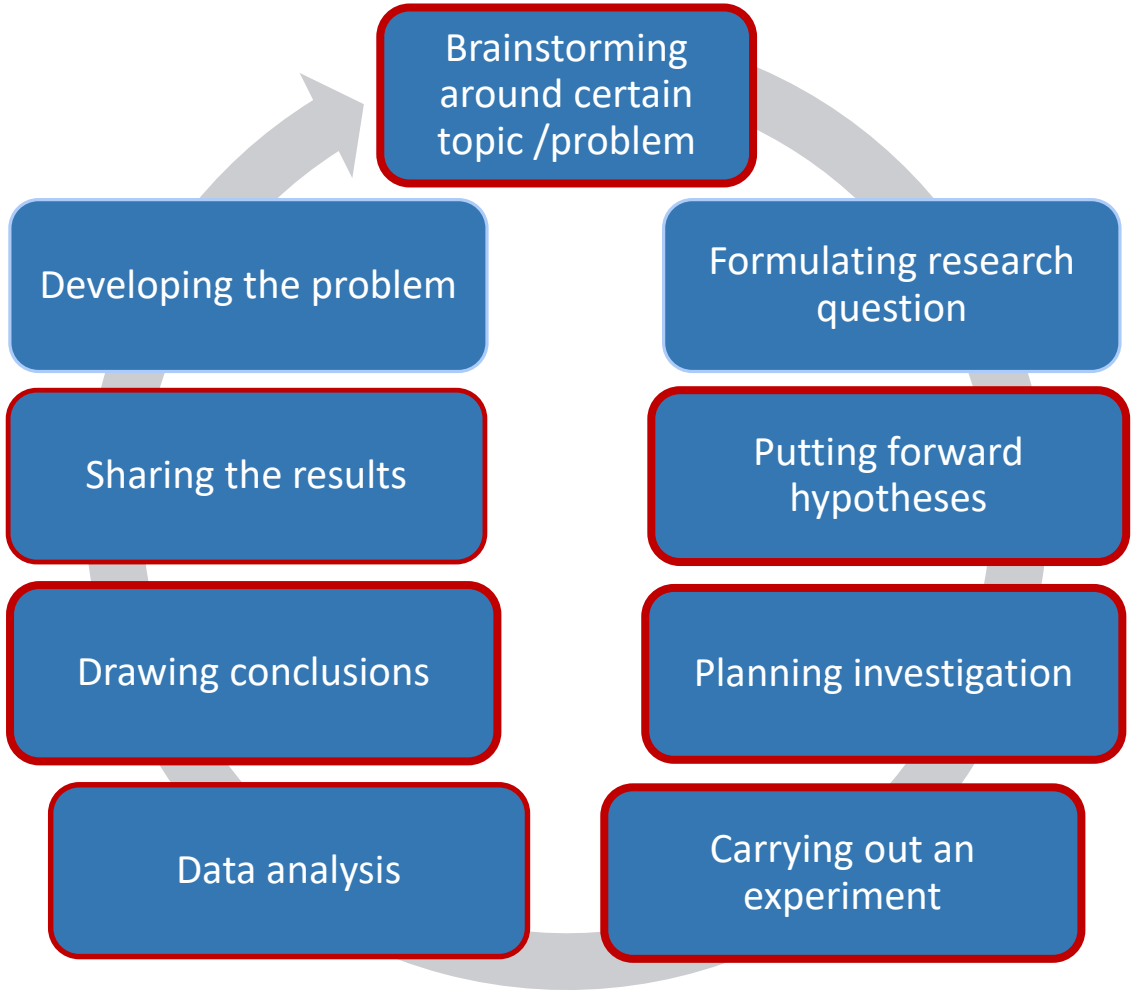
Q1: What is the pupils' learning achievement, in terms of selected research skills and content knowlegde, just after the implementation of a guided inquiry-based instruction?

Q2: What is the retention of learning achievements over the span of 6 months (medium-term retention)?

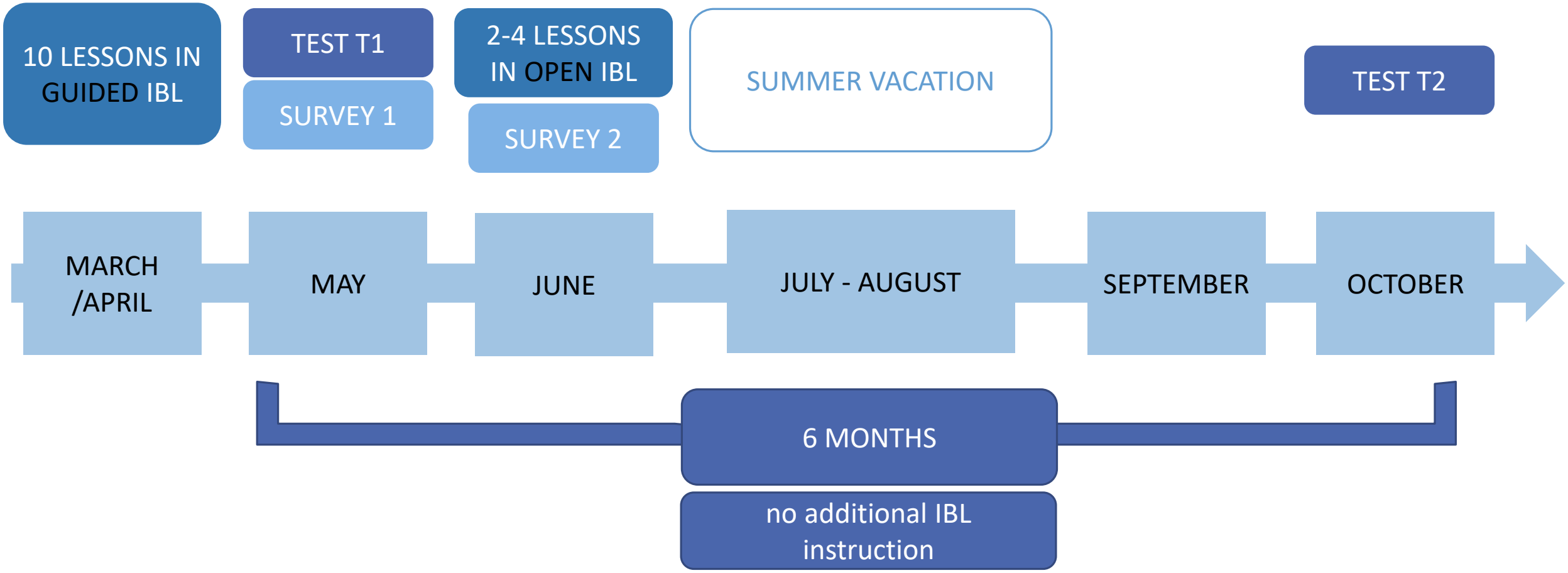
Focus on:

- Boys vs girls
- Different ability levels: L1 (<70%), L2 (70-80%), L3 (>80%)

GUIDED INQUIRY

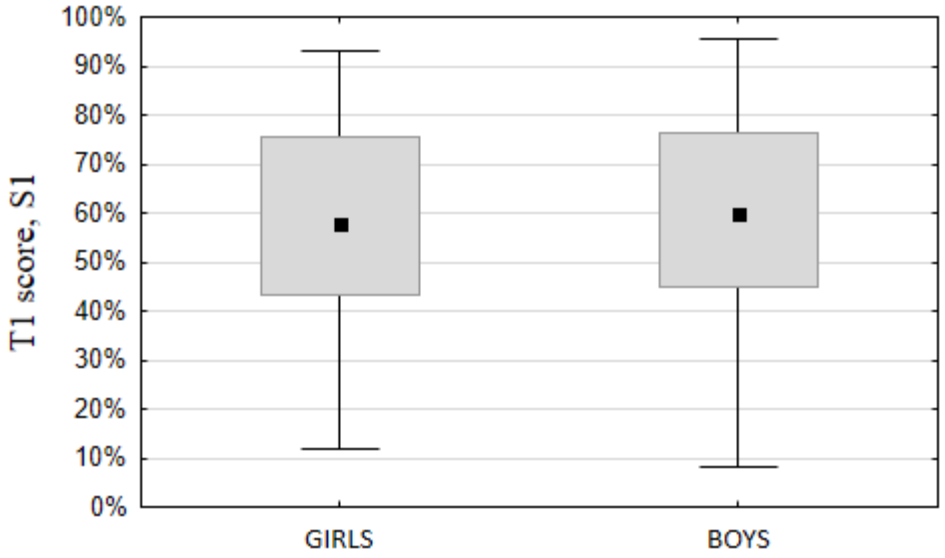


RESERACH PLAN AND DATA COLLECTION



RESULTS – TEST 1
(one week after implementation)

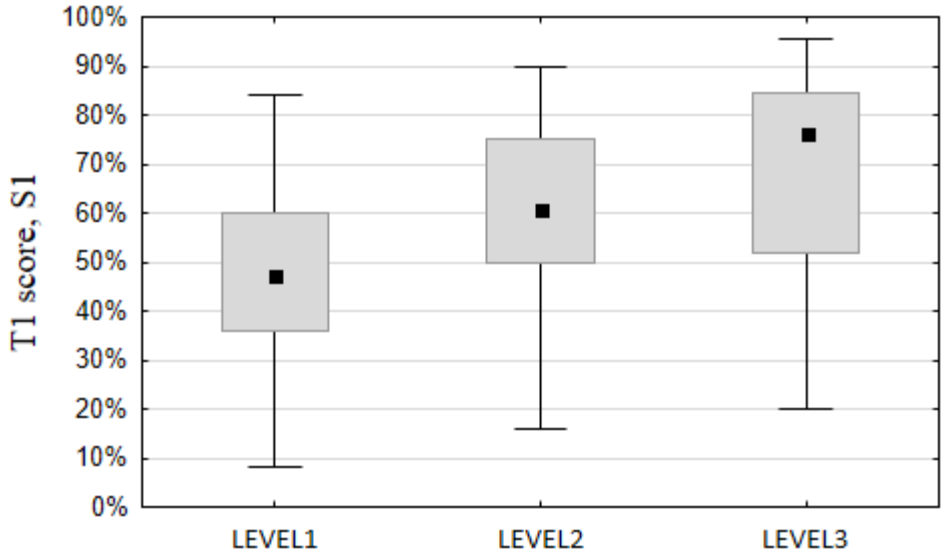
GENDER



Box-and-whisker plots of T1 results for group of boys ($N = 91$, ■ indicates median, $S1_{Mdn} = 60\%$) and girls ($N = 70$, ■ indicates median, $S1_{Mdn} = 58\%$). Grey boxes encompass interquartile ranges (25%-75% percentiles) and whiskers represent min-max values.

The Mann-Whitney test statistics indicated **no statistically significant** difference

ABILITY LEVELS



Box-and-whisker plots of T1 results for L1 ($N = 47$, ■ indicates median, $S1_{Mdn} = 47\%$), L2 ($N = 48$, ■ indicates median, $S1_{Mdn} = 61\%$) and L3 ($N = 66$, ■ indicates median, $S1_{Mdn} = 77\%$). Grey boxes encompass interquartile ranges (25%-75% percentiles) and whiskers represent min-max values.

The Kruskal-Wallis test statistics indicated **statistically significant** differences

NORMALIZED CHANGE FACTOR

Comparing two results based on exactly the same test:

1. just after implementation of guided inquiry (S1)
2. six months later (S2)

$$c = \begin{cases} \dfrac{S2 - S1}{100 - S1}, & for\ S2 > S1 \\ drop, for\ S2 = S1 = 100\ or\ 0 \\ \dfrac{S2 - S1}{S1}, & for\ S2 < S1 \end{cases}$$

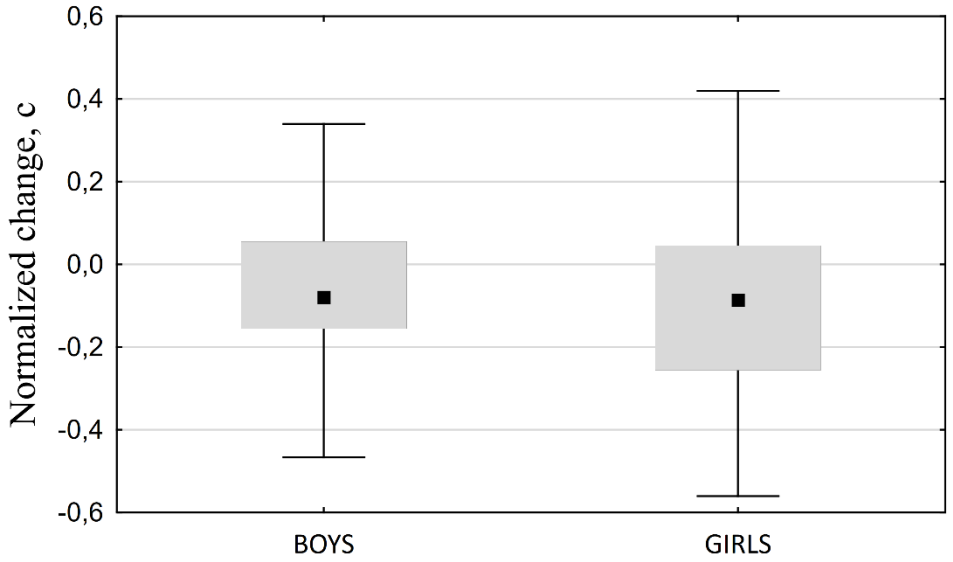
(Marx and Cummings, 2007)

- median of a normalized change in the medium-term was found to be $c_{Mdn} = -0.086$
- no statistically significant difference between GIRLS and BOYS
- no statistically significant difference between groups of different abilities

Sokolowska, 2018 (Springer)

NORMALIZED CHANGE FACTOR

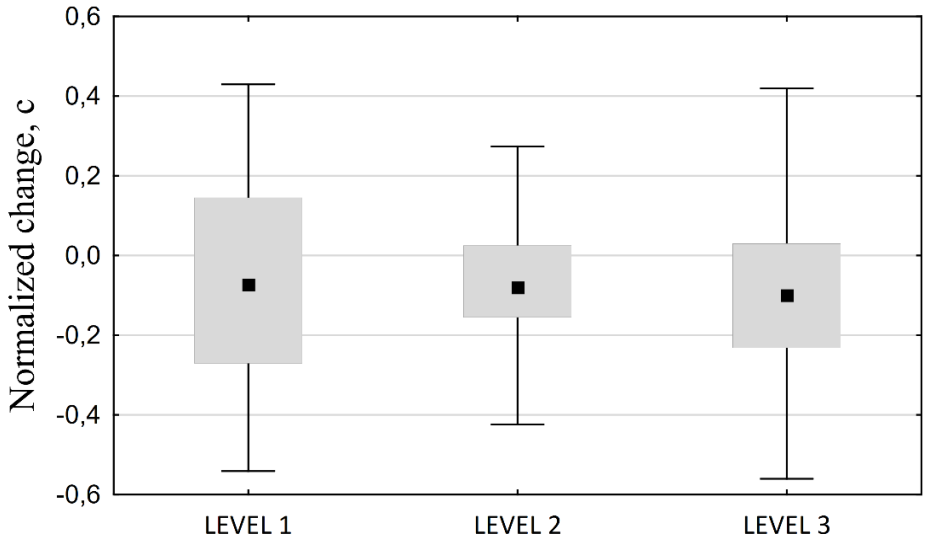
GENDER



Box-and-whisker plots of normalized change for group of boys ($N = 68$, ■ indicates median, $c_m = -0.079$) and girls ($N = 63$, ■ indicates median, $c_m = -0.086$). Grey boxes encompass interquartile ranges (25%-75% percentiles) and whiskers represent min-max values.

The Mann-Whitney test statistics indicated **no statistically significant** difference

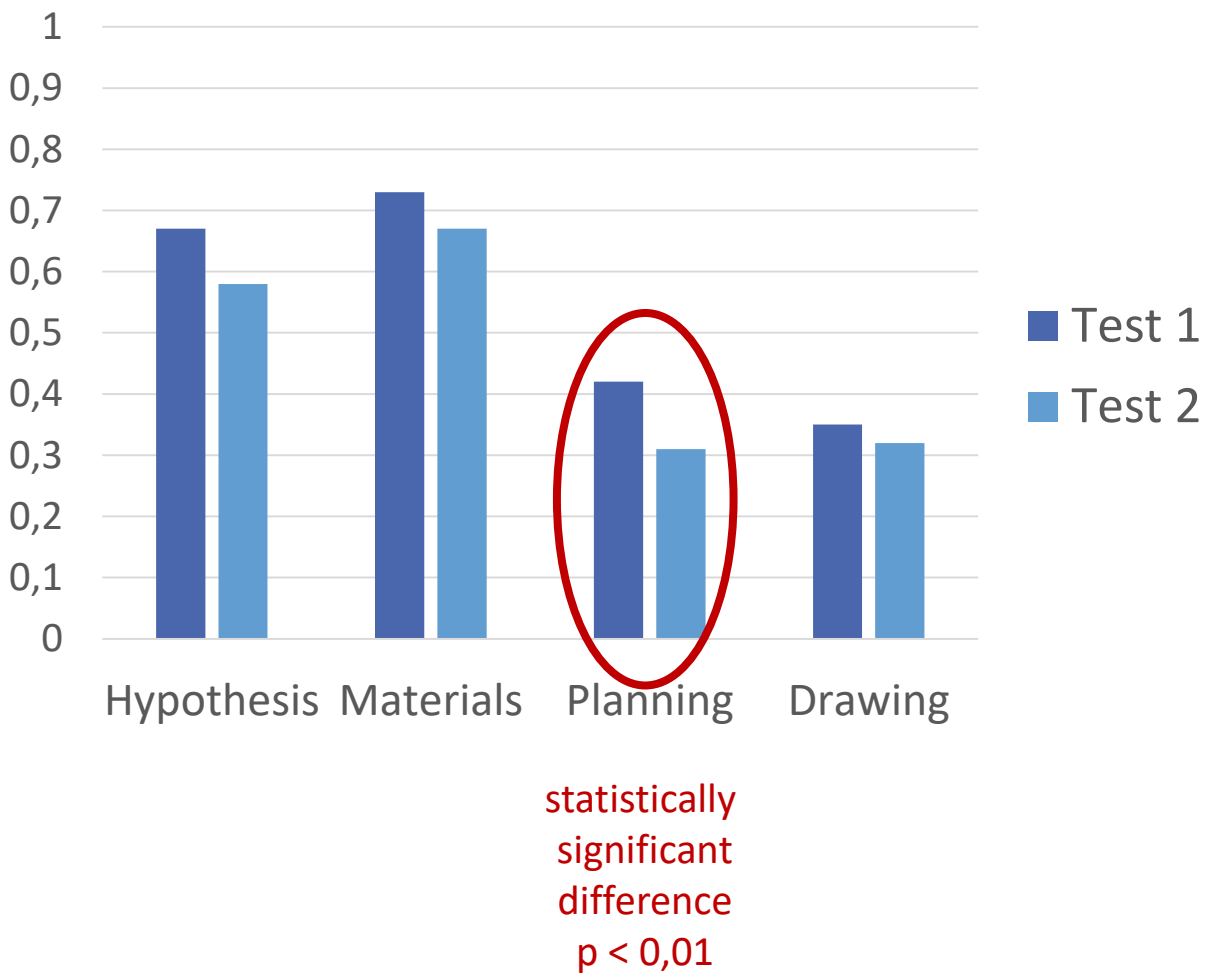
ABILITY LEVELS



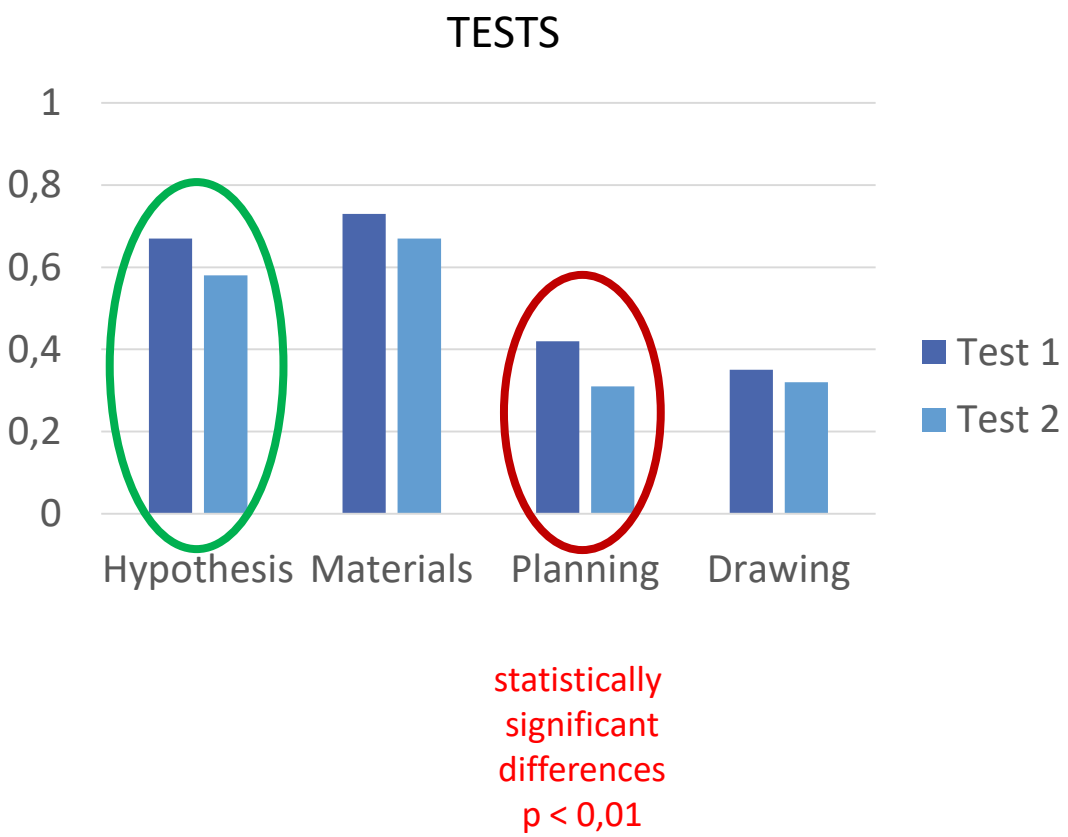
Box-and-whisker plots of normalized change for L1 ($N = 38$, ■ indicates median, $c_m = -0.072$), L2 ($N = 55$, ■ indicates median, $c_m = -0.08$) and L3 ($N = 38$, ■ indicates median, $c_m = -0.099$). Grey boxes encompass interquartile ranges (25%-75% percentiles) and whiskers represent min-max values.

The Kruskal-Wallis test statistics indicated **no statistically significant** differences

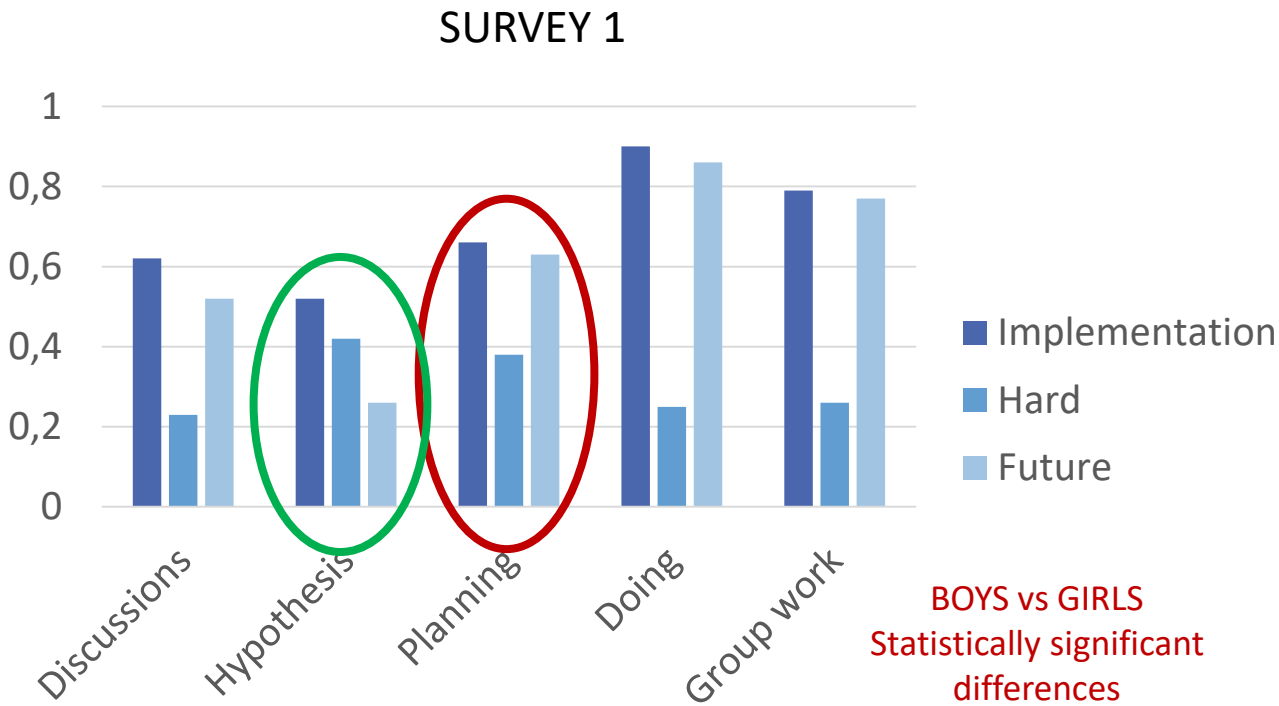
TESTING RESEARCH SKILLS



STUDYING RESEARCH SKILLS



statistically significant differences $p < 0,01$



BOYS vs GIRLS
Statistically significant differences
in favor of boys
(not observed for OPEN IBL)

In addition: Poor results on planning and hypothesising based on the analysis of pupils' worksheets

SUMMARY OF THE RESULTS

- The overall median of **T1 scores** was found to be $S1_{\mathrm{Mdn}} = 60\%$, similarly to the learners' overall performance in science, $P = 70\%$ (including tests, homeworks, participation in activities…)
- **Good retention** of pupils' science knowledge and use of representations in mid-term (six months): 91.6 % (median); no differences between BOYS and GIRLS, groups of different abilities
- Generally **positive attitude towards** both guided and open inquiry approaches. Statistically significant difference in favor of boys only in guided inquiry
- **Planning and putting forward hypothesis** less appreciated than conducting experiments and working in groups; the largest decrease in planning abilities
- In most cases: **no statisticaly significant difference** in relation to gender, ability group

CONCLUSIONS

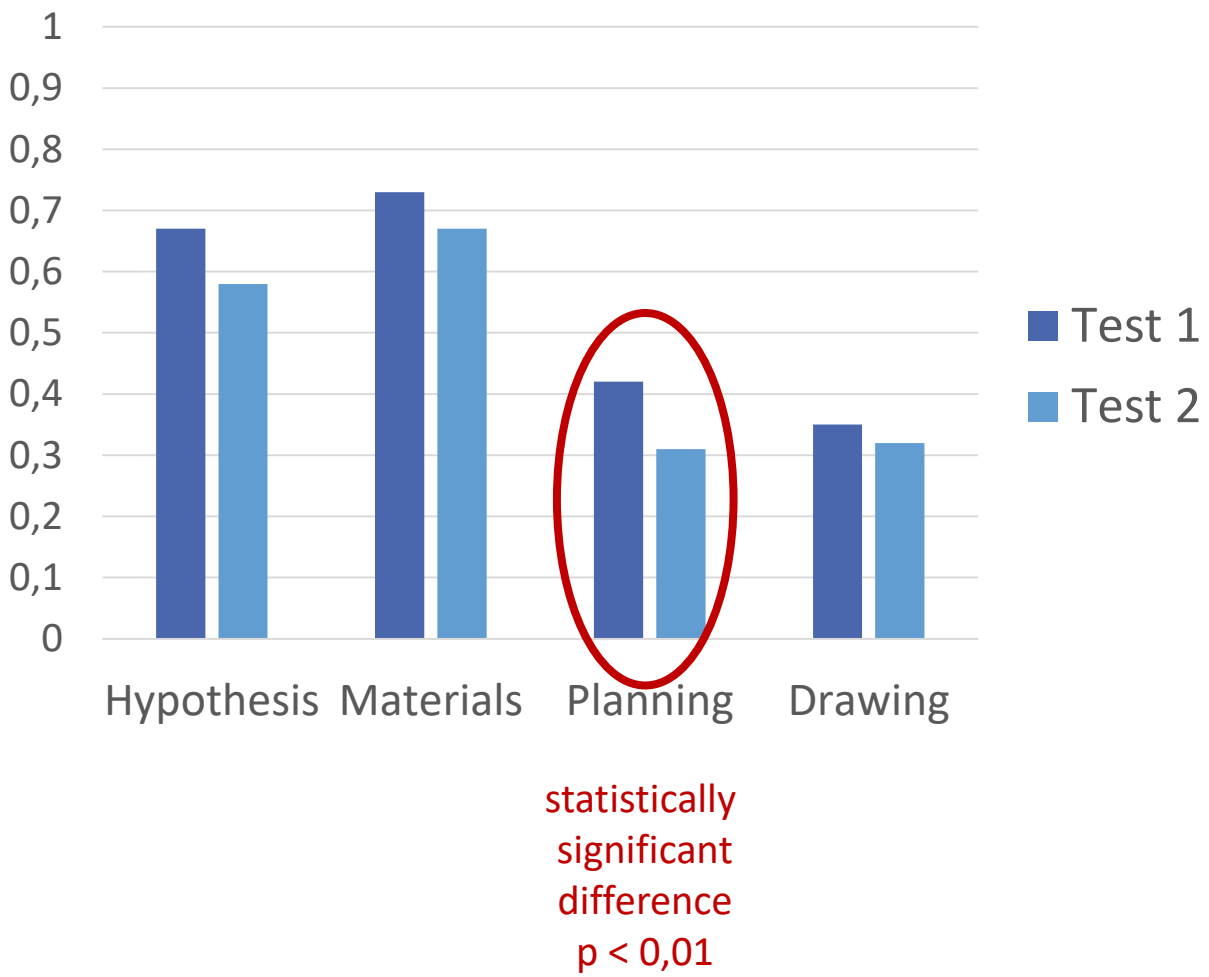
- **Results suport** the IBL method as effective for learning content knowledge and development of some research skills
- **High rate of the retention of knowlegde** in medium-term period, common for both genders and all ability levels
- **Open inquiry** as a method for **increasing girls' positive attitude**

- The format of **testing research skills** should be more practical
- **At ages 11-13** it seems less natural and motivating (and maybe also not necessary) to plan an investigation step by step than to do experiments by adopting **a trial-and-error** method –> initial training in planning – in the form of a receipe of a succesfully performed experiment

Thank you for your attention

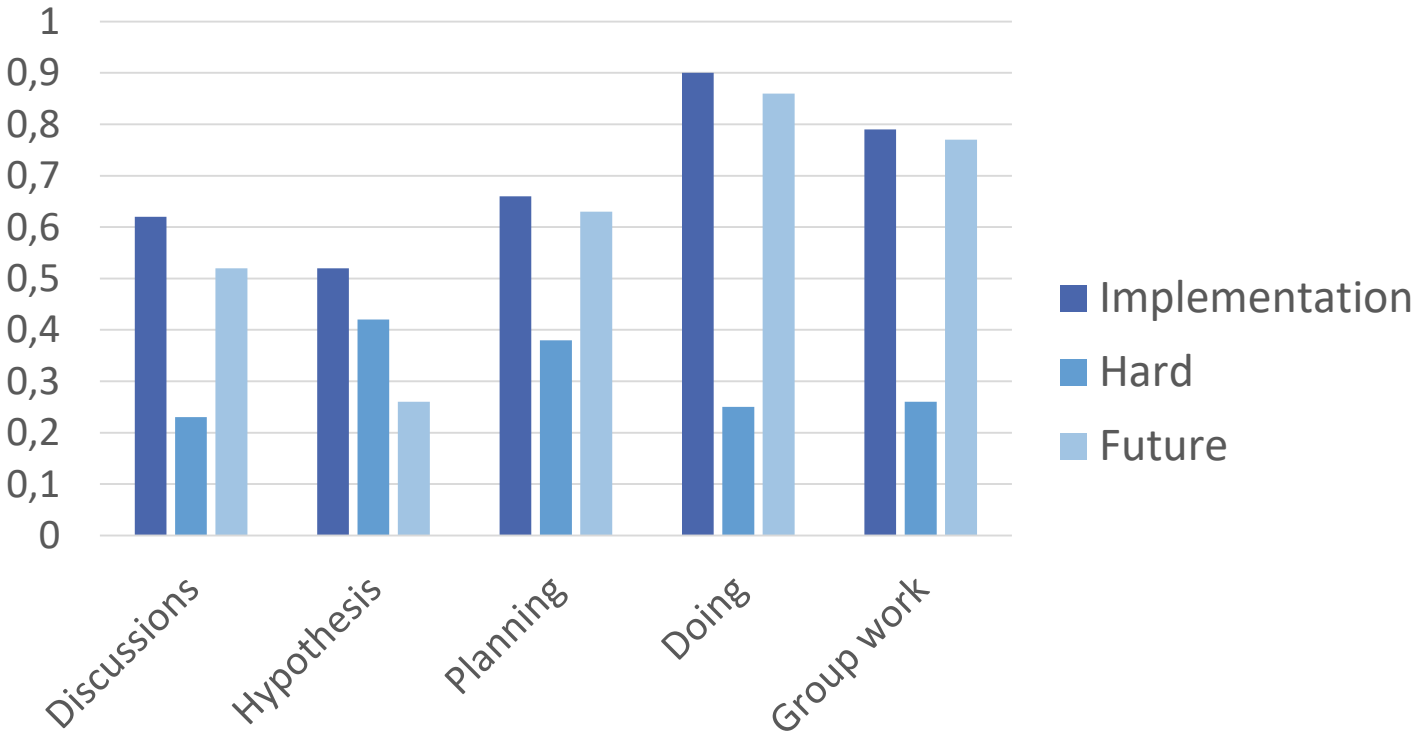
ufdsokol@cyf-kr.edu.pl

TESTING RESEARCH SKILLS

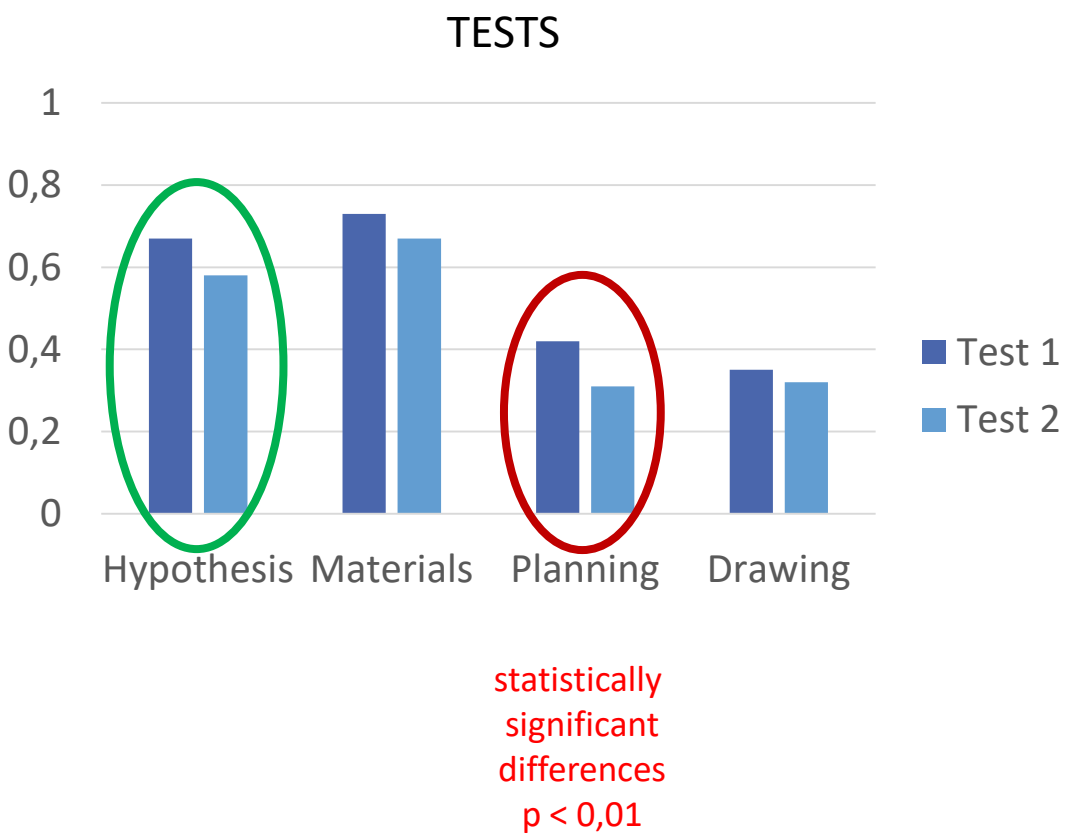


SURVEY 1: ATTITUDE TO GUIDED IBL IMPLEMENTATION AND ITS CONSEQUENCES FOR THE FUTURE

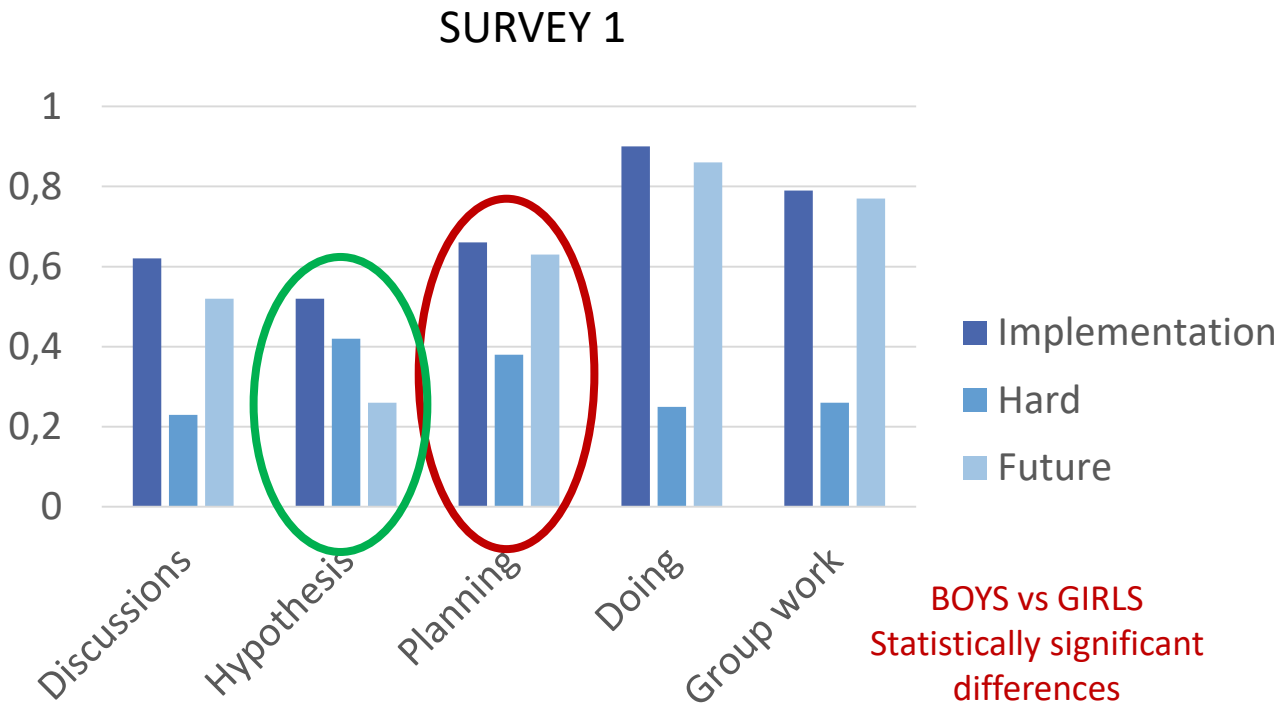
BOYS vs GIRLS
Statistically significant differences
in favor of boys



STUDYING RESEARCH SKILLS



statistically significant differences $p < 0,01$



BOYS vs GIRLS
Statistically significant differences
in favor of boys
(not observed for OPEN IBL)

In addition: Poor results on planning and hypothesising based on the analysis of pupils' worksheets