



המחלקה להוראת המדעים

# The inquiry laboratory in High School Chemistry: Development, Implementation, and Long-term Research



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# **Why Inquiry laboratories?**

- ❖ **Development of high order learning skills**
- ❖ **An effective platform for research and assessment of students' ability and progress.**  
**and mainly**
- ❖ **A reform in the way high-school chemistry is learned, taught and assessed.**

# **Inquiry Skills Involving Chemistry Students and their Teachers in:**

- ❖ **Hypothesizing**
- ❖ **Conducting an experiment**
- ❖ **Observing**
- ❖ **Asking questions**
- ❖ **Analysing**
- ❖ **Planning a new experiment to accept or reject hypothesis**

# **The Inquiry Laboratory**

- ❖ **Duration: 15 years**
- ❖ **About 100 inquiry-type experiments were developed**
- ❖ **5 PhD students were involved**
- ❖ **About 15 papers and book chapters were written**
- ❖ **About 30 CPD initiatives were conducted**

# **Exemplary Research Studies**

- **Asking Questions**
- **Evidence-based Continuous Professional Development (CPD)**
- **Argumentation**

# Argumentation in the Chemistry Laboratory

**Based on the PhD thesis of  
Dvora Katchevich**



**Advisors:**

**Avi Hofstein and Rachel Mamlok-Naaman**

**Katchevich, D., Hofstein, A., & Mamlok-Naaman, R. (2013).  
Argumentation in the Chemistry Laboratory: Inquiry and  
Confirmatory Experiments. *Research in Science Education*,  
43(1), 317-345.**

# **Argumentation in Science Education: Why?**

**Based on literature – argumentation helps students in:**

- **Understanding the Nature of Science (NOS), and how science works.**
- **Attaining cognitive skills : asking questions, using scientific knowledge, hypothesising, drawing conclusions...**

# The Study

## **Hypothesis**

Inquiry-type experiments are a perfect platform for formulating arguments

## **Research question**

What factors encourage the formulation of arguments in a laboratory activity?

## **Population**

11th and 12th grade chemistry students in Israel and their teachers (six classes)



# Students Conducting the Inquiry-Type Experiments

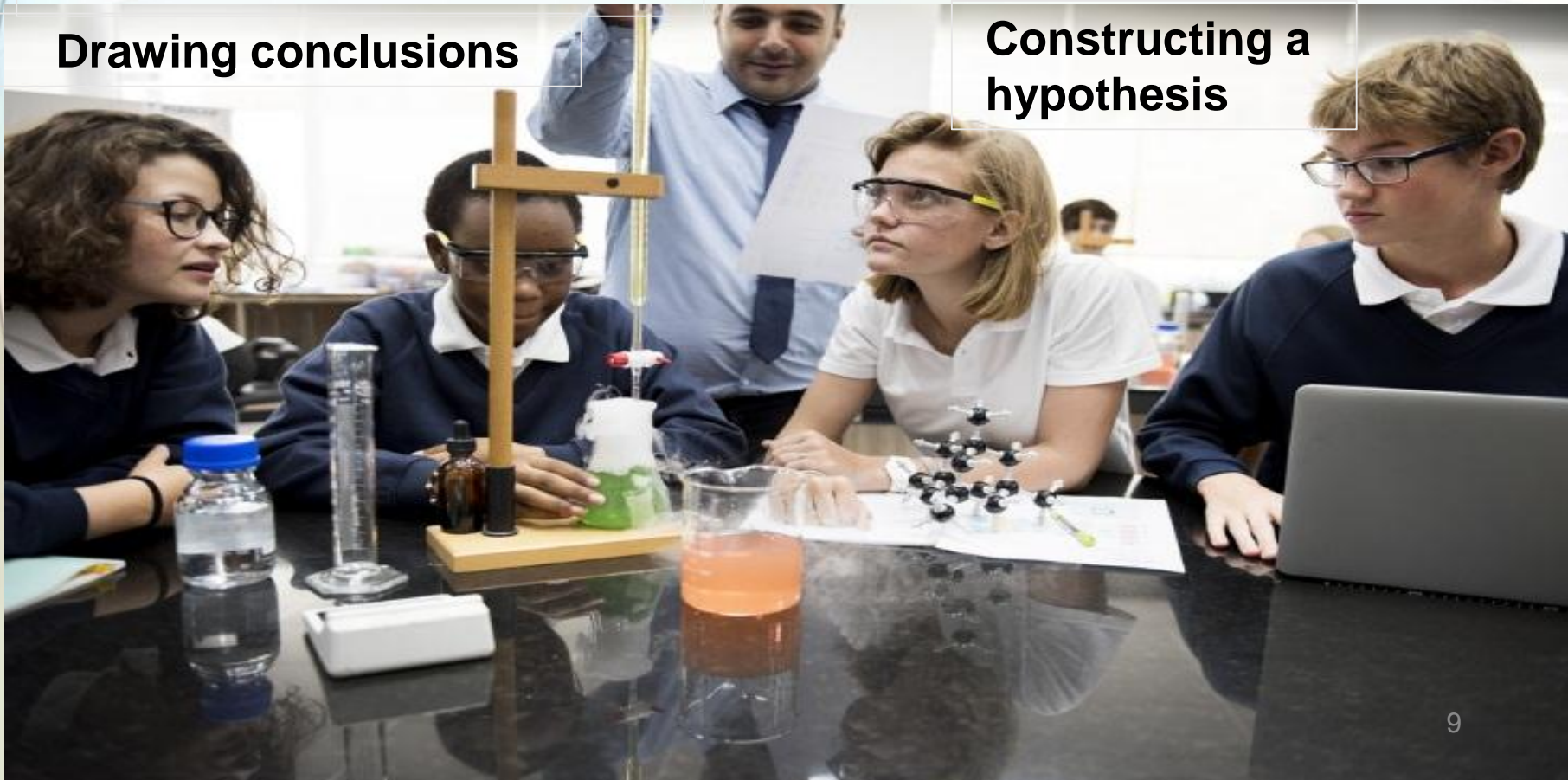
Small group discussions –  
“talking science”

Explanation of  
observations

Defining a research  
question

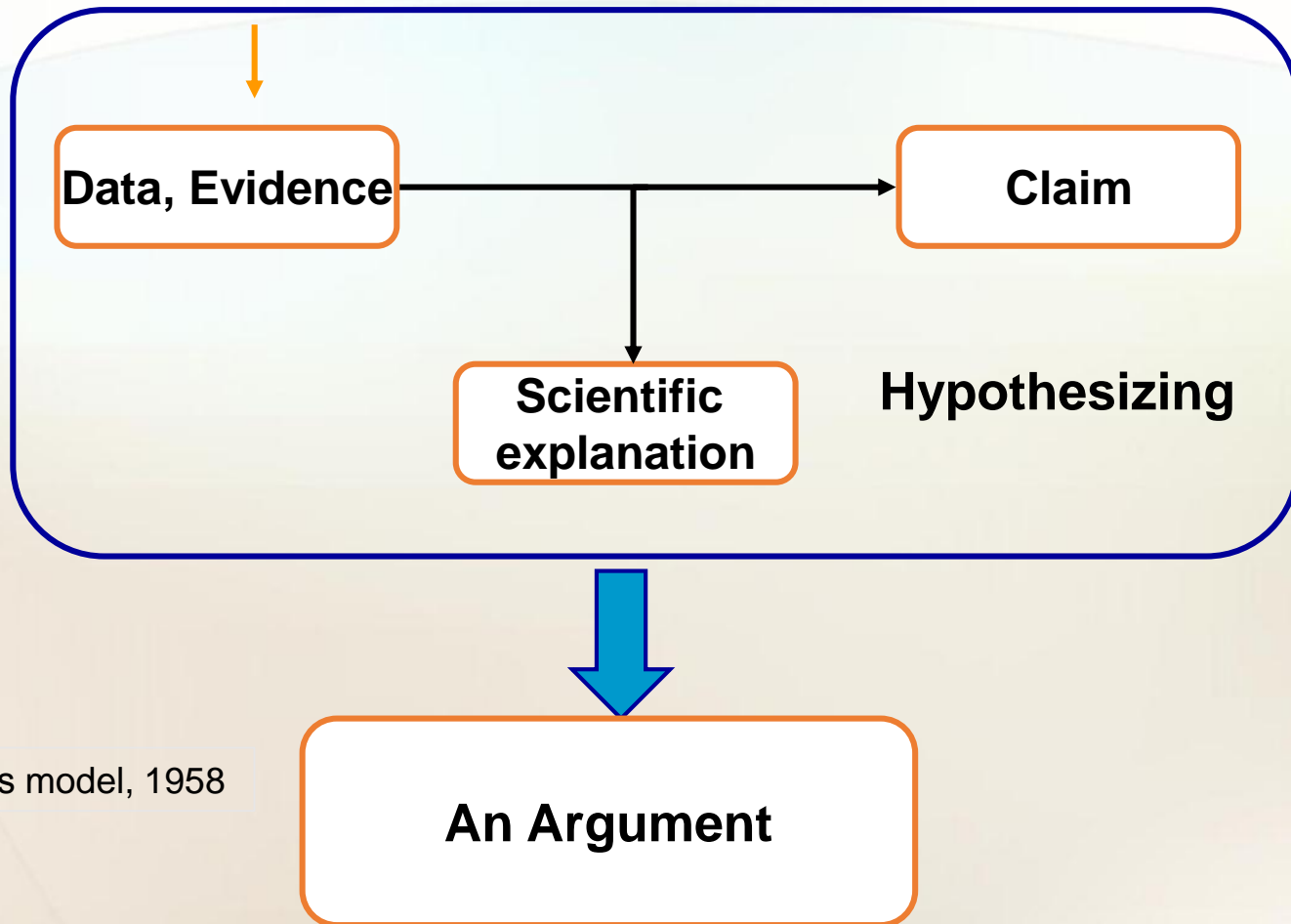
Drawing conclusions

Constructing a  
hypothesis



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

Performing the experiment



Based on Toulmin's model, 1958

# Research Tools

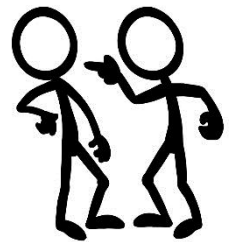
- **Observations focusing on the discourse**
- **Students' laboratory reports**
- **Interviews with the students**



# Findings - based on the Analysis of the Arguments' Components Raised by Students

From one experiment to another –  
an improvement in:

- The **number** of arguments
- The **level** of students' arguments (based on a **coding system**)
- The **frequency** of students' arguments



# Students' Quotations during the Classroom Discourse

*"Come on let's **rationalize our hypothesis**...If there is a scientific basis, let's write it".*

*"We know more or less (the experiment), but when it is necessary to **phrase a research question**, there are more discussions".*

## Conclusions

**The inquiry-type experiments indeed form an effective platform for formulating arguments**

**Help students in improving their cognitive skills**





**Teachers**

**Students**

**Curriculum**

# The CPD phases

1st phase

Development of learning materials  
(student activities and teacher's guide)

2nd phase

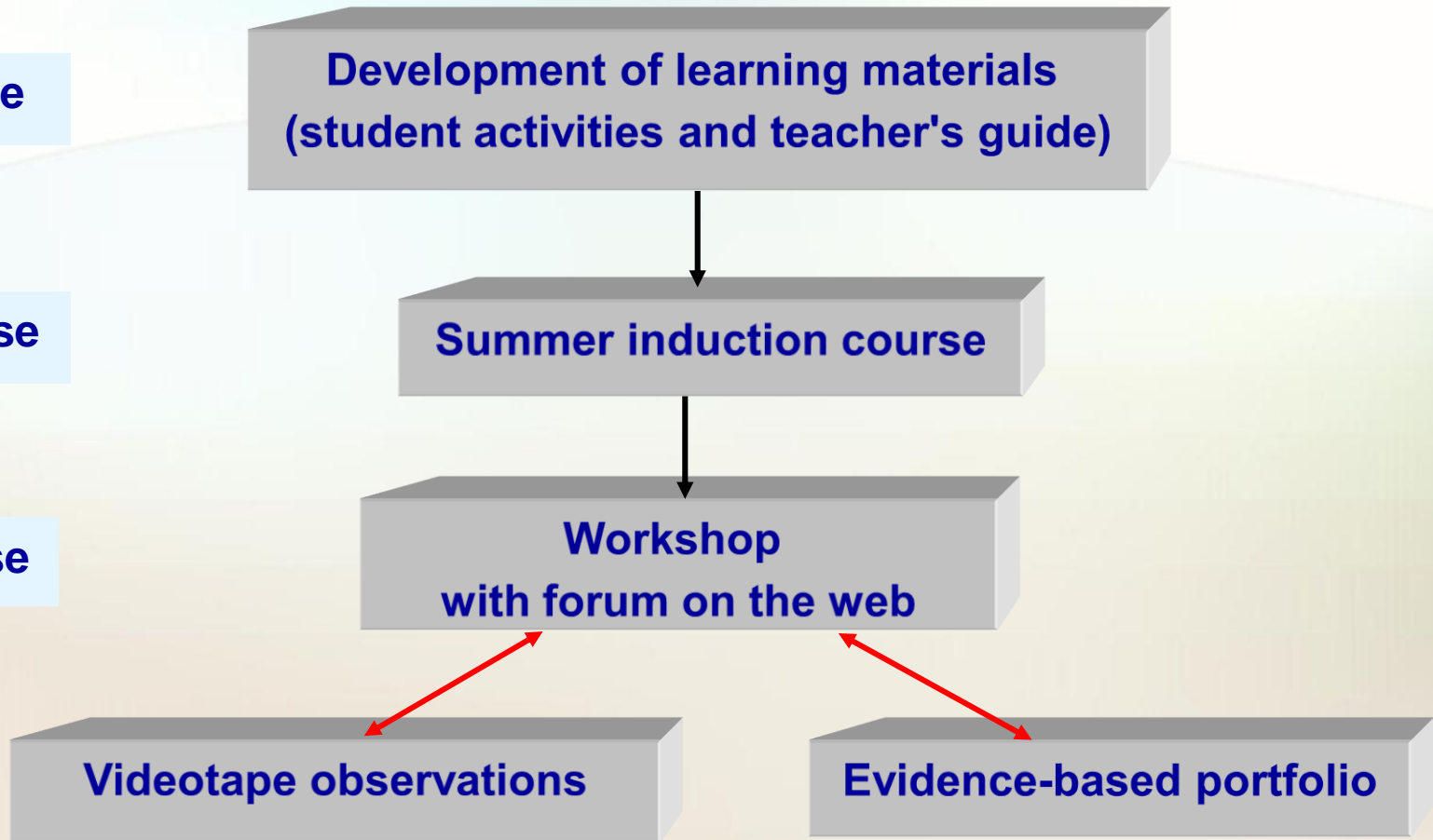
Summer induction course

3rd phase

Workshop  
with forum on the web

Videotape observations

Evidence-based portfolio





# Challenges Based on the CPD Research

**Professionalizing and enhancement  
of chemistry teachers  
To teach by inquiry**



# Challenges

- **Motivating teachers**
- **The need for Continuous Professional Development (CPD)**
- **Assessing students' achievements (e.g., Portfolio)**
- **Ways to encourage teachers to renew the list of the inquiry experiments they perform with their students**

Professional Development (PD) conducted by the Ministry of Education

# Summary

**What have we learned in one of the longest R & D projects:**

- **Development of Inquiry –type chemistry experiments**
- **Design and implementation of effective model for continuous professional development of chemistry teachers**
- **Researching students' development of high–order learning and thinking skills (skills for life)**

# Thank you!

