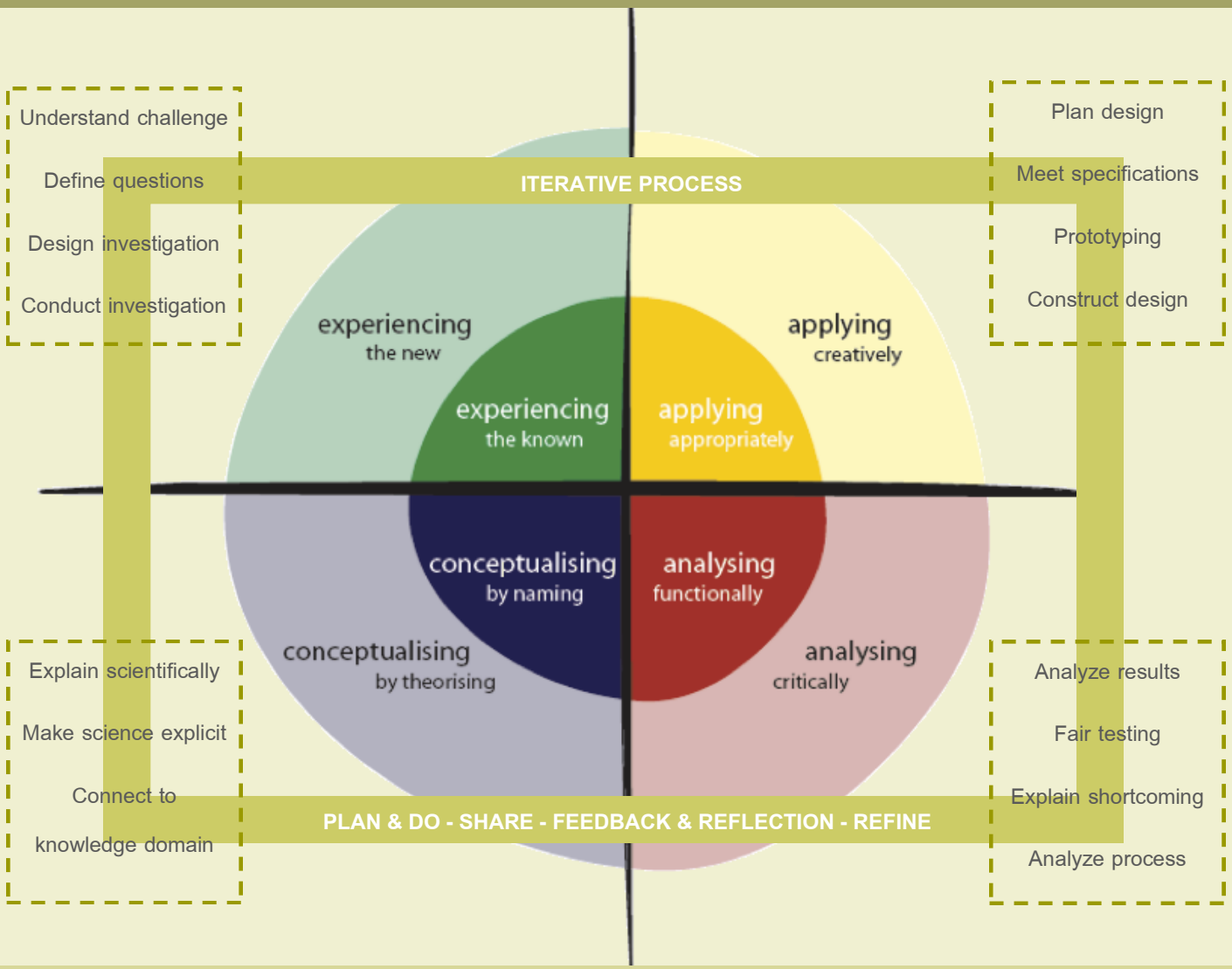
Learning By Design Challenges

A PhD study to investigate the learning of science concepts by design challenges



Reason for Research

LBD students learn science content not (significantly) better compared to non-LBD students.
This in contrast to collaboration skills, metacognitive skills (checking work, reflection) and science skills (designing fair tests).
An improvement in concept learning makes LBD a suitable approach for subject integration.

STUDY 1

LBD Challenge "Back to the Nineties"

Challenge: Design a battery- and foot-operated dance pad

Science: Direct Current Electric Circuits

77 students, 3 teachers (secondary education)

Design Based Mixed Methods Study

Pre- and Post-Testing, Observations, Questionnaires, Interviews

STUDY 2

LBD Challenge "Home Solar Power System"

Challenge: Design a solar power system for a model house

Science: Direct Current Electric Circuits

6 student teachers, 2 teacher trainers (school of teacher training)

Design Based Mixed Methods Study

Pre- and Post-Testing, Observations, Questionnaires, Interviews

Main Results

PRE– AND POST EXAMS: significant gain ($p < 0.001$); Gain-index $\langle g \rangle \approx 0.36$: ratio of actual gain to the maximum possible gain. Results are comparable to gain-indices found in previous (LBD and non-LBD) studies and offer room for improvement.

MAIN PROBLEM: students focus on tasks and products (process) and qualify scientific concepts as succeeding tools. Scientific elements are used as isolated facts. Concepts that were poorly design-related showed no or a low gain.

SIGNS FOR CONCEPT LEARNING

- Results pre– and post exams: post scores are significantly higher.
- Products and reasoning show an increased amount of scientific elements (terms, symbols, concepts).
- Proper use of materials and electric wiring to meet design principles (underlying physics was used).

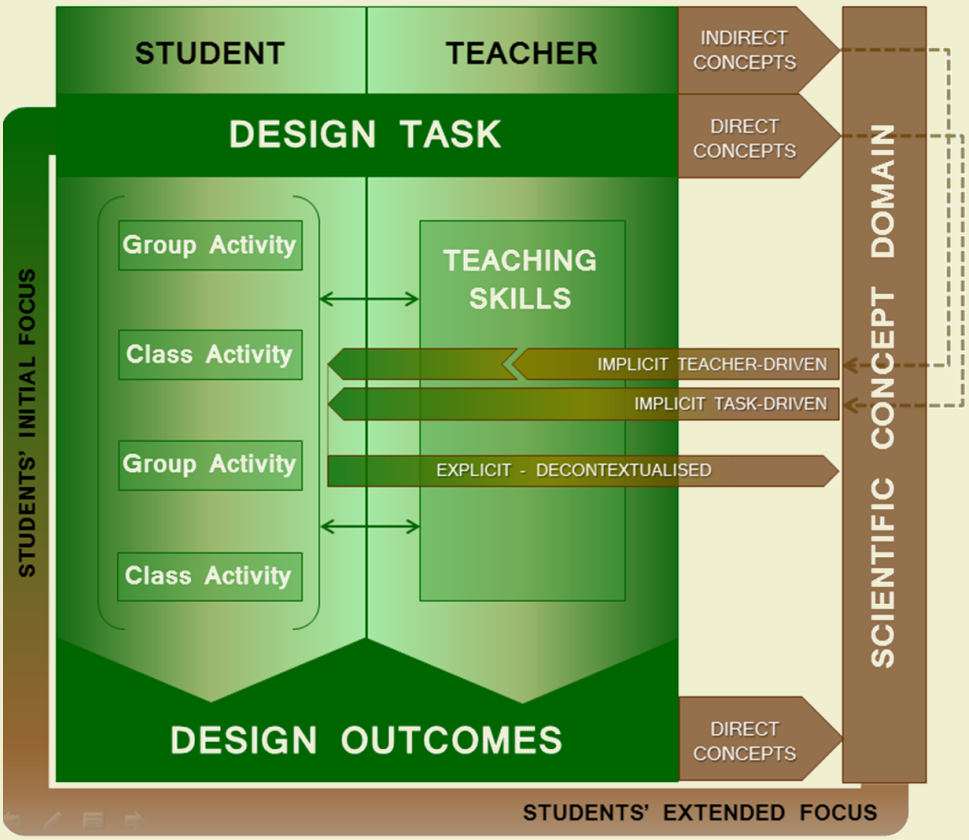
FACTORS THAT STIMULATE CONCEPT LEARNING

MOMENTS OF EXPLICIT TEACHING AND LEARNING ARE CRUCIAL

- Teacher-driven activities: when science is made explicit
- Experimentation (e.g. simulation software): when science is explicitly studied.
- Limited complexity and extensiveness of the learning tasks to enable students to focus on science.

Conclusion

A lack of explicit focus on scientific objectives and concepts causes the learning of isolated facts that stay implicit. Students learn incomplete concepts and too little explicit interrelationships (essential to master the knowledge domain). LBD has a tendency to stimulate incidental, implicit, informal or unintentional learning (Rogers, 1997; Kerka, 2000; Baskett, 1993).



Desgin-Based Science Interference Model

(Van Breukelen, 2014)

Explicit teaching strategies and techniques are necessary to provide students with a clear concept-related and explicit focus. These teaching skills should emerge during the process (anticipatory skills) and in preparation of the process (preparatory skills).

Possible improvements

- Guided Discussion (Brandsford et al., 2003)
- Informed Design (Burghardt & Hacker, 2004)
- Explicit Instruction and Feedback (concepts)
- Scaffolding Strategies (Bamberger & Cahill, 2013)
- Proper Analysis of Related Concepts

TU Delft
Delft University of Technology
Dave H.J. van Breukelen d.vanbreukelen@fontys.nl +31 (0)8850 70041
Fontys University of Applied Sciences