# Inquiry Learning in STEM subjects

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A socio-cultural approach to Inquiry Based Education

How to implement Inquiry Learning?

From Open to Guided Inquiry

The teachers as a companion and a guide

Inquiry vers. research

Science Education has traditionally been assigned the role of transmitting knowledge. However, over the past 50 years, there have been dynamic changes in our conceptualisation of science learning and of science learning environments, integrating concepts such as ‘situated learning’ or the ‘socio-cultural perspective of learning’.

These changes have important implications for how we interpret the role of inquiry in school science education programmes as well as curriculum development, teaching practices and assessment techniques (Duschl & Grandy, 2008).


Capps and Crawford’s (2013) study showed that teachers in the United States, a country in which ‘inquiry has been a buzz word in science education for many years’ (p.523), hold many misconceptions and myths about inquiry and equate it with questioning, student centred teaching approaches, and hands on teaching.

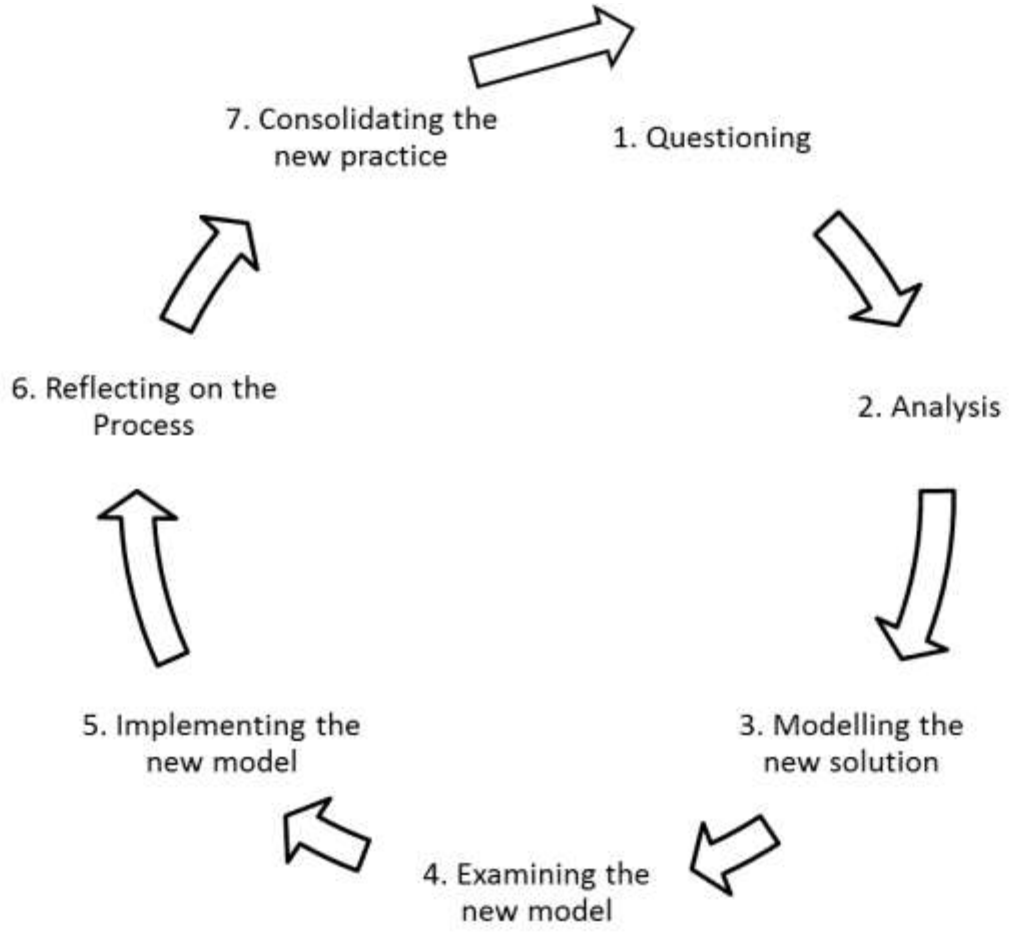
> ‘It was particularly troubling that many teachers in this study believed they were teaching science as inquiry even when they did not (ibid, p. 522).

http://www.scientix.eu/web/guest/home




The Rocard Report on Science Education (2007)
Science Education in Europe Critical Reflection
(J. Osborne , J. Dillon, 2008)

# Expansive learning
(Engeström 2000)




- Questioning/primary contradiction
- Historical analysis and/or actual empirical analysis
- Modelling the new solution
- Examining the new model
- Implementing the new model
- Reflection on the process and realignment with neighbours
- Consolidating the new practice

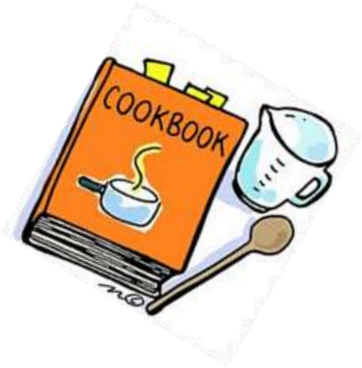

## IBSL? IBST? IBSE?

What is Inquiry Based Science Education ?

How shall we translate the concept into European context ?

Is it all the same or are there differences in teaching inquiry in

- Science — Biology - Chemistry - Physics
- Technology
- Engineering
- Mathematics


# Where should Inquiry Based Science Education take place?

Hands-on?

Minds-on?

Minner, Levy, and Century (2010) argue that inquiry teaching has essential features which should be applied and which are described by the NRC (1996; and 2000, p.25) as following:

- ✓ Learners are engaged by scientifically oriented questions
- ✓ Learners design and conduct investigations
- ✓ Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions
- ✓ Learners formulate explanations from evidence to address scientifically oriented questions
- ✓ Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding
- ✓ Learners communicate and justify their proposed explanation

Problem identification
Formulating of hypothesis

Planning an investigation
Clarifying variables

Carrying out the investigation

Documentation of results

Interpretation and reflection of results

Communication of results
Defining a new question

IBSE

[…] here was no statistically significant association between amount of **inquiry saturatio**n and **increased student science conceptual learning**.

However, subsequent model refinement indicated that the **amount of active thinking**, and emphasis on drawing conclusions from data, were in some instances significant predictors of the increased likelihood of student understanding of science content (Minner et al., 2010, p. 493)

These findings raise the question whether active thinking and decision making needs to be embedded in a full inquiry cycle or might be equally effective when applied outside the investigative context.


IBSE should be linked to:

IBSME: Inquiry Bases Science and Math Education
IBSMTE: Inquiry Based Science, Math and Technology Education
IBSMTAE: Inquiry Based Science, Math and Technology and Art Education

Hooks to motivate learners might be

Botanic Gardens, Science Centers, Museums etc.
Learning about the world of work
Mysteries incorporated
Nano-technology
Creativity – and arts etc.


Therefore, although IBSE has a long history in the United States, Capps and Crawford (2013) concluded that:

> ‘today there is still no consensus as to what it [IBSE] actually is and what it looks like in the classroom` (p.525)


There should be better alignment between pedagogy, curricula and assessment systems, ensuring that assessment reflects new teaching methods and that the curriculum facilitates inquiry rather than constraining it.

There should be better coordination between curricula, textbooks online resources and teacher competences


# IBSE has a great potential but is a challenging task

There is a need for more coherent and learning oriented **professional development** programs for teachers in order to **improve their confidence and their repertoire** of action in relation to Inquiry Based Learning


*‘Teaching isn’t an exact science. Uncertainty is in its nature. This uncertainty calls for wise, well-founded judgment. Uncertainty is the parent of professionalism and the enemy of standardization. It is what makes teaching interesting, variable, and challenging—a job that’s different every day’*. (Hargreaves & Fullan, 2012 cited in Campell, 2013, p. 181)

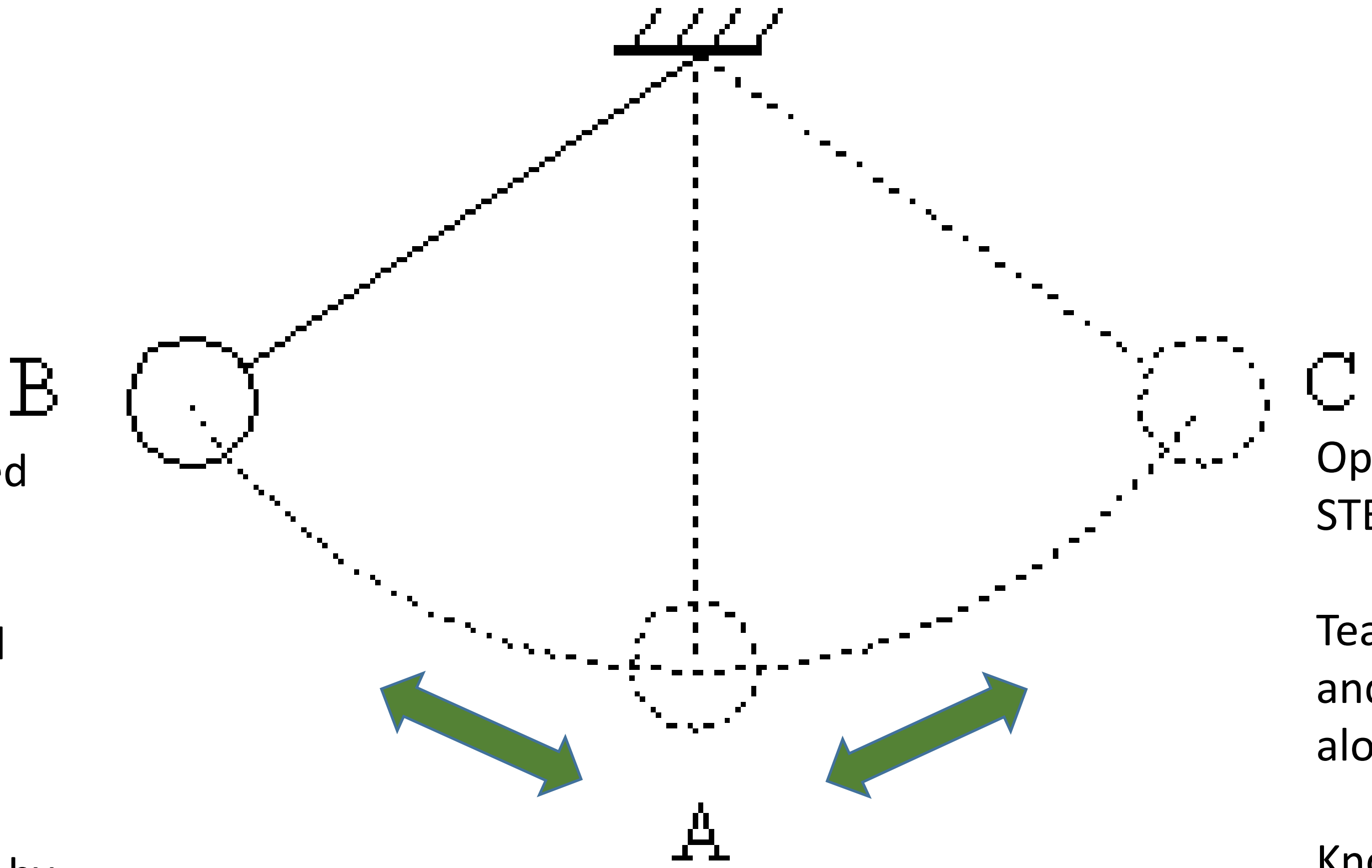
# From ‘open’ to ‘guided’ inquiry


# Levels of Inquiry (Abrams et al., 2007) adapted from Schwab (1962) and Colburn (2000b)

| | | Source of Question | Data Collection Method | Interpretation of Results |
|---|---|---|---|---|
| **Level 0** | Verfication | Given by teacher | Given by teacher | Given by teacher |
| **Level 1** | Structured | Given by teacher | Given by teacher | Open to student |
| **Level 2** | Guided | Given by teacher | Open to student | Open to student |
| **Level 3** | Open | Open to student | Open to student | Open to student |

Abrams, E., Southerland, S. A., & Evans, C. A. (2007). Inquiry in the classroom: Necessary components of an useful definition. In E. Abrams, S. A. Southerland, & P. Silva (Eds.), Inquiry in the science classroom: Realities and opportunities. Greenwich, CT: Information Age Publishing.

Blanchard, M. R., Southerland, S. A., Osborne, J. W., Sampson, V. D., Annetta, L. A. & Granger, E. M. (2010). Is Inquiry Possible in Light of Accountability?: A Quantitative Comparison of the Relative Effectiveness of Guided Inquiry and Verification Laboratory Instruction. *Science Education, 94*(4), 577-616.




Traditional teacher centred STEM Education

Teacher needs to know all the content specific knowledge

Knowledge is **reproduced** by students

Open Inquiry STEM Education

Teacher acts a companion and develops his knowledge alongside his students

Knowledge is totally **produced/constructed** by students

STEM Education **adapted to students** needs

Teacher needs to **know all** the content specific knowledge and knows **when** it is appropriate **to offer it**

Students individual knowledge development is **scaffolded by teachers**

No! 


No! 


Students ‘hands on engagement’ is a motivator but NOT an INDICATOR for learning

Data analysis, interpretation and critical reflection is MOST IMPORTANT for learning STEM.

Scaffolding  is the support needed to assist students in achieving their learning goals

| | |
|---|---|
| Metacognitive | Metacognition reduce the amount of mental processing |
| Procedural | Methods to show a process |
| Strategic | Reduce the problem to it core  finding other ways to approach the task |
| Conceptual | Recognizing relationships between things |

Once the idea is built the scaffolding can be removed

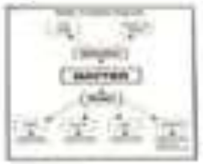
visual phenomenon

prompts and hints

explanation at the right time

articulate current understanding


interpretation graphic



Small group or partner work

links to background knowledge

teachers active engagement

# Inquiry STEM Education is a graudally increasing challange for learners

**Pre and Primary School**

- Simple questions
- observable phenomena
- Ideas for possible solutions based on individual experience
- Plan a simple investigation
- Collect data
- Interpret data based in individual experience

*Discovery Learning*

Informed by NRC (2000). Inquiry and the National Science Education Standards. A Guide for Teaching and Learning: National Research Council

**K 5-8**

- Scientific question
- Plan structured investigations collect, record and analyse data
- Explain, predict and use simple models based on data collected
- Draw conclusions based on data collected. Discuss possible links; apply critical and logic thinking
- Accept alternative ideas and predictions based on evidence
- Present results while using tables and graphs

**K 9-12**

- Questions lead to a research oriented investigation
- Plan and run research oriented investigation
- Use Math and Technology to conduct, interpret and present data and to improve the quality of your investigation, and your communication
- Draw conclusions while taking scientifically accepted knowledge into consideration
- Accept alternative ways to interpret data as long as these are well argued, sound and logic.
- Reflect critically on your own results

# Scientific Literacy

‘Drawing evidence based conclusions’ stands for a whole set of abilities that scientifically literate people are expected to have such as:

- ✓ being able to identify questions which can be answered by science.
- ✓ knowing how and whether this scientific knowledge can be applied
- ✓ being able to select and evaluate information and data, cautiously and consciously (PISA 2006)

The teachers is a guide AND a sensitive master –

- someone who knows what his/her students are able to do the selves already and what kind of support they need to improve their know d skills continuously.


- Someone who knows the characteristics of S-T--EM – re development (Nature of C-B-Ph-T-E-M) as well as

- the content specific learning goals (including the phenomenon) ve nd

- is able to differentiate alternative from wrong/misleading approaches to solve problems.

- He/she listens to students ideas and is able to differentiate between creative approaches and those without any logic.

Evaluation

# Lessons learned

Educational change in Europe should be implemented in line with a well – defined long - term vision, which incorporates the best features of national systems

There should be more clarity about what constitutes impact for STEM projects and more systemic capacity to measure and monitor impact.

The duration of educational projects should reflect the long – term reality of school timeframes, in other words short – term interventions are not enough to ensure long - term change, even when ‘ multiplier ’ effects are taken into account.

# THE 5E INSTRUCTIONAL MODEL

The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications.

Roger W. Bybee, Joseph A Taylor, April Gardner, Pamela Van Scotter, Janet Carlson Powell, Anne Westbrook, Nancy Landes.

Biological Science Curriculum Study , July 2006


Evaluation

*Encourages to* ***assess*** *their* ***understanding and abilities*** *– provide opportunities for the teacher to evaluate the process*

Elaboration

***Challenge and extend conceptual understanding*** *and skills – develop deeper and broader understanding - apply this understanding*


Explanation

*focus* ***attention on a particular aspect of engagement*** *....demonstrate conceptual understanding - directly introduce a concept - learners explain their concept explanation from the teacher is added*

Exploration

Engagement

*.. assesses the learners* ***prior knowledge****... help to engage with a new concept ... and organise* ***students thinking towards outcomes*** *of current activities*

STEM PD Net

European STEM Professional Development Centre Network

http://stem-pd-net.eu/en/