המחלקה להוראת המדעים

What does Research in Science Education Say about Students' Learning?

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IMPACT OF RESEARCH IN SCIENCE EDUCATION

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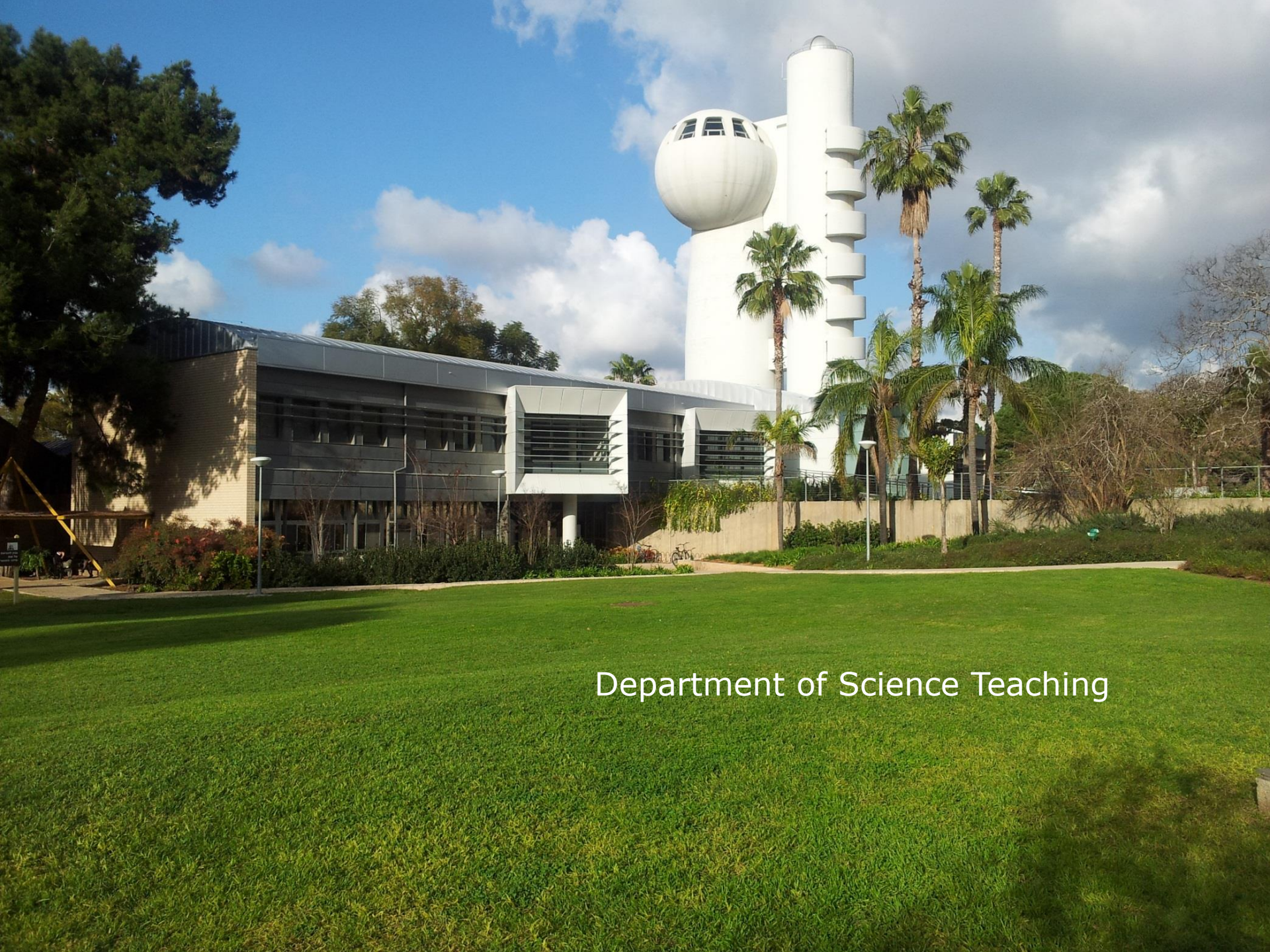

Department of Science Teaching

Outline

- The components of science education
- The meaning of learning
- Standards of science education
- Aspects which influence student learning
  - Student characteristics
  - Types of curricula
  - Teachers' professional development and teachers' style of teaching
- An example of a project based on research in science education
- References


Strategies
CPD
PBS
IBSE
Development
Self-efficacy
Experiment
Pre-service
Professional
Learning
Inquiry Teaching
Leadership
Innovation
Ownership
Science
CK
Dissemination
Creativity
Motivation
PK
Implementation
CPK
Continuous
Curriculum
In-service
Workshop
LLL

Learning

- *The most conspicuous psychological influence on curriculum thinking in science since 1980 has been the **constructivist view of learning*** (Fensham, 1992, p. 801)
- *The students need to learn to cope with their life individually within the society in which they live and operate and also to participate actively in **societal discourse concerning socio-scientific issues (SSI)*** (Roth & Lee 2004).

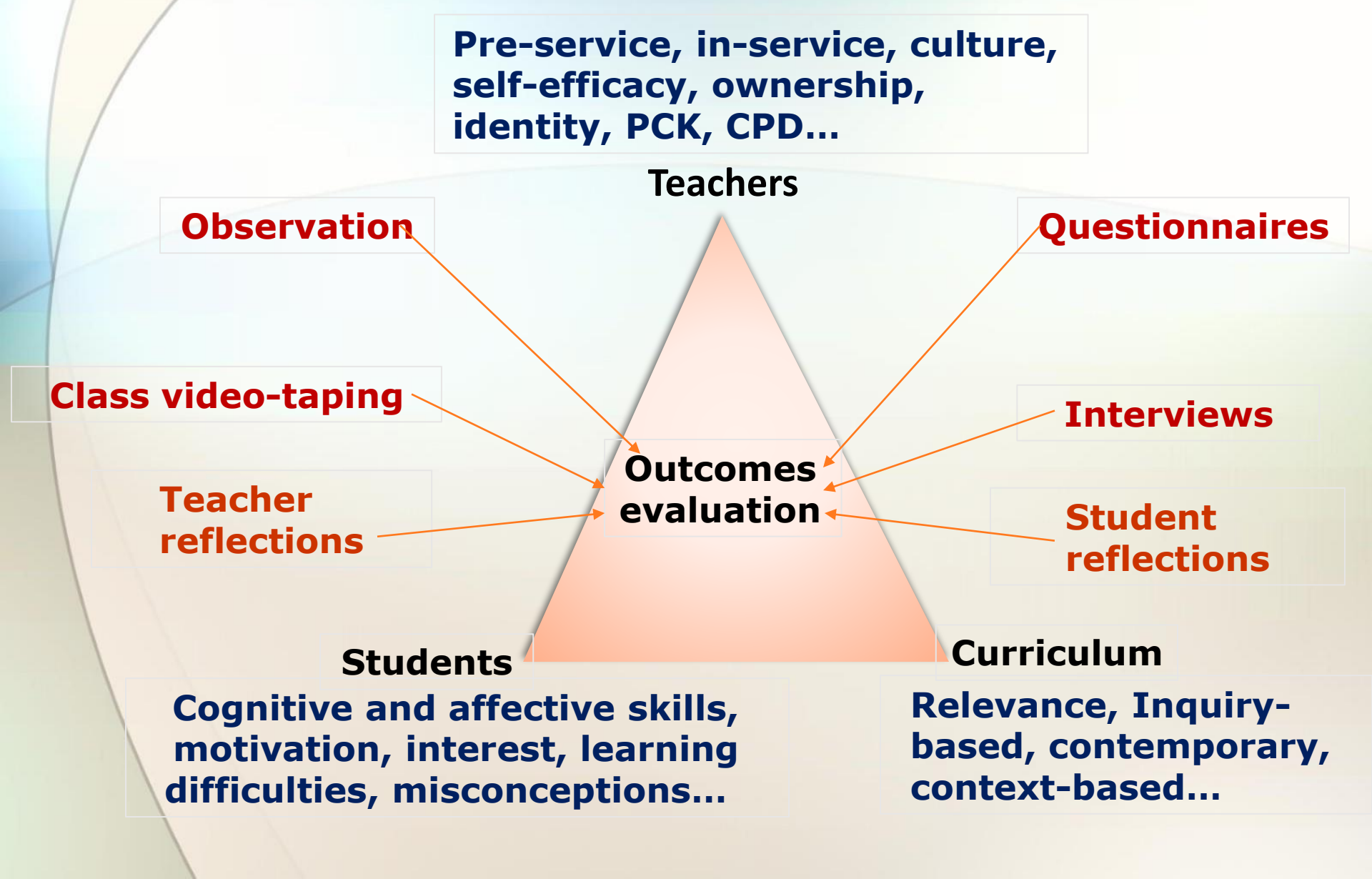
Stuckey, M., Heering, P., Mamlok-Naaman, R., Hofstein, A., & Eilks, I. (2015). The philosophical works of **Ludwik Fleck** and their potential meaning for teaching and learning science. *Science & Education,* 24(3), 281-298.

New Standards in Science Education

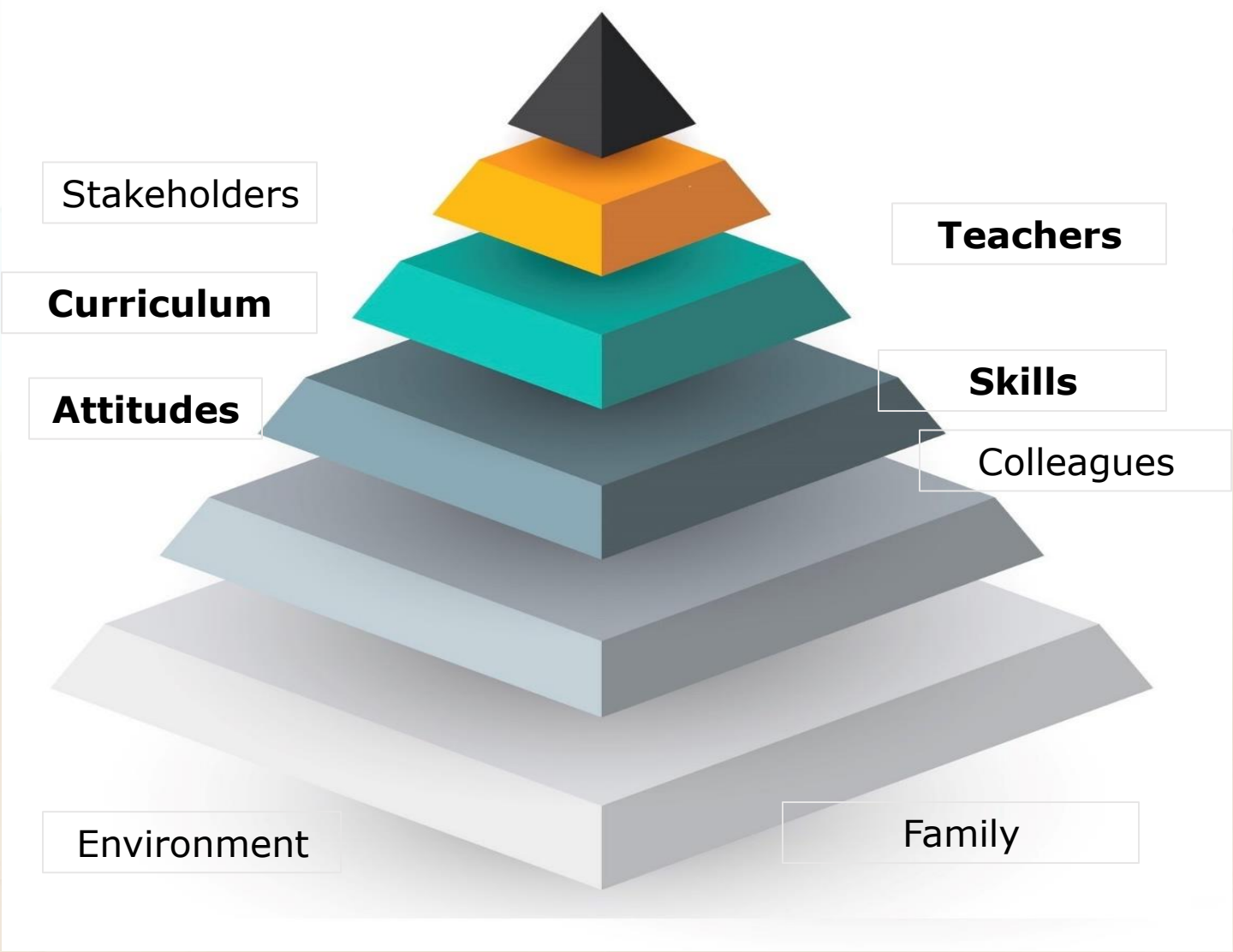
- The Content of Science that Every Student Should Learn
- The Pedagogy of Teaching Science
- The Assessment of Students
- Professional Development of Teachers
- Organization of Learning

National Research Council (2013)

What influences student learning?



Student

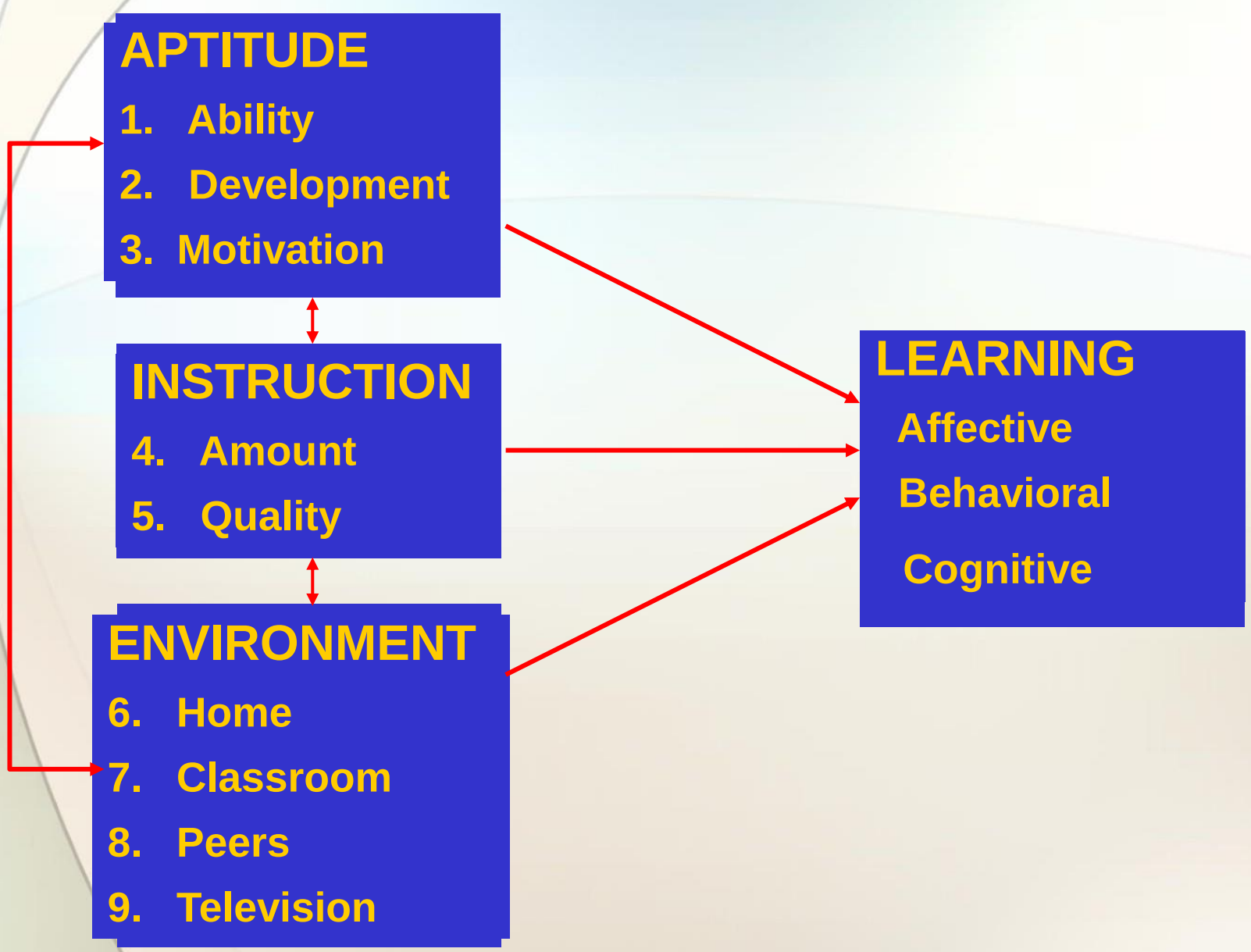

Stakeholders
Teachers
Curriculum
Skills
Attitudes
Colleagues
Environment
Family

Students

- Cognitive and affective skills
- Motivation vs. **learning difficulties**
- Misconceptions and alternative conceptions
- Assessment methods
- Language
- Learning environment
- Cultural background

……

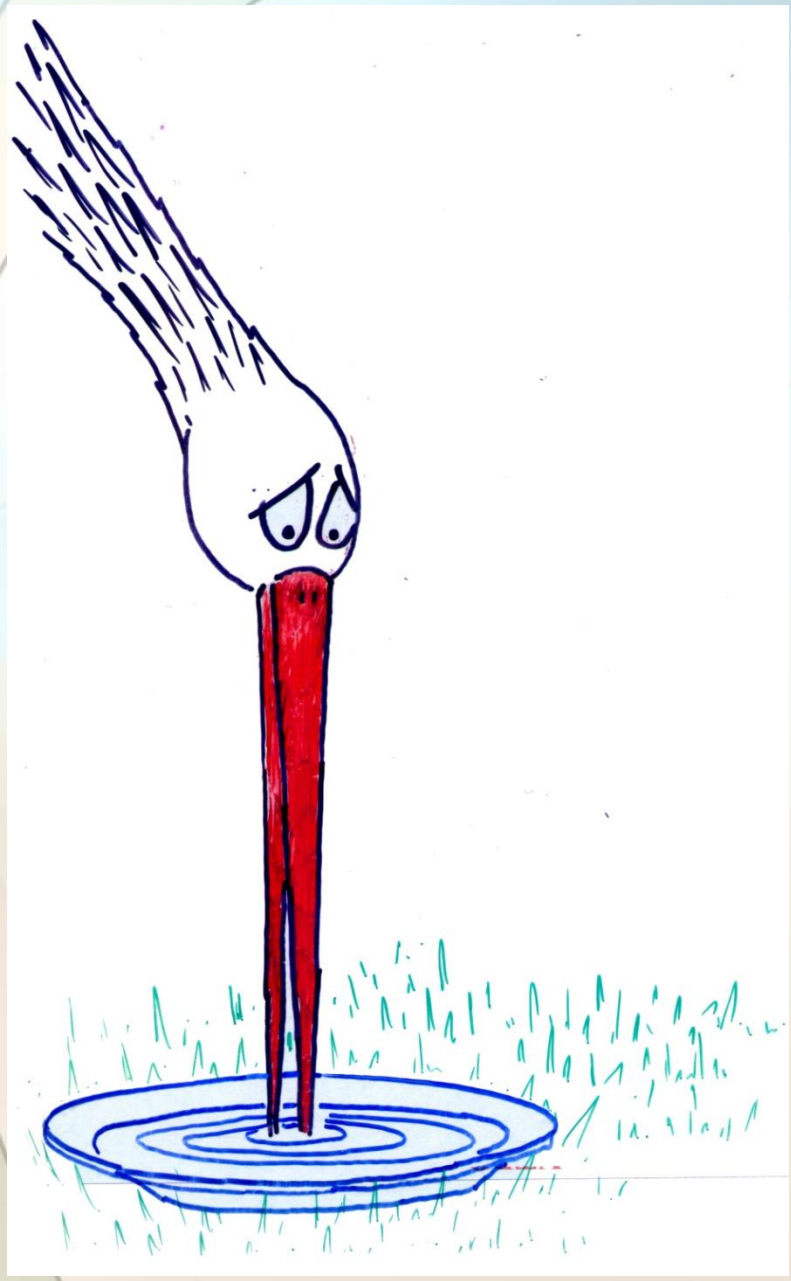
Causal Influences of Student Learning (Walberg, 1974)



Motivational pattern

- Achiever
- Curious
- Conscientious
- Social

Holbrook, et. al. (2013);
Mamlok-Naaman and Blonder (2019).



Langauge

Cultural diversity

Ruschenpohler, L., & Marcik, S. (2020). Secondary School Students' Chemistry **Self-Concepts: Gender, Culture, and the Impact on Learning Behaviour**. *CERP*, 21, 209-219

Science Language

H_2O

HIJKLMNO

$HCHO$ (CH_2O) – Formaldehyde

Sea Water

Curriculum

- Is it **relevant** to students' lives?
- Is it up-dated according to **scientific and technological** discoveries?
- Is it up-dated according to **societal and economic** changes?
- Does it enhance **scientific and technological literacy**?
- Does it increase students' **interest and motivation** to study science?
- Does it enhance students' interest in **scientific careers?** (Addressing Attractiveness of Science Career Awareness - **SciCar**)

How?

- Inquiry-type approach (asking questions, hypothesizing, drawing conclusions…)?
- Argumentation (focusing on discourse)?
- Context-based?
- Design-based?
- Socio-scientific issues based?
- Using a contemporary research-based, a historical approach, or both?

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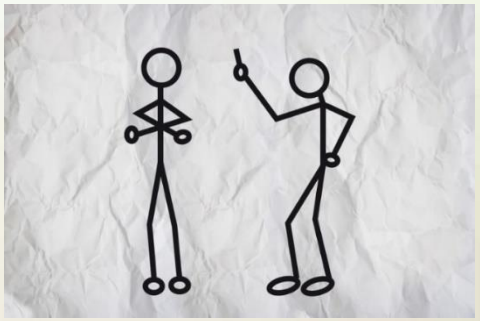
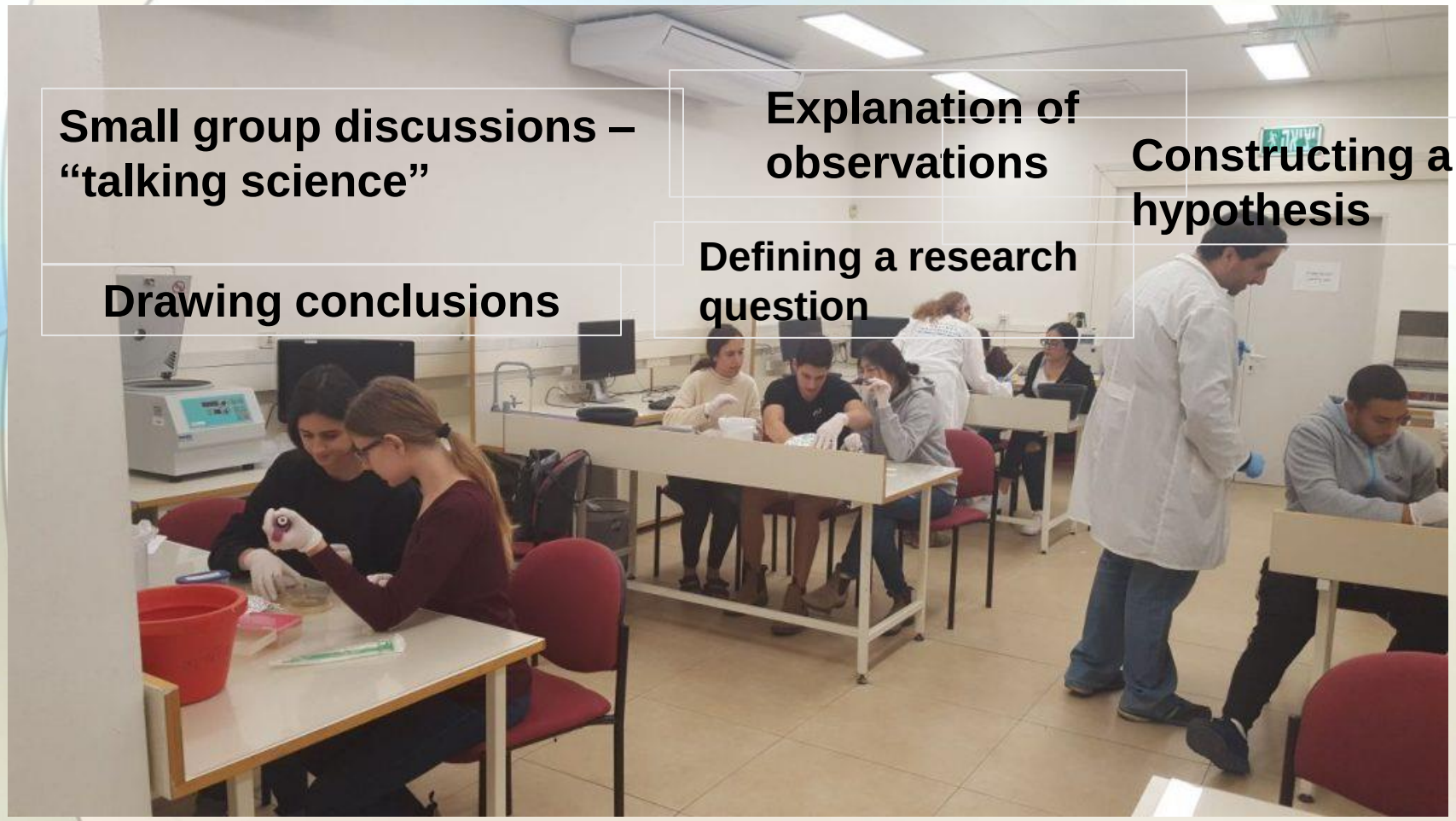


Students Conducting the Inquiry-Type Experiments



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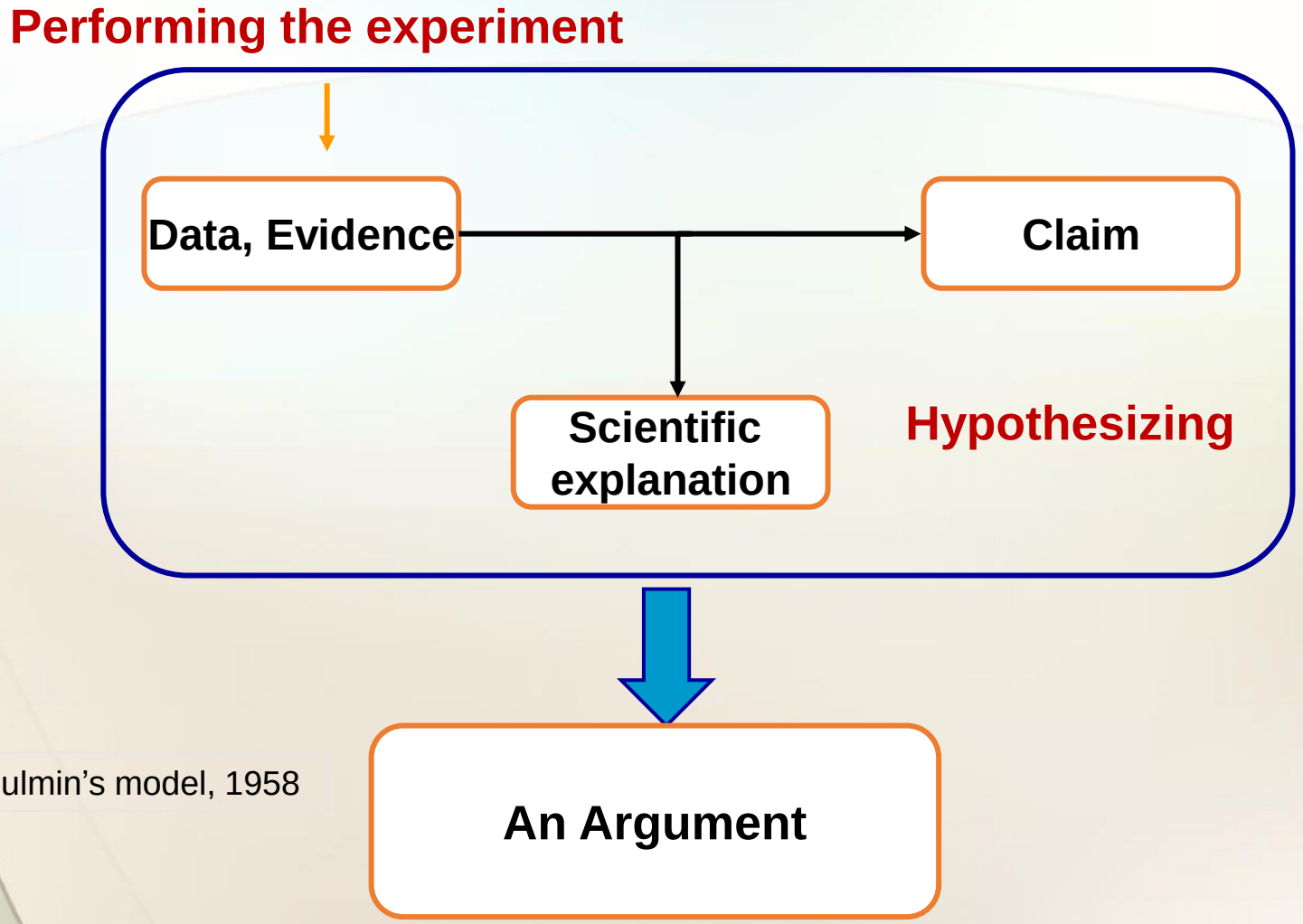
Students Learn the Argument's Components in the Inquiry-type Experiments



Based on Toulmin's model, 1958

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Context/design-based, need to know, socio-scientific driving questions

How can I design a cellular phone that is safer to use?

Radiation , Plastics, Sound, Disposal of batteries ….

- Mamlok-Naaman, R., Fortus, D., Dershimer, R.C., Krajcik, J., & Marx, R.W. (2005). How do I design a **cellular phone** that is safer to use? In: P. Nentwig and D. Waddington (Eds.). *Making it Relevant: Context-based Learning of Science* (215-241). Munster / New York / Munchen / Berlin: Waxmann.

- Krajcik, J., & Mamlok-Naaman, R. (alphabetical **order).** (2006). Using **driving questions** to motivate and sustain student interest in learning science. In: K. Tobin (Ed.). *Teaching and Learning Science: A Handbook* (317-327). Praeger, Westport, Connecticut, London.

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The role of history in school science programs

To know what something is today we have to learn about what it was like yesterday.

Chinese Daily Newspaper, 2002

Lavoisier

History and philosophy in school science programs

Conant, 1957; Klopfer, 1961; Brush, 1974;
McKenzie, & Martin, 1983; Ihde, 1984; Duschl, 1993;
Matthews, 1994; Sparberg, 1996; Irwin, 1997;
Monk & Osborne, 1997; Hayes & Perez, 1997;
Meyling, 1997; Abd-El-Khalick, 2002; Irzik, 2009;
Lederman, Abd-El-Khalick, Bell & Schwartz, 2002;
Erduran, Aduriz-Bravo & Mamlok-Naaman, 2006;
Lederman, et al., 2007; Lederman, et. Al., 2020, 2021.

Research findings

- Students' initial scientific knowledge is analogous to the knowledge of scientists in the ancient world, and it is made up of observations and conclusions that are often intuitive.

- Children believe in what they sense and tend not to believe in what is out of the scope of their senses.

Thagard (1992); Irwin (1997); Erduran (2001); Mamlok-Naaman, et. al. (2005); Erduran, Aduriz-Bravo, & Mamlok-Naaman (2007).

Using history and philosophy in school science programs, in order to promote a better understanding of:

- The nature of science **(NOS)**
- How is science generating evidence?
- How does science contribute to the development of students' skills in communication, evaluation and decision making?
- How do scientists develop their scientific knowledge?

Galileo

NOS

Chapter 28

Norman Lederman

Nature of Science: Post, Present and Future.

In: Sandra Ebell & Norman Lederman (2007). *Handbook of research on Science Education.*

Recommendations

•The historical approach may help to achieve a better understanding of the essence of **scientific phenomena, scientific methodology, and overall scientific thinking;**

• The historical approach, which integrates scientific development and historical analyses of scientific events, may help to achieve **a better understanding of the essence of science;**

• The students should become familiar with various projects of **scientists** on a specific subject, and the **effect of various cultures on scientific development.**

Erduran, Aduriz-Bravo & Mamlok-Naaman (2007)

Teachers are the key to any successful implementation

Teachers should get a sustained preparation and support in guiding their students in their activities:

A crucial ingredient for meaningful learning in inquiry activities is to provide for each student opportunities to reflect on findings, clarify understanding and misunderstanding with peers, and consult a range of resources, which include other students, the teacher, and books and Materials.

Tobin (1990)

Teachers are the key to any successful implementation

The **critical role of teachers** in attaining the goal of **quality education** in the sciences is **highlighted in the research literature on education.**

Osborne and Dillon (2008):

Good quality teachers with up-to-date knowledge and skills are the foundation of any system of formal science education. Systems to ensure the recruitment, retention, and continuous professional training of those individuals must be a policy priority in Europe.(p.25)

But-

- Lack of **effective communication** between students and teachers can lead to a mismatch between what is taught and what is learned.

- In the context of science lessons, there is **no symmetry** between the nature of teachers' understanding of a particular science topic and students' ideas regarding this topic.

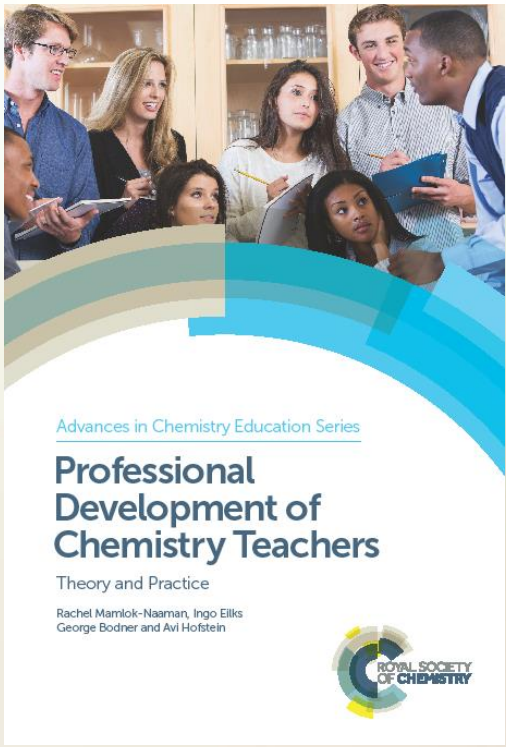
Erduran (2003)

Challenges

- **Acquaintance with the curriculum**
- **Designing lesson plans**
- **Assessing students' achievements (e.g., alternative assessment)**
- **Managing the classroom**
- **Ability to conduct changes - towards gaining pedagogical content knowledge in conveying important issues in education**
- **Developing ownership of innovations in education, becoming more student-centered**
- **Preparing the future citizen in a mixed cultural society, in order to enable students to be innovative, creative, reflective and critical.**

How can be teachers supported?
Standards of Professional Development

- **Content Knowledge (CK)**
- **Pedagogical Knowledge(PK)**
- **Pedagogical Content Knowledge (PCK)**
- **Experiences**
- **Reflection**
- **Self Efficacy**
- **Ownership**



Mamlok-Naaman, R., Eilks, I., Bodner, A., & Hofstein, A. (2018). *Professional Development of Chemistry Teachers.* Cambridge: RSC Publications.

Models of Professional Development

- Development of leadership
  Hofstein, Carmi, and Ben-Zvi (2003)
- Involving teachers in the development and assessment of the science curriculum Mamlok-Naaman, Hofstein, and Penick, (2007)
- Evidence-based professional development
  Taitelbaum, Mamlok-Naaman, Carmeli, and Hofstein (2008)
- Action Research (Mamlok-Naaman and Eilks, 2012)
- Communities of practice
  Mamlok-Naaman (2018)

Akiri, E., Dori, Y.J. Professional Growth of Novice and Experienced STEM Teachers. *J Sci Educ Technol* (2021). https://doi.org/10.1007/s10956

Projects based on research findings: An example

PROFILES - Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science

A project in the framework of FP7 projects on: Science & Society
(20 European institutions)

Inquiry; Socio-Scientific Issues; Design; Problems; Argumentation; Relevance; Contemporary issues

Bolte, C., Streller, S., Holbrook, J., Rannikmae, M., Mamlok Naaman R., Hofstein, A., & Rauch F. (2011). *PROFILES: Professional Reflection-Oriented Focus on Inquiry based Learning and Education through Science.*

PROFILES

Science teaching materials :

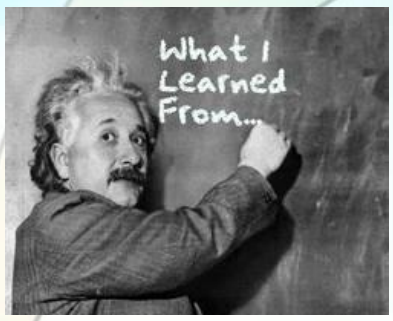
- Context-based (Pilot Bulte, 2006)
- Relevant (Stuckey et al., 2013)
- Focused on –
  - Inquiry-Based Science Education **(IBSE)**
  - Socio-scientific problem-solving, and decision-making (Chowdhury, Holbrook, Reis and Rannikmäe, 2021).
  - Ideas related to **scientific literacy for all** students (Shwartz, 2006).
- Disseminated in an interactive forum
- Teachers' professional development workshops

Focus on both intrinsic and extrinsic motivation of students in the learning of science

PROFILES
Measures of success

- Determining the **self-efficacy** and **ownership** of science teachers in developing self-satisfying science teaching methods, and more effective ways of teaching students, supported by stakeholders.
- **Reflective teachers**
- **Attitudes of students** toward a more student-involved approach.

School science teaching becoming more meaningful, related to 21st century science and incorporating interdisciplinary socio-scientific issues and IBSE-related teaching, taking particular note of gender factors.



What have we learned in science education research?

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Thank
You