Investigation & Evaluation of the Teaching & Learning of Higher-Order Academic Skills in Engineering Education

Research Project in Progress

Status November 2020

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Nameplate

Project Title	Developing Higher-Order Academic Skills in Biomedical Engineering Education
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Period	July 2020 – July 2023
Funding	University of Twente
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Sign-up for BMS Lab Support	Project-ID-1596454455

Content

- Situation
  - Problem formulation & Research Purpose
  - Context of Study
  - Methodology
- Inventory of Data Collected & Analysed + Research Support
- Focus → Survey + Delphi + FGD with Teachers
- Work Packages & Plan
  - Overall
  - Focus: Next coming + Dissemination
  - Proposal for next cycle
- Discussion

Problem Formulation

- Higher-order academic skills
  - Such as: creative, critical, and integrative thinking
  - Considered necessary in (interdisciplinary) scientific research, design, and decision making
  - Expected to promote the intellectual resilience and agility in the further professional life

- Engineering education needs to assist students in developing these skills

- However, little is known about how to 'teach and learn' these skills in a deliberate way
  - The literature is not specific about methods
  - Instructional designers often expect this development to happen automatically

Research Purpose & Context

To advance effective ways to teach and learn

higher-order cognitive skills

required in biomedical engineering,

while promoting the development of meta-cognitive skills.

- Through the investigation and evaluation of
  the learning and teaching of higher-order academic skills in project-based activities
- Focus on conceptual modelling as a key scaffold

- Demarcation
  - Emphasis on cognitive skills
  - Focus on BMT Module 1
  - Focus on learning process and output aggregated at the teams level

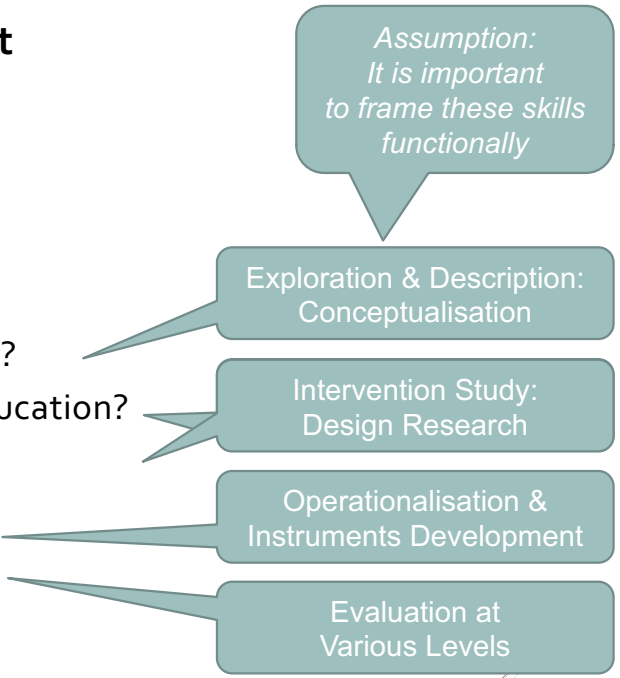
Problem Based Learning:
Project Work in Groups
Regarding Biomaterials

Research Purpose & Methods

- Overarching central question:

How can
the cognitive and meta-cognitive development
of students be promoted,
with the aim of forging the profile
of the engineer as a researcher?

- Research questions:
  - **RQ1.** What are the specific higher-order skills required by biomedical engineers?
  - **RQ2.** How can these skills effectively be taught or promoted by engineering education?
  - **RQ3.** How can students effectively learn or develop these skills?
  - **RQ4.** How can these skills be measured?
  - **RQ5.** How can an intervention (e.g. introduction of a scaffolding) be evaluated?



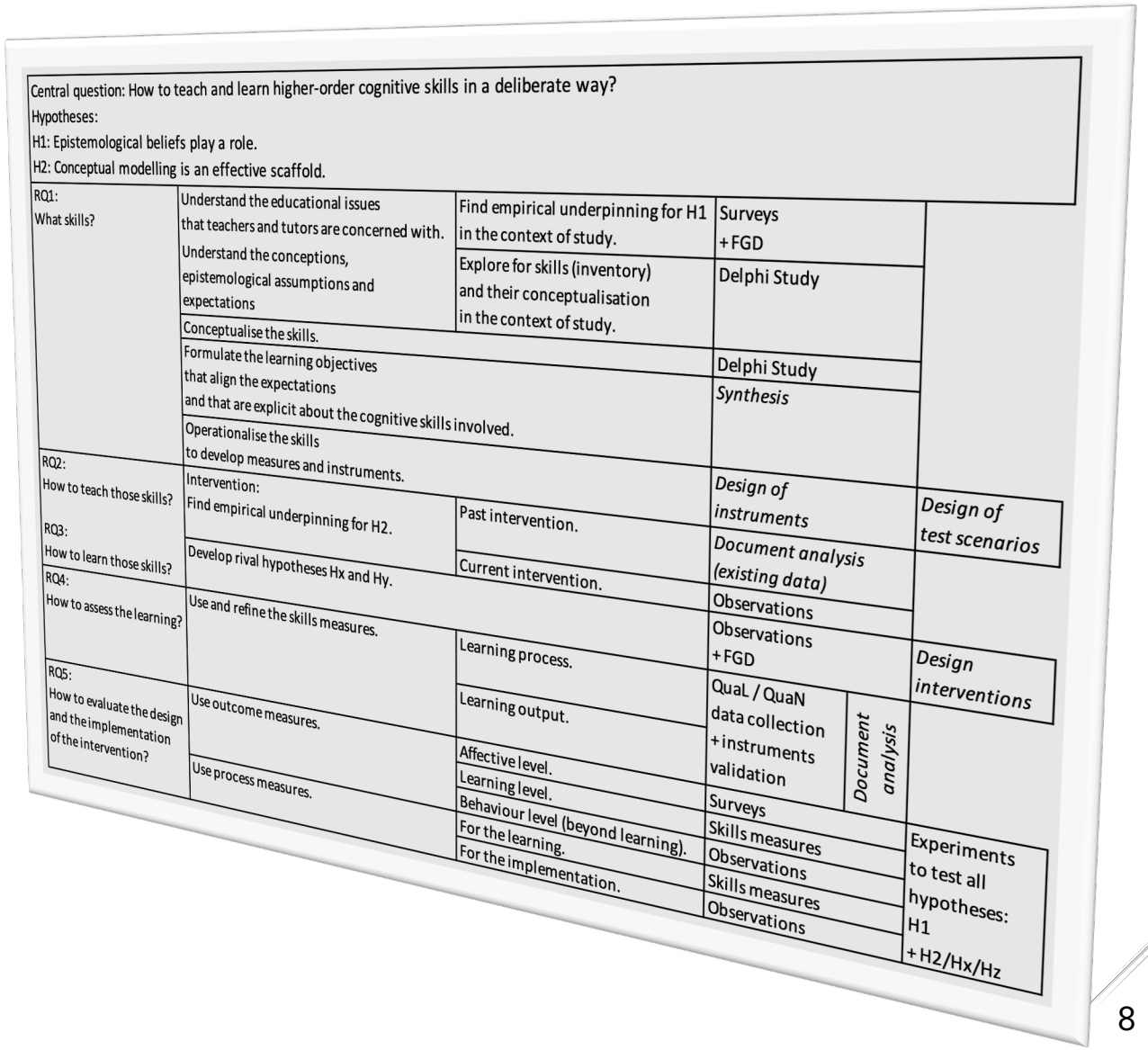
Methodology

- Longitudinal investigation → design-research approach
  - Exploration
  - Iterative prototyping → (re)design, implementation, testing, refinement
  - Reflection

- Multiple units of analysis
  - progress in skills development
  - the evolution of epistemological beliefs
  - the changes in perceptions and interpretation of the ILOs
  - the performance during the development of intermediate and final products

- Mixed-methods investigation → various sources and kinds of data
  - Existing data
  - New data → natural settings & data generated for research

From RQs to Methods



Central question: How to teach and learn higher-order cognitive skills in a deliberate way?
Hypotheses:
H1: Epistemological beliefs play a role.
H2: Conceptual modelling is an effective scaffold.

RQ1: What skills?	Understand the educational issues that teachers and tutors are concerned with.	Find empirical underpinning for H1 in the context of study.	Surveys + FGD		
	Understand the conceptions, epistemological assumptions and expectations	Explore for skills (inventory) and their conceptualisation in the context of study.	Delphi Study		
	Conceptualise the skills.		Delphi Study		
	Formulate the learning objectives that align the expectations and that are explicit about the cognitive skills involved.		*Synthesis*		
	Operationalise the skills to develop measures and instruments.		*Design of instruments*		*Design of test scenarios*
RQ2: How to teach those skills? RQ3: How to learn those skills?	Intervention: Find empirical underpinning for H2.	Past intervention.	*Document analysis (existing data)*		
	Develop rival hypotheses Hx and Hy.	Current intervention.	Observations		
RQ4: How to assess the learning?	Use and refine the skills measures.	Learning process.	Observations + FGD		*Design interventions*
		Learning output.	QuaL / QuaN data collection + instruments validation	*Document analysis*	
RQ5: How to evaluate the design and the implementation of the intervention?	Use outcome measures.	Affective level.	Surveys		Experiments to test all hypotheses: H1 + H2/Hx/Hz
		Learning level.	Skills measures		
	Use process measures.	Behaviour level (beyond learning).	Observations		
		For the learning.	Skills measures		
		For the implementation.	Observations		

NEW DATA collection	Survey T0	~~Interview~~	Delphi Study	Single Focus Group	Obs. Project Groups at Work	Obs. Feedback Meetings	~~Follow-up Focus Groups~~	Assessed Interm. Products	Assessed Project Report	Survey T1	Interview	Skills Measures Test Run	Survey & Debrief.	Interview
	collected; analysis in progress	none	collected; analysis in progress	planned	none	collected	none	collected; assessment missing	collected; assessment missing	?	?	delayed	delayed	?
Students	pop.	*sample*			pop.	pop.		pop.	pop.	pop.	*sample*	pop.	pop.	*sample*
population	140					30 groups								
100 % completion	71					6 groups								
5-95 % completion	33					4 groups								
participation (any)	104	0			2 groups	10 groups								
no participation	36					20 groups								
informed consent	53							...	...					
Tutors	pop.	*sample*	pop.			pop.	pop.			pop.	*sample*	pop.	pop.	*sample*
participation (any)	19	0	7			20	0							
informed consent	11													
Teachers	pop.	*sample*		pop.						pop.	*sample*			
participation (any)	6	0		2,5										
informed consent	4													
Total	pop.	*sample*			pop.	pop.		pop.	pop.	pop.	*sample*	pop.	pop.	*sample*
participation (any)	129	0			9	67		...	...					
informed consent	68													