

**LUMA:  
15-YEAR-  
ANNIVERSARY  
IN 2018**

**NEW SOLUTIONS AND PEDAGOGICAL INNOVATIONS  
INTO MATH, SCIENCE AND TECHNOLOGY EDUCATION  
THROUGH **DESIGN-BASED RESEARCH****

**Maija Aksela**

Dr, Professor, Research director  
**Director of LUMA Centre Finland**  
**University of Helsinki, Finland**

[\*\*maija.aksela@helsinki.fi\*\*](mailto:maija.aksela@helsinki.fi)





- ❑ 5 million people in Finland (belongs to EU)
- ❑ **12 universities**
- ❑ Beautiful nature: about 180 000 lakes, about 1 million islands
- ❑ About 2 million summer cottages and saunas

**GREETINGS FROM FINLAND!**

More info at the webpage:  
**VisitFinland**



A photo from Lappland

- ❑ 12 universities in Finland
- ❑ **University of Helsinki** is the biggest and oldest research university in Finland
  - 36 000 students
  - 11 faculties
  - about 400 years old
- ❑ **LUMA Centre is coordinated from Faculty of Science**



**University of Helsinki**  
<https://www.helsinki.fi/en/university>



## CONTENTS OF MY TALK TODAY:

- ❑ MY BACKGROUND "STORY": **WHY TO USE DESIGN-BASED RESEARCH?**
- ❑ **LUMA** ECO SYSTEM AND THE USE OF DESIGN-BASED RESEARCH
- ❑ **DESIGN-BASED RESEARCH**: DEFINITION, HOW TO USE IT IN PRACTISE? OPPORTUNITIES AND **CHALLENGES**
- ❑ **EXAMPLES**

Northern Lights in a photo



**National LUMA strategy: new solutions and pedagogical innovations collaboratively through the newest research**



**Kids and youth  
—future makers  
in heart**

## **Maija Akselas' background info**

- ❑ **Motto: "Together we are more"**
  - ❑ Over **35** years in science education
  - ❑ Over **300** publications in science education
  - ❑ **16 years experience on design-based research**
  - ❑ Over 30 years collaboration with scientists and industry
- 
- ❑ **Promoting education from 6 experiences:**
    - (i) **researcher in science** (chemistry; in Canada)
    - (ii) 6 years math and science **teacher** at senior high school
    - (iii) 22 years **teacher educator (math and science teacher program) and researcher** in University of Helsinki
    - (iv) about 30 years in-service training
    - (v) 15 years **LUMA** work beside teacher education ("mom of LUMA")
    - (iv) mom of two children (adults)

The oldest **LUMA lab**, ChemistryLab Gadolin —**research and development centre**— at the Faculty of Science, University of Helsinki since 2008

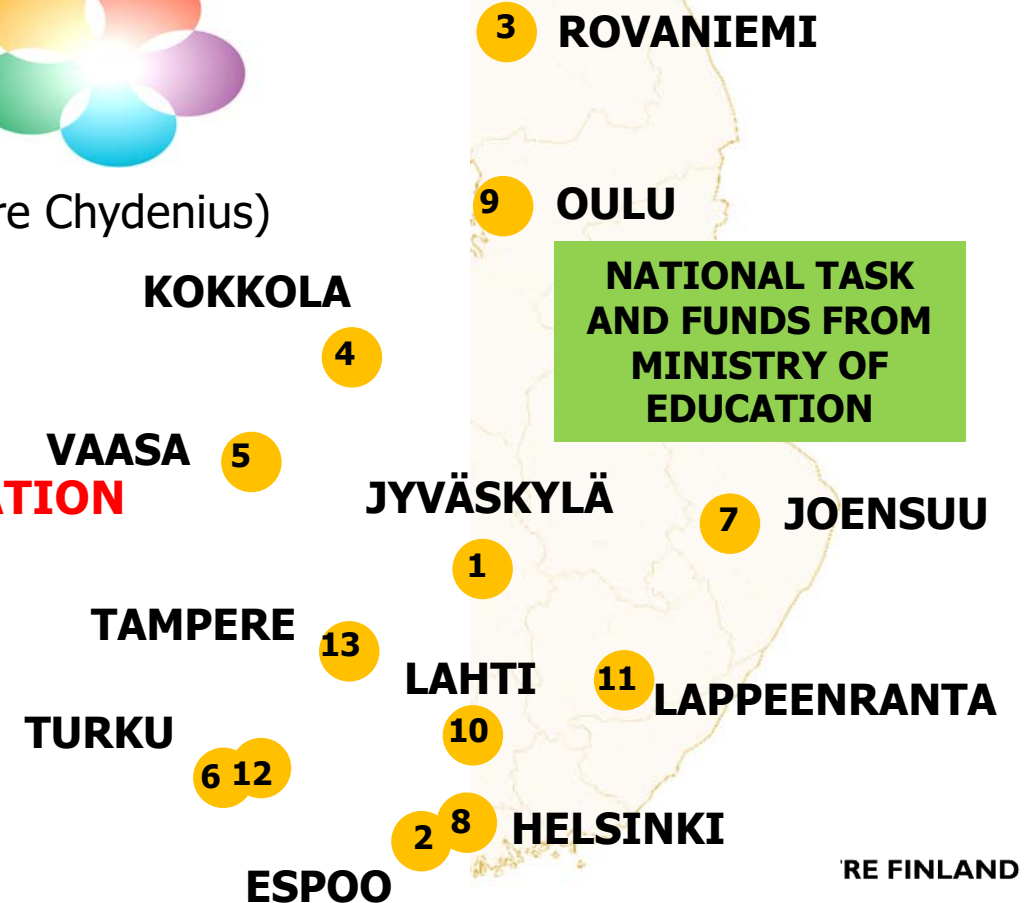
New solutions and pedagogical innovations for math, science and technology education through research.

## LUMA ECOSYSTEM: LUMA CENTRE FINLAND

1. Central Finland LUMA Centre (University of Jyväskylä)
2. Aalto Junior (Aalto University)
3. LUMA Centre Lapland (University of Lapland)
4. LUMA Centre of Central Ostrobothnia (Kokkola University Centre Chydenius)
5. LUMA Centre of Ostrobothnia (University of Vaasa)
6. LUMA Centre of Southwestern Finland (University of Turku)
7. LUMA Centre of the University of Eastern Finland
- 8. LUMA Centre of the University of Helsinki – COORDINATION**
9. LUMA Centre of the University of Oulu
10. LUMA Centre Päijät-Häme (Lahti University Campus)
11. LUMA Centre Saimaa (Lappeenranta University of Technology)
12. LUMA Centre Åbo Akademi (Åbo Akademi University)
13. Tampere LUMATE Centre (University of Tampere & Tampere University of Technology)



- ABOUT 1 MILLION PARTICIPANTS 2014-17
- 40 DIFFERENT FORMS OF ACTIVITIES
- ABOUT 100 "LUMA-WORKERS"



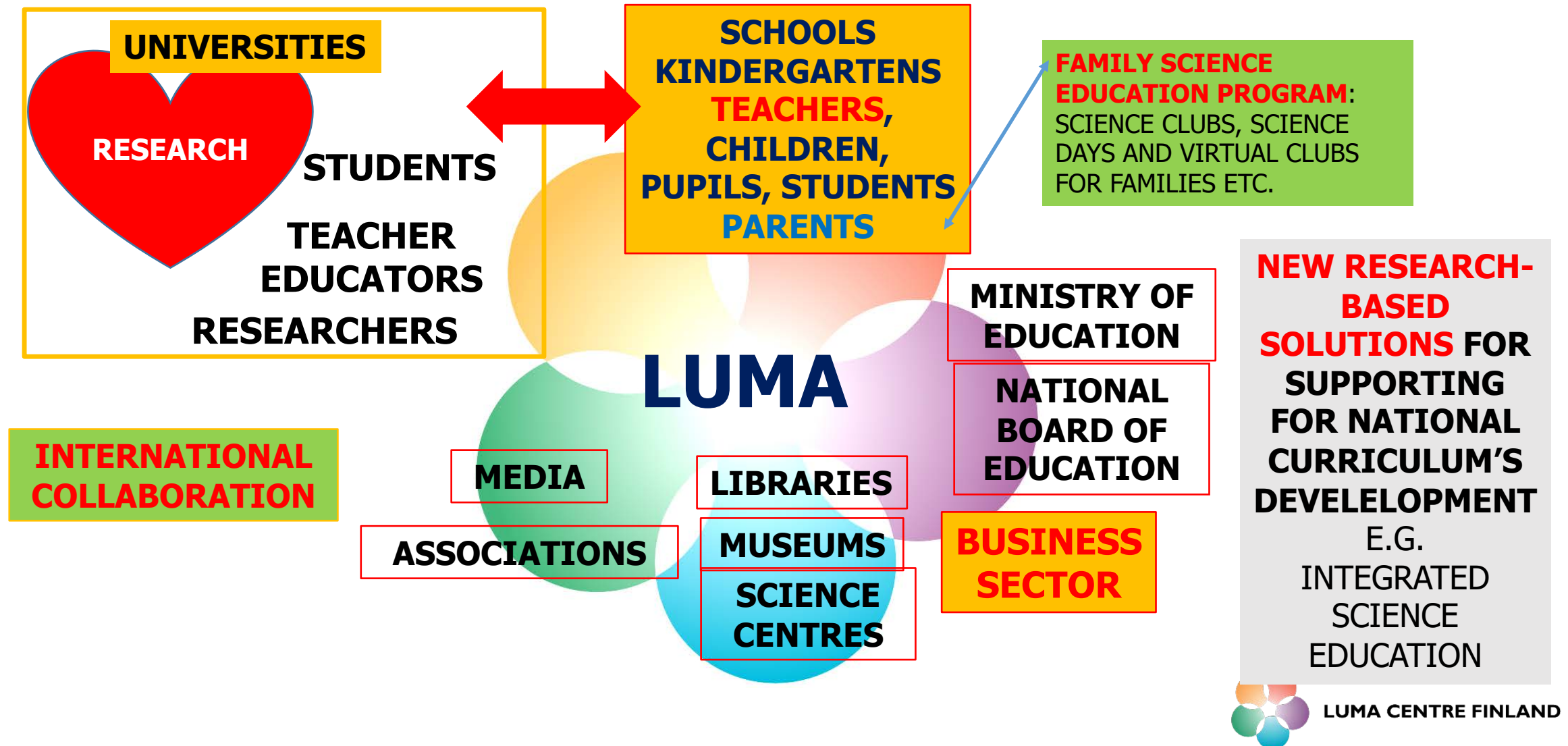
# THE AREAS of THE LUMA NATIONAL MISSION

(funded by Ministry of education)

1. Increasing the amount of **international collaboration** enhancing learning and funding possibilities in future
2. Offering **informal, nonformal and formal science education** for children and youth to support recruiting students for higher education
3. Conducting **LUMA-related research** brings valuable information for developing activities furthermore and making LUMA fields more appealing
4. **Promoting pre-service and in-service teacher education**
5. Supporting studying LUMA subjects with the aid of **StarT projects** inspires children and youth for STEM areas
6. **LUMA Labs** provide and offer facilities and equipment for STEM activities



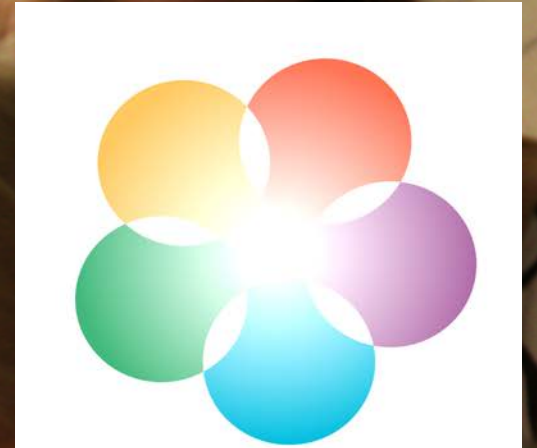
# THE FINNISH LUMA MODEL: COLLABORATION IS A KEY FOR SUCCESS







# WHAT IS LUMA?



- ❑ **LUMA** IS A **FINNISH MODEL** TO PROMOTE MATH, SCIENCE AND TECHNOLOGY EDUCATION.
- ❑ IT MEANS **LIGHT (SHINE): JOY IN KIDS' AND YOUTH'S EYES**
- ❑ THE FLOWER LOGO MEANS **"TOGETHER WE ARE MORE"** (our motto)

**LUMA** comes from the words: "**LU**onnontieteet" (science) and MA "**MA**tematiikka" (math) in Finnish.





**ENJOY OF  
MATH,  
SCIENCE AND  
TECHNOLOGY**

**15th anniversary  
in 2018**

Collaboration also with families

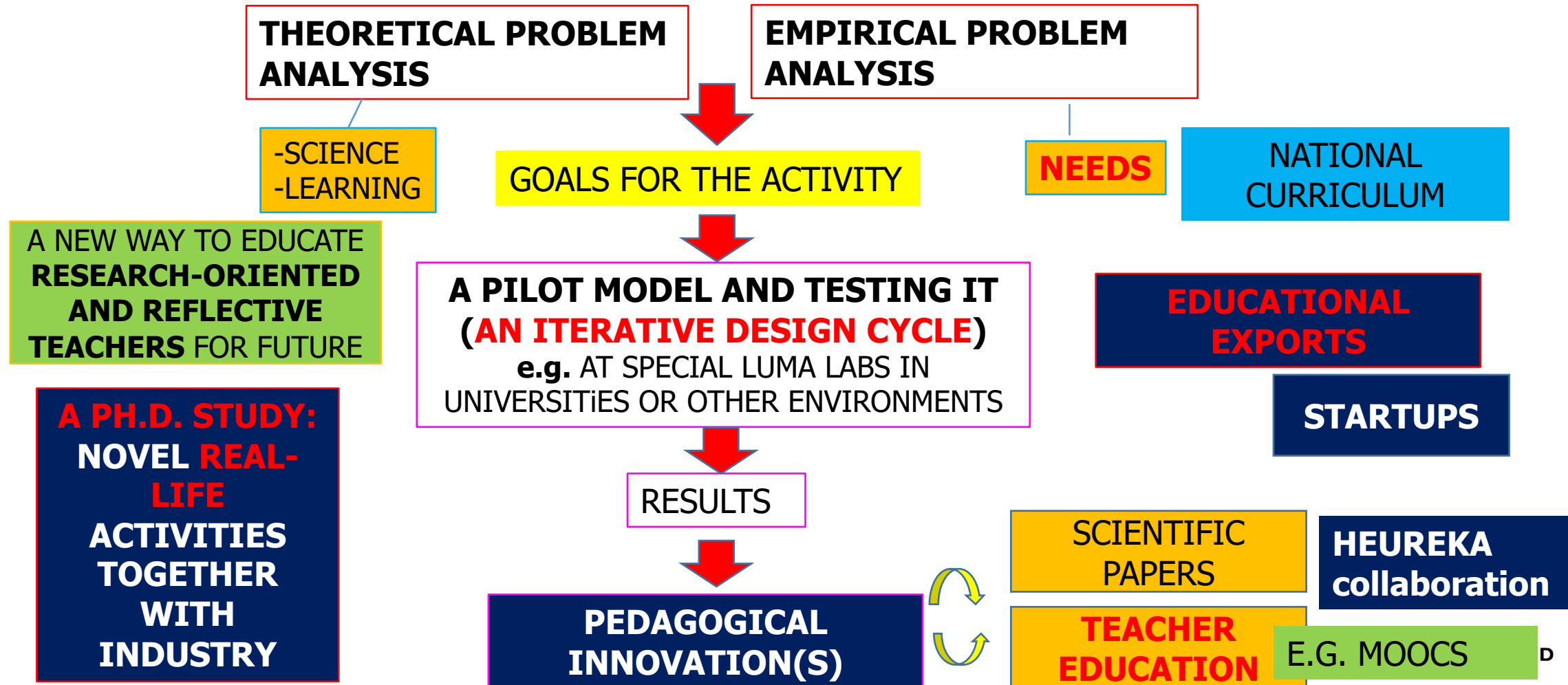
## **THE MAIN AIM OF THE LUMA MODEL :**

**To engage children and young people –both girls and boys- from age 3 to 19 in science, technology, engineering, and mathematics and teachers at all levels in life-long professional development.**

Promoting curiosity, creativity and learning through collaboration



# COLLABORATIVE DESIGN-BASED RESEARCH AS A TOOL FOR NEW SOLUTIONS AND PEDAGOGICAL INNOVATIONS





# New solutions and pedagogical innovations: **37 DEVELOPMENT PROJECTS GOING ON**



**DESIGN-  
BASED  
RESEARCH  
FRAMEWORK**

**SUPPORTING  
NEW  
CURRICULUM  
FRAMEWORK**

## ☐ **MATHEMATICS**

(e.g. creative problem solving; playful learning)

## ☐ **SCIENCE AND ENVIRONMENT**

(e.g. good questions, integrated science education)

## ☐ **TECHNOLOGY EDUCATION** (e.g. **programming**, robotics)

15 MOOCs for  
teachers and  
future teachers

**LUMA SUOMI PROGRAMME  
FOR YEARS 2014-19**

**(RESOURCES from the Ministry of Education and Culture)**



**LUMA CENTRE FINLAND**



## Example 1: GOOD QUESTIONS

Research-based pedagogical models  
produced together with teachers

- ❑ **Promoting students to ask questions**
- ❑ **Promoting “better” questions**
- ❑ **Using the questions in teaching**
  - Questions in integrated science teaching
  - Questions in project-based learning
  - Questions in inquiry-based teaching
  - **Finding out about students pre-knowledge**
  - Questions as discussion promoters
  - **Questions in planning teaching**



**MOOC Course:** Good questions and argumentation in science education



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## Example 2:

# **A SUCCESSFUL JIPPO PROGRAM** SINCE 2013 FOR 3 TO 6 YEARS OLD KIDS



**A pilot program:**

**335 families or kindergarten groups took part in these virtual science clubs.**

- ☐ **SCIENCE CLUBS**
- ☐ **A COURSE FOR THE GUIDES IN THE CLUBS**

- ☐ **TRAINING FOR TEACHERS IN KINDERGARTEN**
- ☐ **A JIPPO PROGRAM AS A PART OF KINDERGARTEN'S CURRICULUM -> SPECIAL KINDERGARTENS**

- ☐ **VIRTUAL JIPPO SCIENCE CLUBS WITH FAMILIES**





## Example 3. Collaboration with Business PRE-SERVICE AND IN-SERVICE EDUCATION TOGETHER

- ❑ It is carried out in collaboration with the industry and schools through the course called **Math and Science in Society** (LUMA)
- ❑ **Students, a company and a school (two teachers from the school) in each team**
- ❑ **A project work** with Industry Companies: designing a collaboration model for the school close to it

**MOOC Course:** How to make collaboration with companies?

Kousa, Aksela & Ferck-Savec, 2018



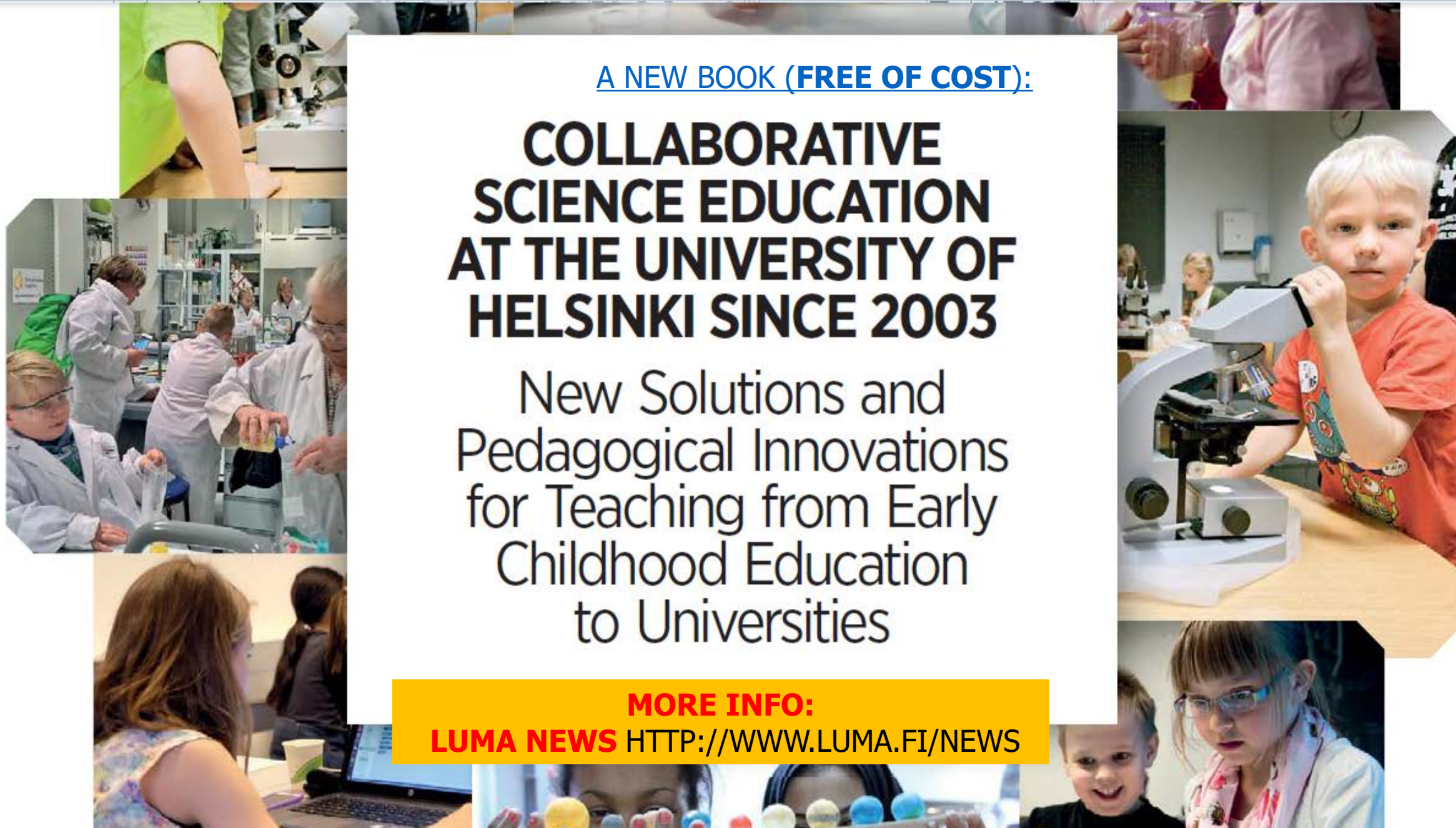
[A NEW BOOK \(FREE OF COST\):](#)

# COLLABORATIVE SCIENCE EDUCATION AT THE UNIVERSITY OF HELSINKI SINCE 2003

New Solutions and  
Pedagogical Innovations  
for Teaching from Early  
Childhood Education  
to Universities

**MORE INFO:**

**LUMA NEWS** [HTTP://WWW.LUMA.FI/NEWS](http://www.luma.fi/news)





EDUCATING **FUTURE**  
**CHEMISTRY TEACHERS**  
COLLABORATIVELY  
THROUGH **NON-FORMAL**  
**EDUCATION IN THE LUMA**  
**ECOSYSTEM.**

**15th anniversary book** of the  
Unit of Chemistry Teacher  
Education in **Department of**  
**Chemistry**, Faculty of Science,  
University of Helsinki

PROMOTING INNOVATIVE AND COLLABORATIVE  
CHEMISTRY EDUCATION

Through Evidence-Based Chemistry Teacher Education

Maija Aksela (Ed.)

**Free of cost; LUMAT**



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# LUMA RESEARCH STRATEGY: DESIGN-BASED RESEARCH AS A TOOL

*Design-based research is **a research methodology** aimed to improve **educational practices** through systematic, flexible, and iterative review, analysis, design, development, and implementation, based upon collaboration among researchers and practitioners **in real-world settings**, and leading to **design principles or theories**” (Wang & Hannafin, 2004, page 2).*

Other names, for example: **design experiments** (Brown, 1992; Collins, 1992), **design research** (Cobb, 2001), and **development research** (Richey & Nelson, 1996; van den Akker, 1999).



Mikä tahansa päiväys  
Vuodesta 2018  
Vuodesta 2017  
Vuodesta 2014  
Oma ajanjakso...

Lajittele osuvuuden mukaan  
Lajittele pvm mukaan

☒ hae patenteista  
☒ sis. lainaukset

☐ Luo ilmoitus

### Design-based Research

M Knogler - Planspiele-Analyse und Wirk...  
Design-based research blends a theory- (simulation game "Energetingen"-please with empirical educational research. As p

### Design-Based Research Education

T Cochrane, NE Davis, J Mackey  
An innovative approach to effective Environments (MUVE) in vocation development with design based

### Using design-based research and learning of Chinese w

X Li, SKW Chu - Computers & Ed  
In this research, a conceptual model (WCPWP) is developed using a d to help the teaching and learning

[KIRJA] Conducting educational design research

S McKenney, TC Reeves - 2018 - taylorfrancis.com

... 280 References Barab, S. & Squire, K. (2004). Design-based research: Putting a stake in the ground. Journal of the Learning Sciences, 13(1), 1-14 ... Bell, P. (2004). On the theoretical breadth of design-based research in education. Educational Psychologist, 39(4), 243-253 ...

**DESIGN-BASED RESEARCH:** 16 000 RESULTS THROUGH GOOGLE SCHOLAR

**EDUCATIONAL DESIGN RESEARCH:** 32 400 RESULTS THROUGH GOOGLE SCHOLAR

"Educational design research blends **scientific investigation with the systematic development and implementation of solutions to educational challenges.** Empirical inquiry is conducted in real learning settings – not laboratories – to craft effective solutions to the complex challenges facing educational practitioners. At the same time, the research is carefully structured to **produce theoretical understanding** that can serve the work of others."

**By Susan McKenney & Thomas C Reeves, 2018**

[PDF] pushtopause.nl



Category	Psychological Experimentation	Design-based Research
Location of research	Conducted in laboratory settings	Occurs in the buzzing, blooming confusion of <b>real-life settings</b> where most learning actually occurs
Complexity of variables	Frequently involves a single or several dependent variables	Involves <b>multiple dependent variables</b> , including climate variables (e.g. collaboration among learners, available resources), outcome variables(e.g. learning of content, transfer), and system variables (e.g., dissemination, sustainability)
Focus of research	Focuses on identifying a few variables and holding them constant	Focuses on <b>characterizing the situation in all its complexity</b> , much of which is not now <i>a priori</i>

Category	Psychological Experimentation	Design-based Research
Role of participants	Treats participants as Subjects Involves	Involves <b>different participants</b> in the design to bring their differing expertise into producing and analyzing the design
Level of social interaction	Isolates learners to control interactions	Frequently involves <b>complex social interactions</b> with participants sharing ideas, distracting each other, and so on
Unfolding of procedures	Uses fixed procedures	Involves <b>flexible design revision</b> in which a tentative initial set is revised, depending on its success in practice
Characterizing the findings	Focuses on testing hypotheses	Involves looking <b>at multiple aspects of the design</b> and developing a profile that characterizes the design in practice

**The characteristics of good design research** (Dede, 2004; Design-Based Research Collective, 2003) guides design process, and are described **in detail** in a report:

- 1) design meet needs of practitioners and policymakers
- 2) goals of designing interventions and developing theories are intertwined
- 3) development and research occurs through **continuous cycles of design, enactment, analysis, and redesign**
- 4) research relies on **methods** that document and link implementation to outcomes of interest
- 5) research accounts for how designs function in authentic settings and research leads to theories that communicate relevant implications to practitioners and other designers.



# MY VIEW: WHY ENGAGE IN DESIGN-BASED RESEARCH?

1. New relevant solutions and pedagogical innovations from research into **practice**. At same time you'll get new findings to theories. "All in a same package".
2. It involves researchers to promote science education **directly**.
3. It gives opportunities for **systematic collaboration** with other partners (e.g. schools, scientists, business, science centers). **All are learning from each others**.
4. It is a motivating tool **for professional development** and **to educate** future teachers and teachers at all levels and **future researchers in science education**.
5. A good tool for **promote higher education**, e.g. teacher education at university level.
6. The best **professional development for myself**.



## Examples of published articles in English:

[Pernaa, Johannes ; Aksela, Maija.](#) / [Model-Based Design Research : A Practical Method for Educational Innovations](#). Advances in Business-Related Scientific Research Journal. (2013), 4 (1)1, pp.71-83

[Vesterinen, Veli-Matti ; Aksela, Maija.](#) / [Design of Chemistry Teacher Education Course on Nature of Science](#). Science & Education (2013); 22 (9). pp. 2193-2225

[Tuomisto, Maiju ; Aksela, Maija Katariina.](#) / [Design and evaluation framework for relevant chemistry-related educational card and board games](#).  
Julkaisussa: LUMAT: Research and Practice in Math, Science and Technology Education (2015); 3 (4), pp. 429-438





# HOW TO PROMOTE RESEARCH INTO PRACTISE?


## DESIGN-BASED RESEARCH IN THE CONTEXT OF LUMA ECOSYSTEM

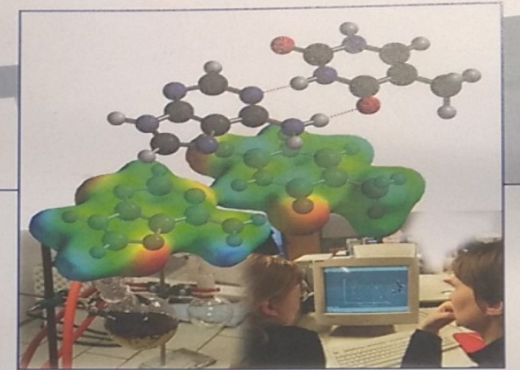
DESIGN RESEARCH: WHAT WE LEARN  
WHEN WE ENGAGE IN DESIGN  
(**EDELSON, 2002**)

*The Journal of the Learning Sciences,*  
11(1), 105–121.

[Aksela, Maija Katariina](#) ; Oehlschlager, Allan C./  
[Modelling the Substrate Binding Domain of Horse  
Liver Alcohol Dehydrogenase, HLADH, by Computer  
Aided Substrate Overlay](#). *Studies in Natural Products  
Chemistry*. 1995 ; 17(Part D), pp. 479-548

## ACADEMIC DISSERTATION:

Faculty of Science  Department of Chemistry



Maija Aksela

Supporting Meaningful Chemistry Learning  
and Higher-order Thinking  
through Computer-Assisted Inquiry:  
A Design Research Approach

HOW TO PROMOTE MEANINGFUL  
LEARNING AND HIGHER-ORDER  
THINKING?

“Design research methodology helps to build **an understanding of *how, when, and why* this educational innovation** works when implemented in classrooms.”

**“Three types of knowledge** can be obtained through a design research approach (Edelson, 2002), applicable to this study, are:

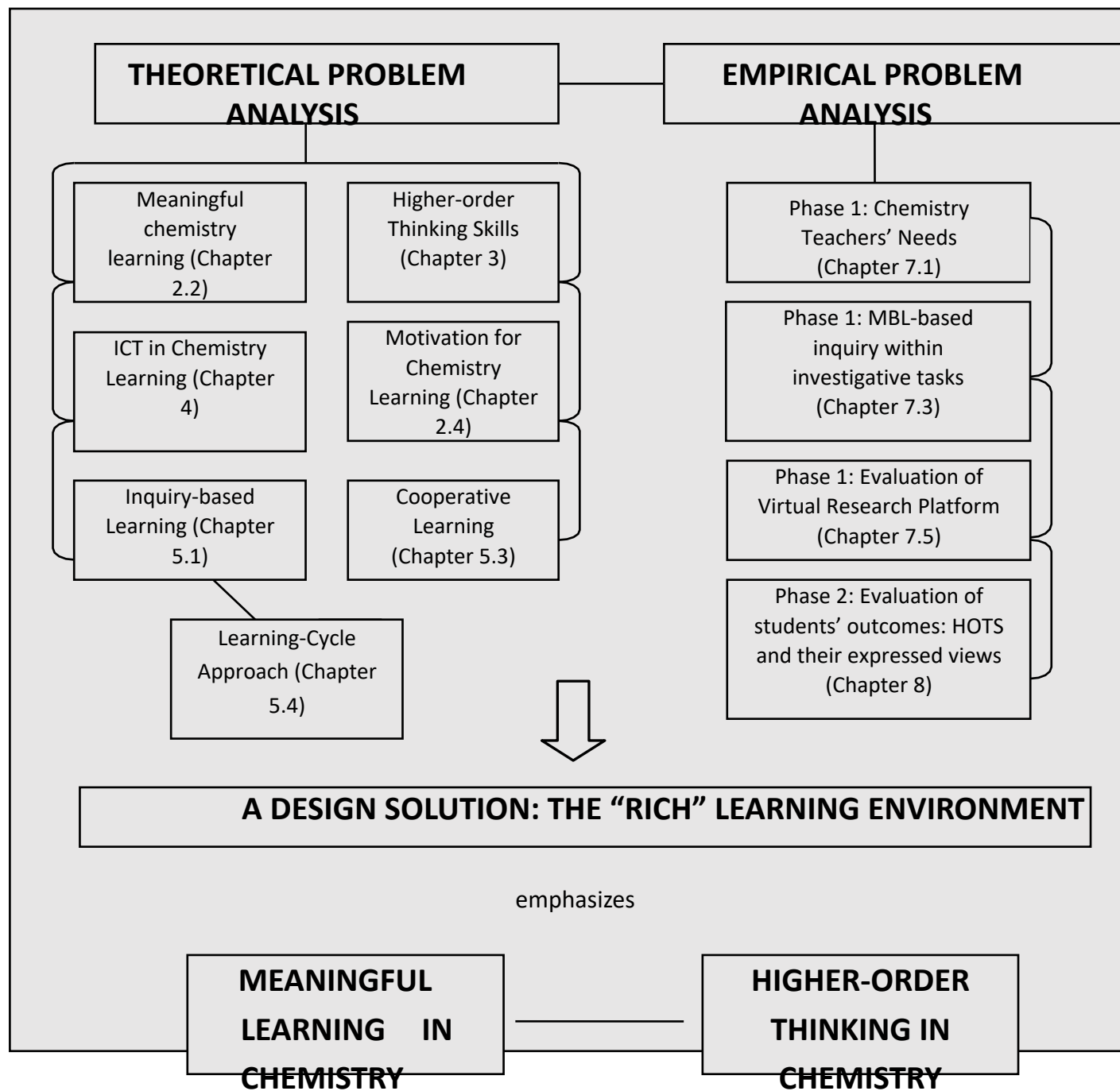
- (a) design frameworks about properties of the learning environment—***the design solution***,
- (b) ***design methodologies*** about the design process of a “rich” learning environment
- (c) ***domain knowledge*** about meaningful learning and higher-order thinking through computer-assisted inquiry.”

Maija Aksela, academic dissertation, 2005



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Main elements of the design research: **(a) theoretical problem analysis** and **(b) empirical problem analysis** (Edelson, 2002).

## ACADEMIC DISSERTATION



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## DESIGN-BASED RESEARCH: DIFFERENT METHODS USED

- ❑ **Different methods** were employed during **six** empirical studies, including **video-recordings**, **naturalistic observations**, **group interviews**, **concept maps**, **learning diaries**, **students' research reports**, and **surveys**.
- ❑ Students' meaningful chemistry learning and higher-order thinking were studied through their social discourse and actions in various stages of the six-stage learning cycle.
- ❑ The **design research** **triangulated methods** of qualitative and quantitative research (a mixed methodology) to understand important features of an educational innovation.

