Science Teaching, Learning, and Motivation in Classrooms – What Can we Learn From Empirical Research?

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Profiles-Meeting, Berlin, September 26, 2012

Overview

- Science competencies and motivation as central goals of modern societies
- What do we know from empirical research about antecedents of academic learning?
- Challenges for future research
- Summary and conclusion

Science competencies and motivation as central goals of modern societies

- In today's world, some understanding of science is imperative if citizens are to make informed decisions about themselves and the world in which they live.
- Scientific knowledge is relevant in almost all issues of everyday life, from the treatment of diseases, global warming to applications of technology.
- People are faced with a barrage of information, and sifting fact from fiction is possible only if they have the tools to accomplish this.
- It is important, therefore, to make certain that students leaving school are equipped with a fundamental understanding of science such that the decisions they make are informed decisions

Science competencies and motivation as central goals of modern societies

- Horizon 2020 Framework of the European Commission: Funding of projects that care for ..
  - longer and healthier lives
  - reliable, clean, efficient energy
  - efficient use of resources for protection of our planet
  - inclusive innovation and secure society
  - safe, secure food supply
  - smart, green transport

What does this mean for us?

Enhance Students' Scientific Literacy!

Olaf Köller, Leibniz Institute for Science and Mathematics Education

Scientific literacy as an educational goal

Scientific literacy refers to an individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues.

PISA 2006 Framework

PISA 2006 Science Framework

Context

Life situations that involve science and technology

Competencies

- identify scientific issues
- explain phenomena scientifically
- use scientific evidence

Knowledge

- about the natural world (knowledge of science)
- about science itself (knowledge about science)

Attitude

- How you respond to science issues (interest, support for scientific enquiry, responsibility)

How can schools meet these challenges? Simple answers

- Hire teachers with high professional knowledge (PK, CK, and PCK, Shulman, 1986, 1987)
- Ask teachers to provide cognitively demanding and motivating lessons
- Provide enough lessons per week for science instruction (time on task)
- Provide enough time and resources for continuous TPD

A closer look: What do we know from empirical research on teaching and learning?

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Some Theory Seidel et al., 2006

Students: Quality of Utilization

Teaching & Learning Processes

Teacher: Quantity & Quality of instruction

4) Individual perception of supportive learning conditions

5) Individual processes of learning content
- elaborative & organizing processes
- quality of learning motivation

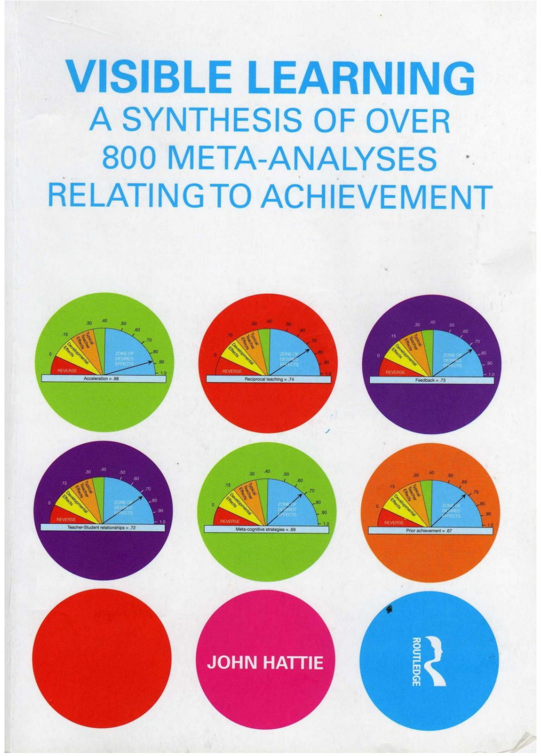
3) Individual prerequisites
- cognitive
- motivational / affective

2) Offering learning opportunities, e.g.
- clarity & coherence
- learner orientation
- student conceptions
- scientific enquiry

1) Opening time frames for different learning activities

6) **Multi-dimensional learning outcomes**
Domain specific competencies, skills, interest, attitudes, beliefs, etc.

The Holy Grail: Hattie's synthesis of over 800 meta-analyses



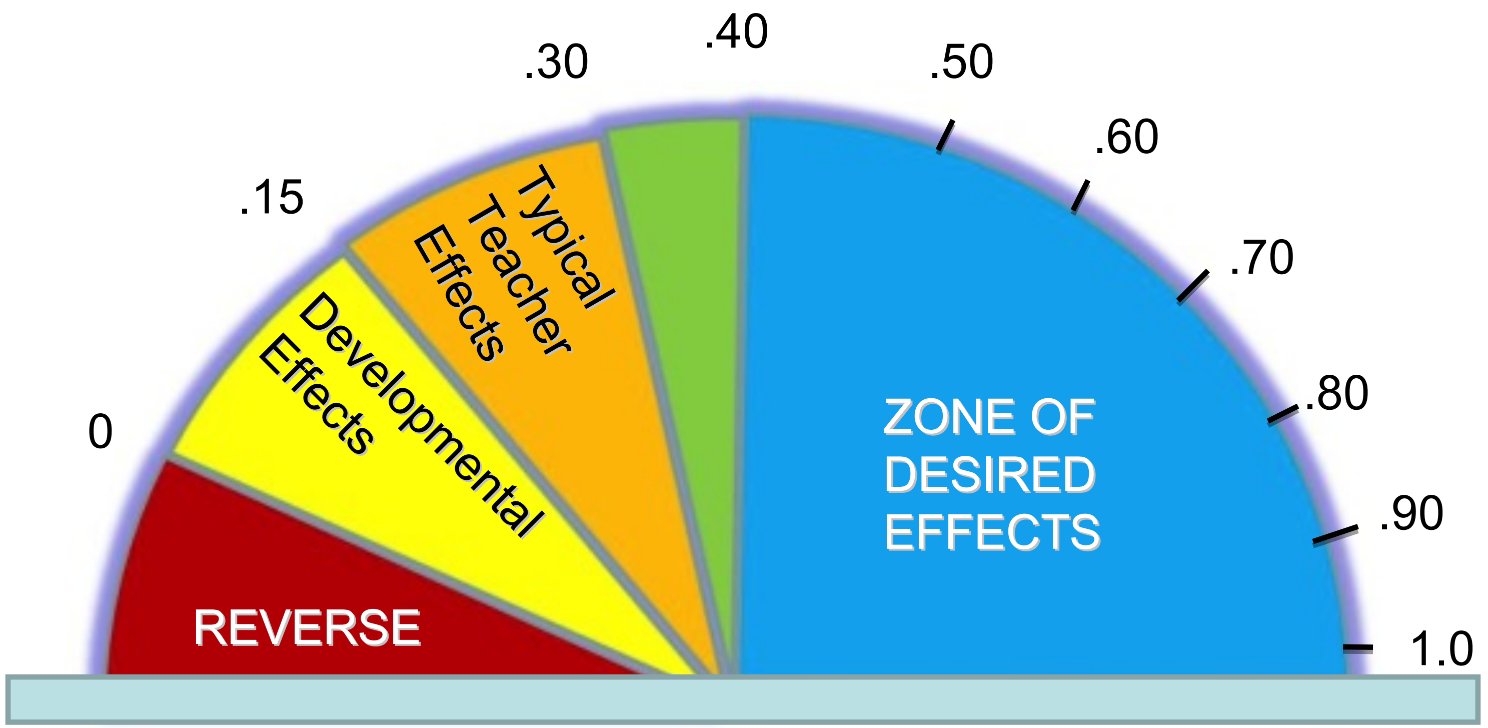
What is the typical effect of teaching variables on learning …

- across more than 800 meta-analyses?
- across more than 50.000 studies?
- across more than 80 Mio. Students?

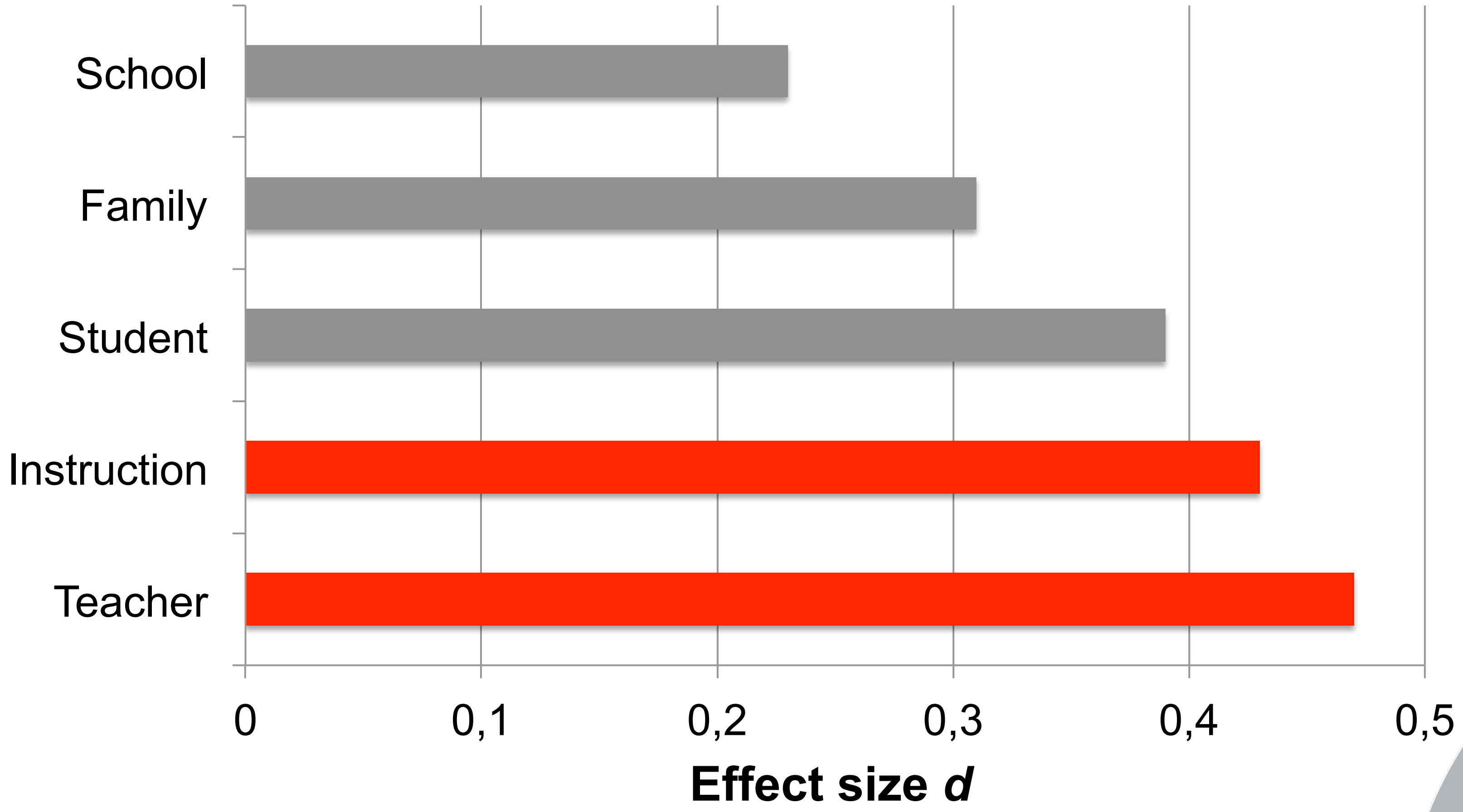
Effect size d

An effect-size of	.20	1.0
advancing achievement	6 - 9 mths	2 - 3 yrs
% improving rate of learning	10%	45%
r variable & achievement	.10	.45
% of students with treatment exceeding those not treated	8	34

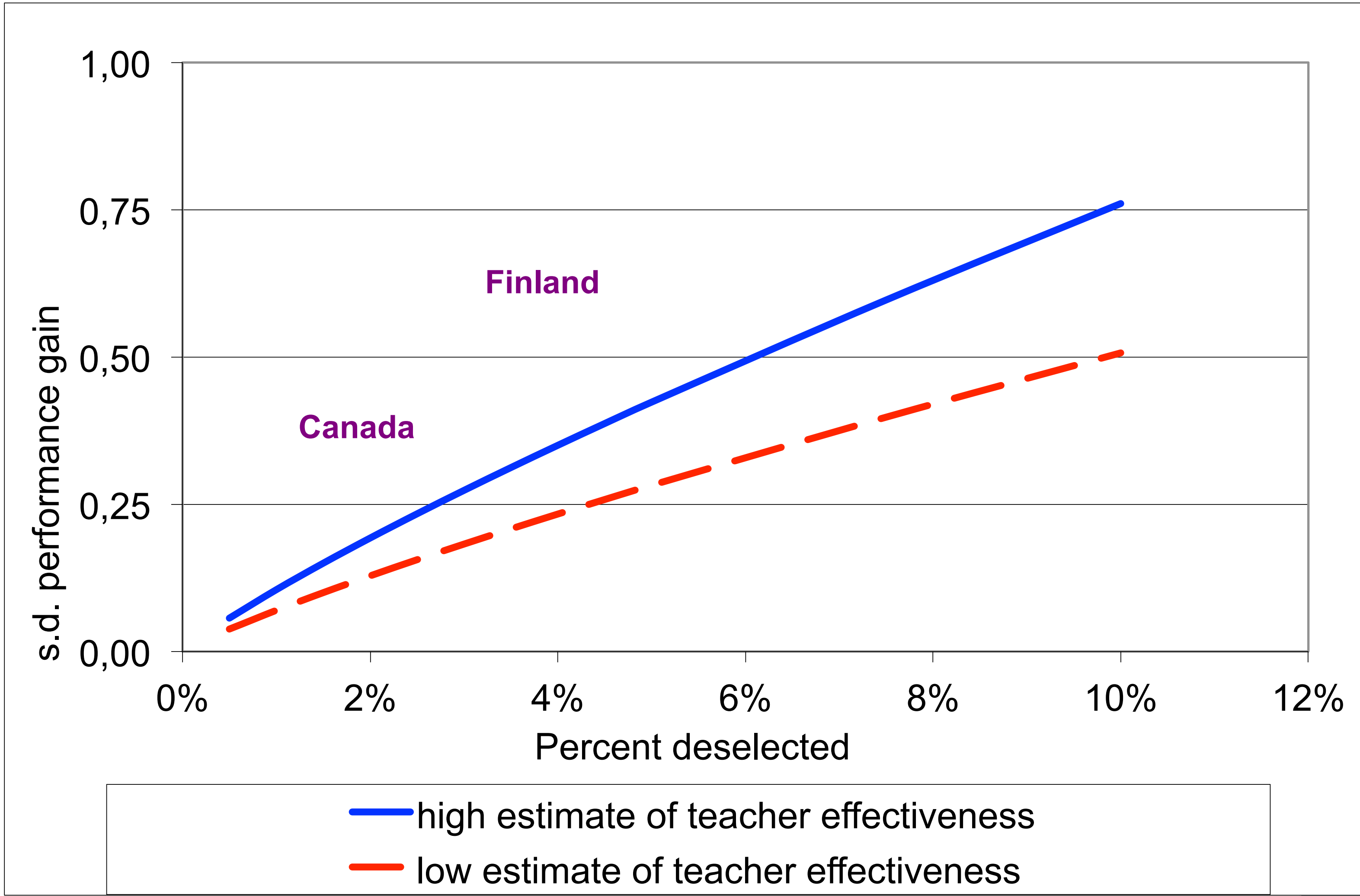
Effect size d: “Nearly any innovation is better than its absence“



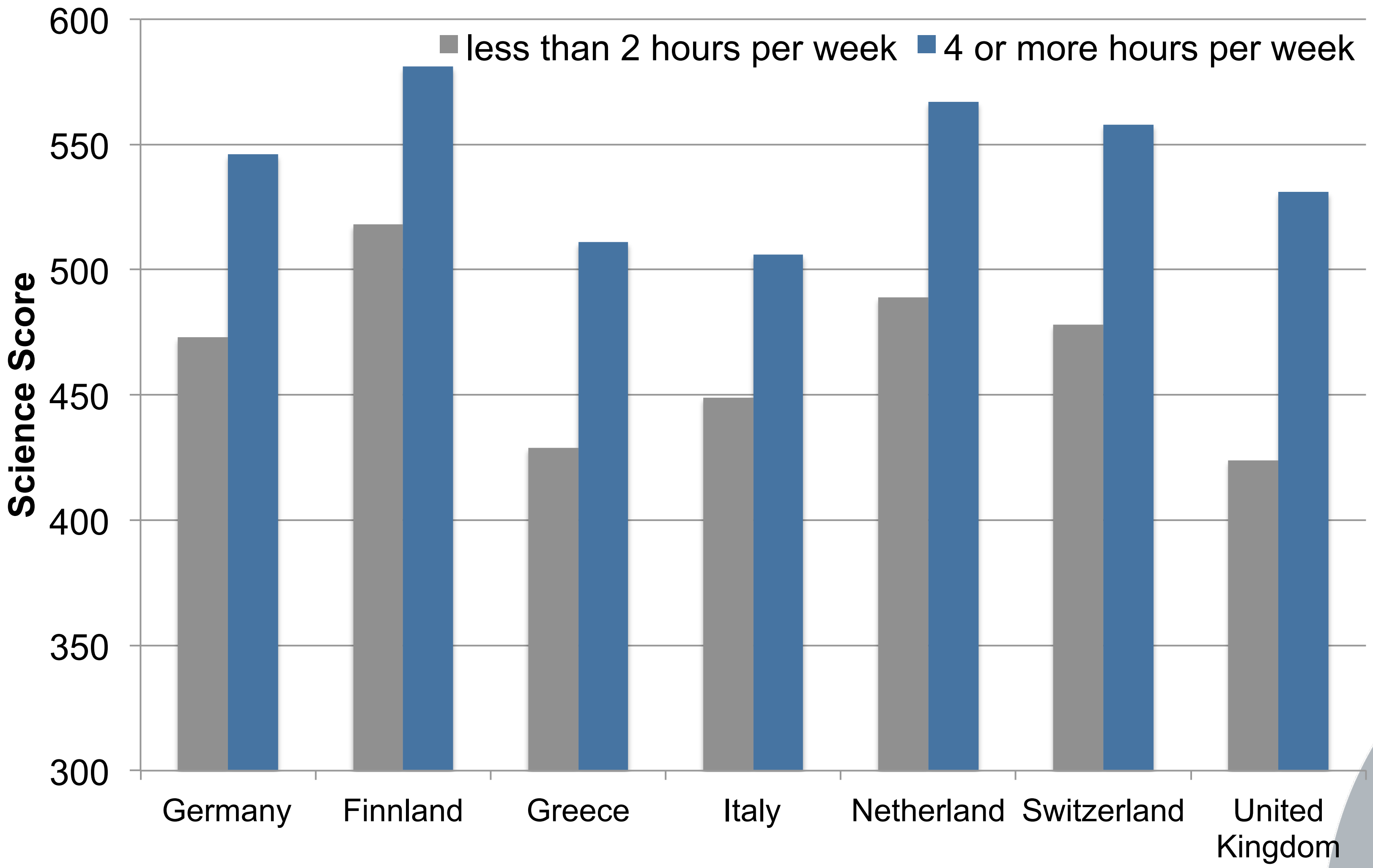
Teachers and Instruction matter!
Hattie (2012)



Teachers matter (Hanushek & Woessmann, 2011)



Instruction time matters: Findings from PISA 2006 (Kobarg et al., 2011)



Instruction vs. working conditions (Hattie, 2009)

Teaching	*d*	*Working conditions*	*d*
Quality of teaching	.77	Within-class grouping	.28
Reciprocal teaching	.74	Adding more finances	.23
Teacher-student relationships	.72	Reducing class size	.21
Providing feedback	.72	Ability grouping	.12
Teaching student self-verbalization	.67	Multi-grade/age classes	.04
Meta-cognition strategies	.67	Open vs. tradit. classes	.01
Direct instruction	.59	Summer vacation classes	-.09
Mastery learning	.57	Retention	-.16
Average	*.68*	*Average*	*.08*

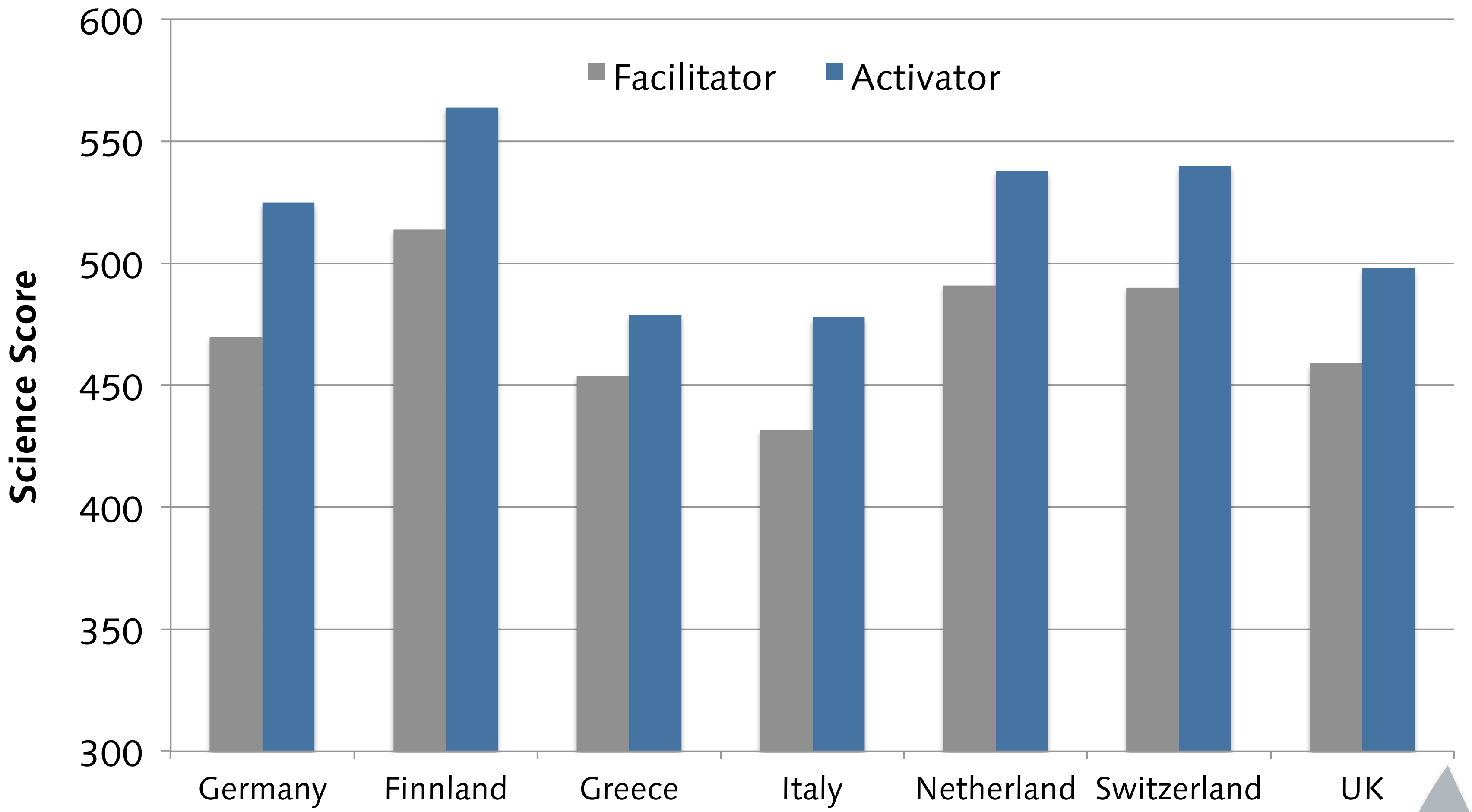
Activators vs. Facilitators (Hattie, 2009)

An Activator	*ES*	*A Facilitator*	*ES*
Reciprocal teaching	.74	Simulations and gaming	.32
Feedback	.72	Inquiry based teaching	.31
Teaching students self-verbalization	.67	Smaller class sizes	.21
Meta-cognition strategies	.67	Individualized instruction	.20
Direct Instruction	.59	Problem-based learning	.15
Mastery learning	.57	Different teaching for boys & girls	.12
Goals - challenging	.56	Web-based learning	.09
Frequent/ Effects of testing	.46	Whole Language Reading	.06
Behavioral organizers	.41	Inductive teaching	.06
ACTIVATOR	***.60***	***FACILITATOR***	***.17***

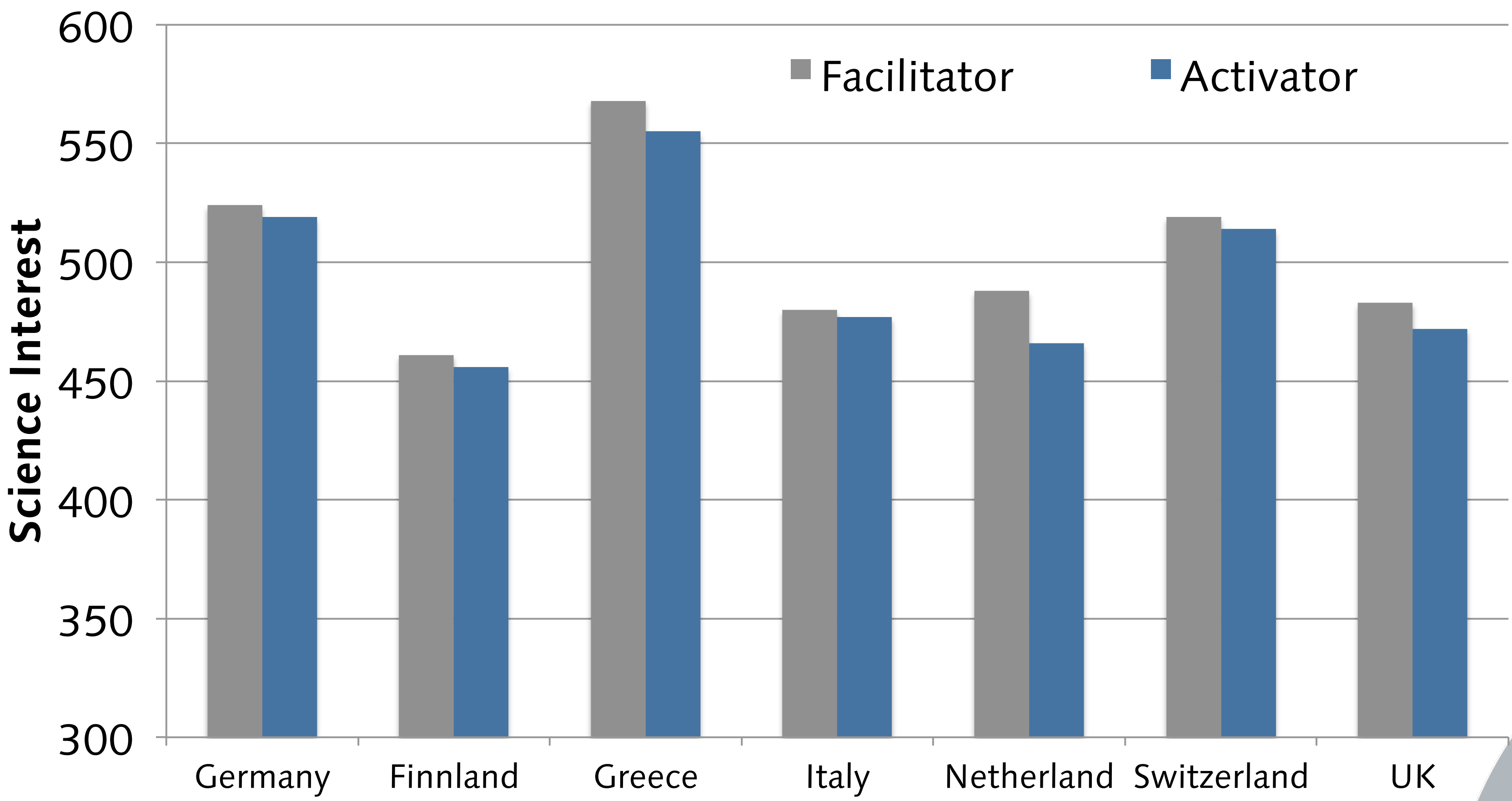
Activators vs. facilitators in PISA 2006 (Kobarg et al., 2011)

Teachers as facilitators	Teachers as activators
• Students can plan their own experiments in most lessons • Students very often carry out practical experiments • Students draw conclusions from the experiments • Students explain their own ideas • Students relate scientific concepts to the real world	• Students can plan their own experiments in some lessons • Students often carry out practical experiments • Students draw conclusions from the experiments • Students explain their own ideas • Students relate scientific concepts to the real world

Activators vs. facilitators in PISA 2006 (Kobarg et al., 2011)



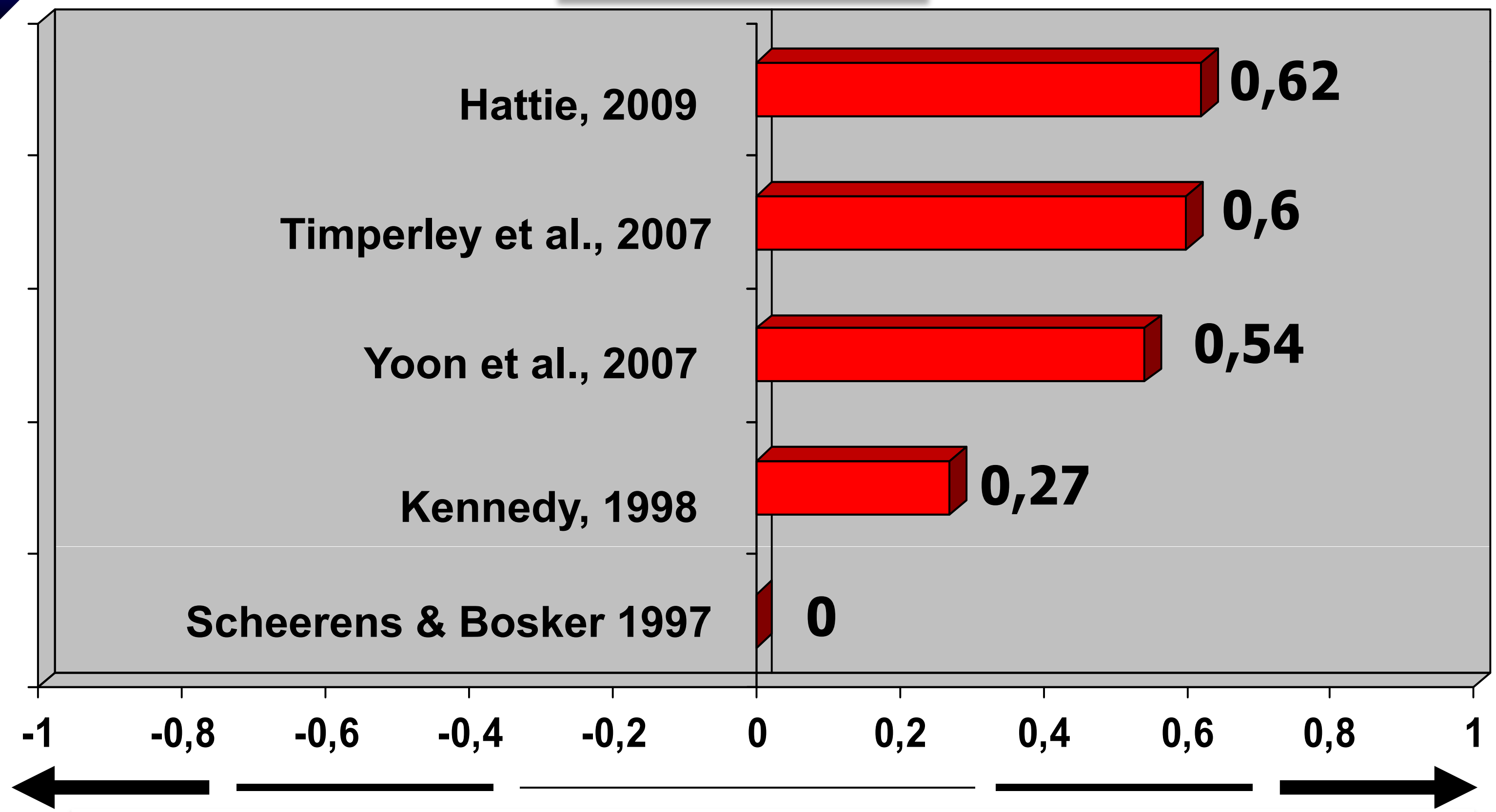
Activators vs. Facilitators in PISA 2006 (Kobarg et al., 2011)



Some top performers (Hattie, 2009)

Factor	d
Direct Instruction	.59
TPD	.62
Testing with feedback	.62
Feedback	.72
Reciprocal teaching	.74
Teacher clarity	.75
Acceleration	.88

Professional development works –



Feedback/formative assessment (Hattie, 2009)

- Where am I am going? (learning intentions, goals, success criteria)
- How am I going? (self-assessment and self-evaluation)
- Where to next? (progression, new goals)

Formative assessment

"An assessment functions formatively when evidence about student achievement elicited by the assessment is interpreted and used to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions that would have been made in the absence of that evidence."

Black & Wiliam (2009)

Aspects of formative assessment (Wiliam, 2008)

	Where the learner is going	Where the learner is	How to get there
Teacher	**Clarify and share learning intentions**	**Engineering effective discussions, tasks and activities that elicit evidence of learning**	**Providing feedback that moves learners forward**
Peer	**Understand and share learning intentions**	**Activating students as learning resources for one another**	
Learner	**Understand learning intentions**	**Activating students as owners of their own learning**	

Combining IBSE and formative assessment: A new EU project (ASSIST-Me)

- Starting in 2013
- Bring together IBSE and formative assessment
- Cooperation-project funded by the EU
- Partners:
  - University of Copenhagen (Denmark)
  - IPN (Germany)
  - University of Cyprus
  - University of Applied Sciences, Basel (Switzerland)
  - Centre National de la Recherche Scientifique (France)
  - Kings College London and Pearson Educational International (UK)
  - University of Jyväskylä (Finland)
  - University Joseph Fourier Grenoble (France)
  - University of South Bohemia (Czech Republic)

What does this all mean for science education?

- Fight for enough lessons per week
- Have a look at teacher education and TPD in science education
- Understand teachers as (cognitive) activators in science education
- ISBE needs highly professional teachers who guide students to make their own science-related experiences
- Combine IBSE with formative assessment/good feedback strategies

Mitglied der Leibniz-Gemeinschaft

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Tank you very much for your intention!

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