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KoM@ING

Modeling and Developing Competences
Integrated IRT-Based and Qualitative Studies with a Focus on
Mathematics and its Usage in Engineering Education

Subprojects A/B
Subproject A: Leibniz Universität **Hannover**/ Universität **Paderborn**
Subproject B: TU **Dortmund** University / Humboldt-Universität zu **Berlin**

Qualitative and Quantitative Studies on Task and Process Analyses
Technical-Cognitive, Metacognitive, Learning Culture and Communities of Practice

Subproject C
University of **Stuttgart**
IPN – Leibniz-Institute for Science and Mathematics Education, **Kiel**

IRT-Based Modeling of Competence Structures in Basic Engineering Studies,
Proficiency Scaling and Modeling of Competence Development

Applying an Extended Praxeological ATD-Model for Analyzing Different Mathematical Discourses in Higher Engineering Courses

(Subproject A – Hannover, Jana Peters, Reinhard Hochmuth, Stephan Schreiber)

Situation

Engineering students face Mathematics in the contexts:

- Higher mathematics courses (HM)
- Advanced engineering courses, Signals and System Theory (SST)

Problem

Mathematical discourse in SST-courses:

- Includes HM-practices
- Combines HM practices with electrotechnical rationales
- Constructs new mathematical practices (specific electrotechnical reasoning patterns)

Focus

A SST-exercise and the sample solution given by the lecturer

Research Question

What praxeologies arise in the sample solutions and how are the different established mathematical concepts related?

Analytical Tool: Extended Praxeological ATD-Model

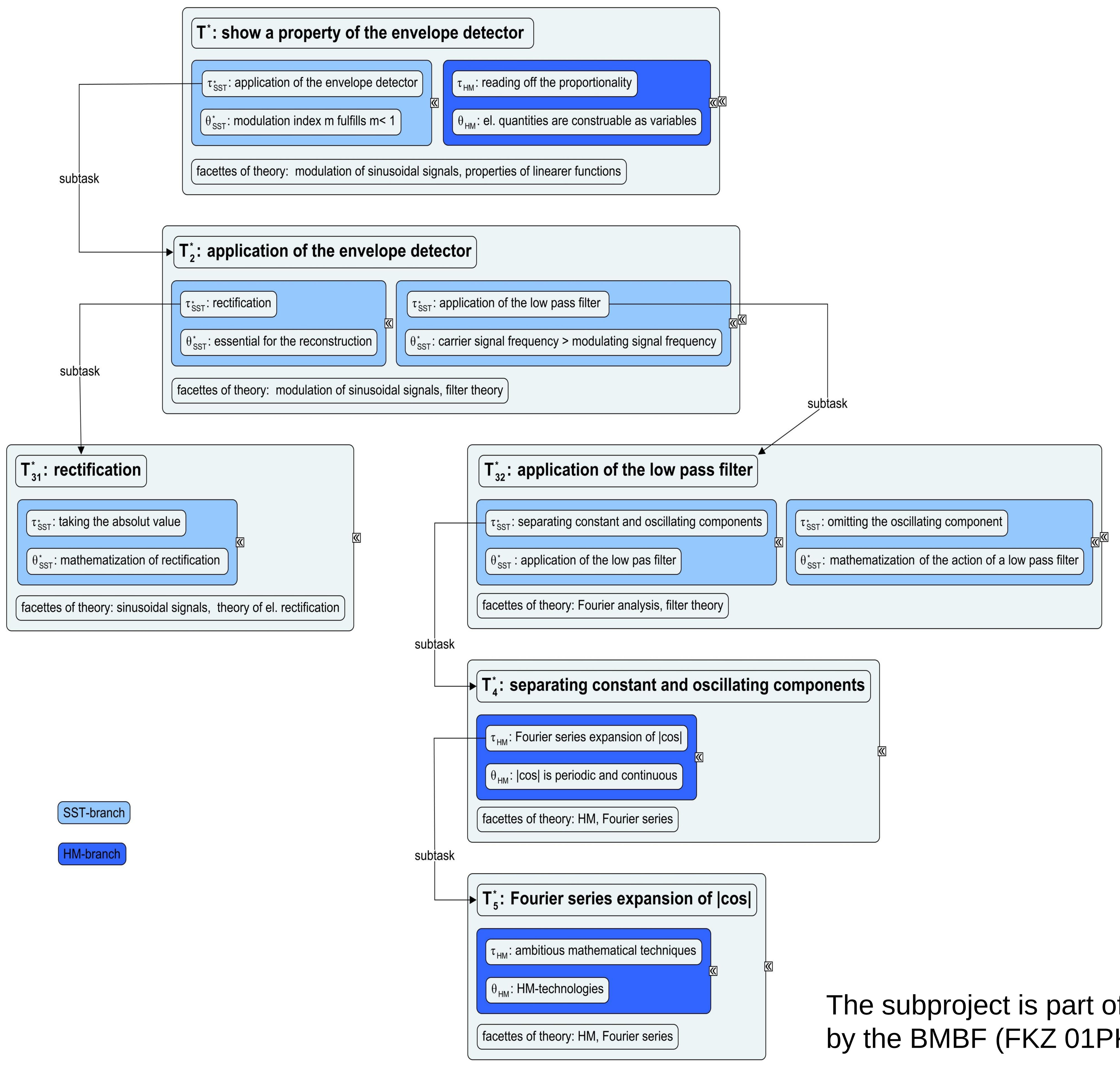
$$\left[T^*, \begin{matrix} \tau_{HM} \\ \tau^*_{SST} \end{matrix}, \begin{matrix} \theta_{HM} \\ \theta^*_{SST} \end{matrix}, \Theta^*_{SST} \right]$$

- Based on the 4T-model $[T, \tau, \theta, \Theta]$ in Anthropological Theory of Didactics (ATD, Chevallard, 1992,1999)
  - T task (applicable to every human activity)
  - τ techniques to solve the task
  - θ technologies, explaining and justifying the techniques
  - Θ theory justifying the technologies
- Two branches
  - HM-branch: math. concepts established in the HM-courses
  - SST-branch: motivated, explained or justified by electrotechnical or physical reasoning
- * Didactic transposition process (Chevallard, 1991; Castela, 2015), indicates focus on course materials from higher engineering courses

Praxeological Analysis of a Sample Solution to a SST-Problem and Discussion

The exercise is given as follows (see handout for the sample solution):

Assuming $0 < m < 1$, thus $A(t) > 0$, (the envelope of an AM-signal is always positive), show that the above-mentioned envelope detector actually delivers a signal proportional to $A(t)$.



- The structure of the solution and the result of the praxeological analysis are shown in the graph:
  - Complex techniques become subtasks on the next level
  - Application of the extended prax. model to each level
  - Different colors for HM- and SST-branch
  - The extended praxeological model is in principle capable of discriminating different discourses
- Remarks
  - Taking the absolute value is classified as SST-technique because of electrotechnical reasoning
  - Ambitious HM-techniques in level 5 involves manipulation of infinite sums due to symmetry arguments
  - Full Fourier series expansion of the signal is not necessary to solve the task (level 4 and 5)
  - With electrotechnical reasoning: calculating the first coefficient would be sufficient because of application of low pass filter (involves only simple integral techniques)
- Hypotheses
  - Students can solve exercises more effectively and efficiently if they keep electrotechnical reasoning patterns and justifications in mind.
  - Being able to recognize the different mathematical discourses in SST-courses enables students to determine effective solution steps.

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