



What makes a problem complex?

Item difficulty and competence levels in dynamic situations

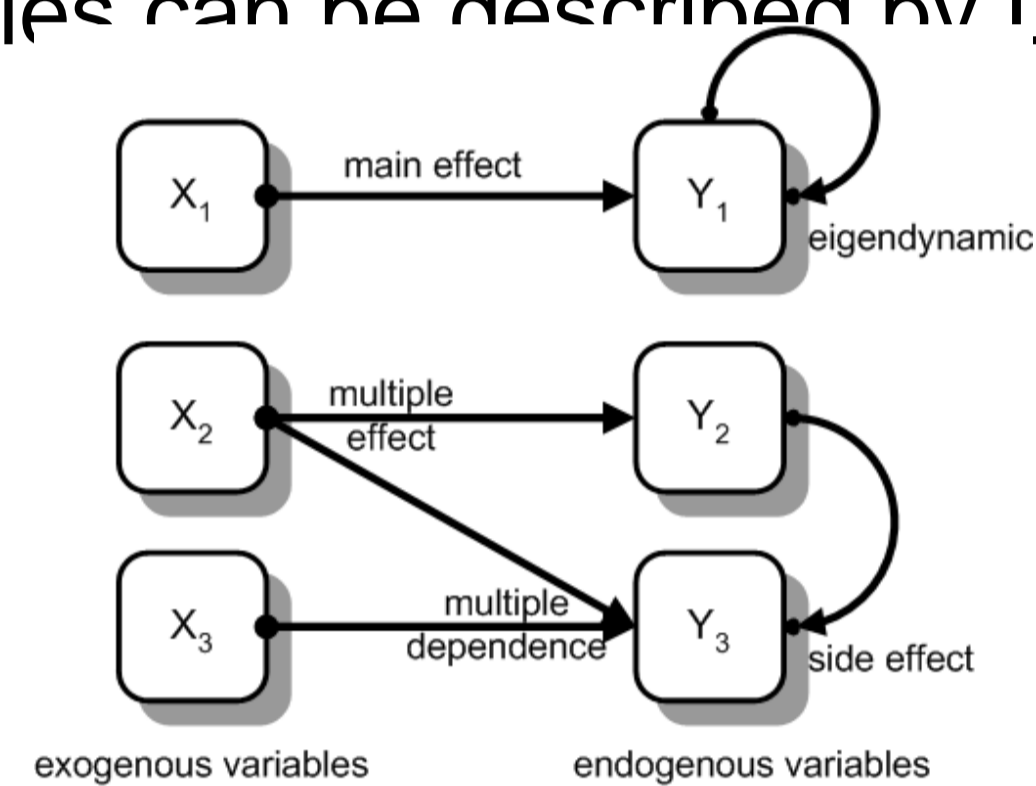
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1) Introduction

- Complex problem solving (CPS) has been an area of major interest in experimental research over the last decades. Comparatively little research has been conducted regarding theoretical frameworks and individual differences. However, CPS can be understood as cross-curricular competence.
- Here the formal framework of linear structural equation systems (LSE-systems) is chosen primarily for three reasons.

- The lack of sound theoretical frameworks calls for a different kind of framework, which LSE-systems offer formally.
- LSE-systems are easily constructed and can be varied in difficulty freely.
- Many everyday activities can be described by LSE-systems.

A typical LSE-Item is presented on the right



2) Current research

- Up to now little knowledge exists about how LSE-systems behave and which attributes cause their difficulty.
- Based on a detailed task-analysis, seven factors are identified as potentially relevant for item difficulty. Testing these item-characteristics is understood as a first step on the road to competence levels.

Item attributes in LSE-Systems

| Attribute | Explanation of attribute |
|--------------------------------|---|
| (1) Quality of effects | different causal relationships (as depicted in figure above) |
| (2) Quantity of effects | number of effects (regardless their quality) |
| (3) Strength of paths | Specifies strength of an effect (and hence its detectability) |
| (4) Number of variables | Mere number of exogenous and endogenous variables |
| (5) Variable dispersion | Specifies how closely a given number of effects clusters on the variables |
| (6) Effect configuration | Order and alignment |
| (7) Starting & target values | Self-explaining; target values influence only end. variables |

Bold attributes are focused in our current research

Design

- Within-subject design (n=50); repeated measures on all factors
- An overall of 15 LSE-systems are presented, each lasting about 6 minutes (split on two sessions)

Dependent variables

- Correctness of mental model:** Subjects are asked to draw the connections between variables as they suppose.
- Control performance:** After exploring the system extensively, subjects are asked to reach given target values on the endogenous variables as control task (results not yet available).

3) Implementation

- Software is in the process of development (currently version 1.2). Program runs stable with minor bugs.
- Authoring tool integrated in the open-access platform TAO will be released late 2008/early 2009.

Screenshot
Version 1.2

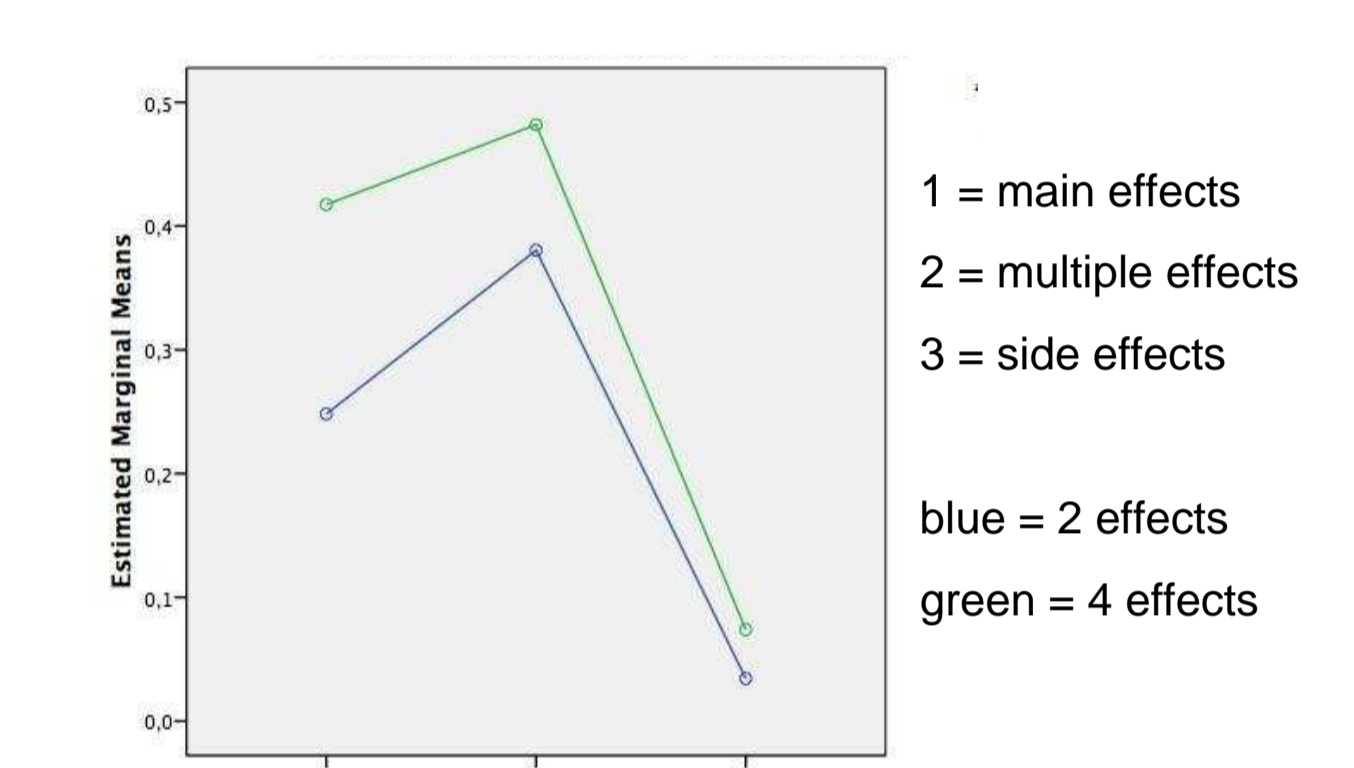
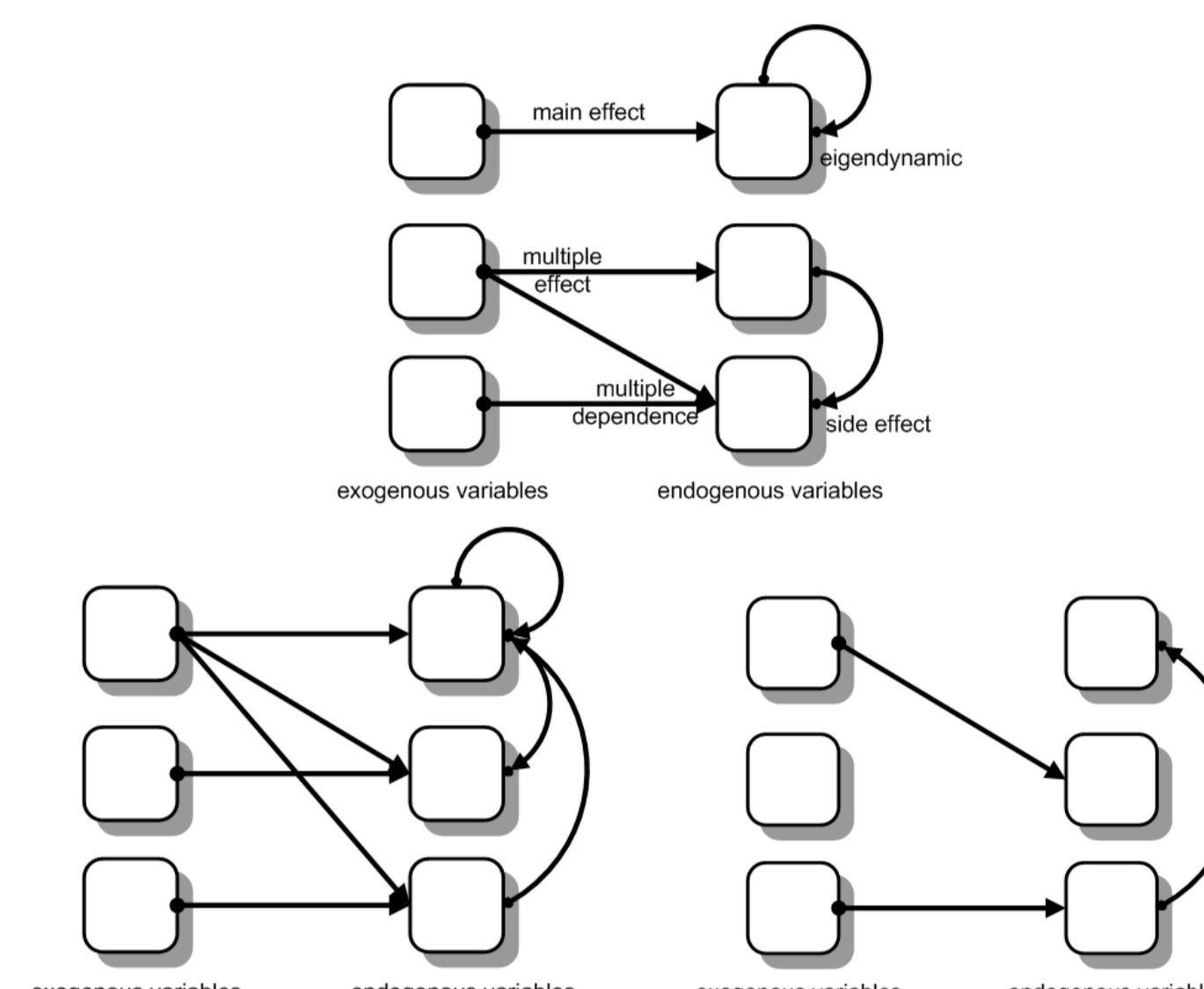
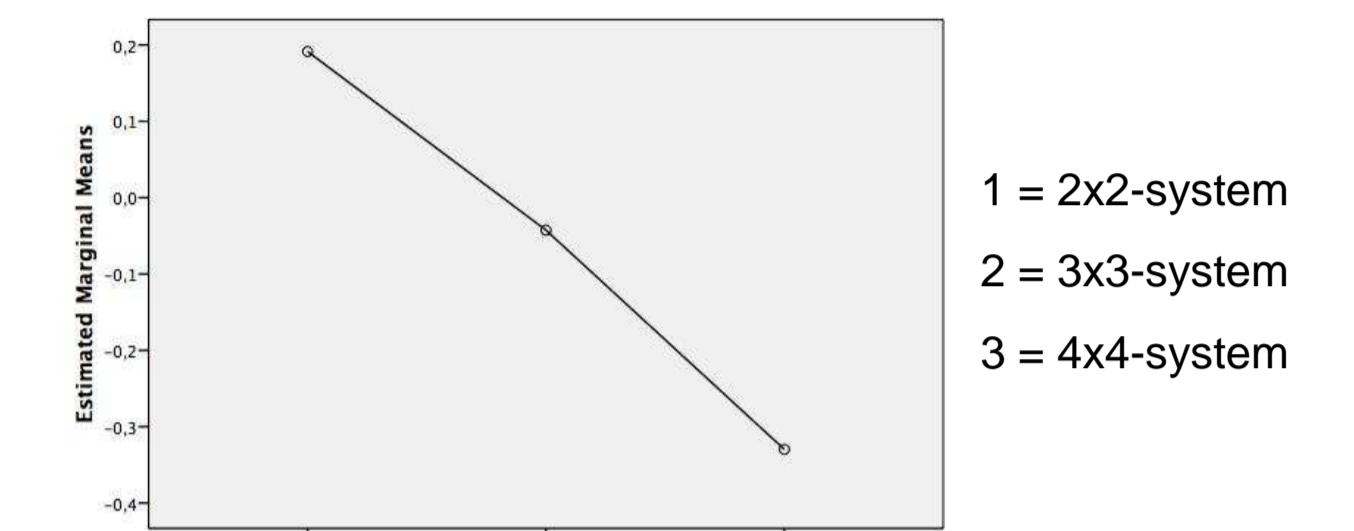
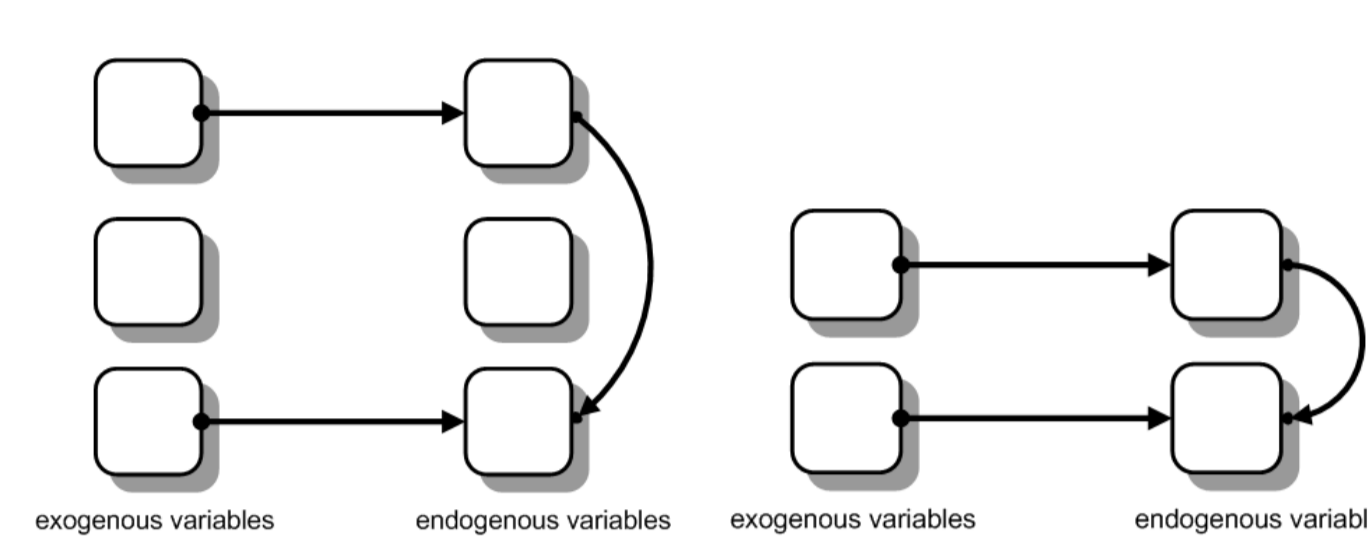


4) Results

A.) Quality of effects, quantity of effects & number of variables

- Main effects and interactions

| Independent variable | F | df _{Num} | df _{Denom} | P | Eta ² (partial) |
|--------------------------------|--------|-------------------|---------------------|---------|----------------------------|
| Number of ex. & end. Variables | 8,650 | 2 | 92 | 0,001** | 0,158 |
| Quality of effects | 18,270 | 2 | 90 | 0,001** | 0,289 |
| Quantity of effects | 2,290 | 1 | 45 | >,0,10 | 0,048 |
| Quality x Quantity | 0,500 | 2 | 90 | >,0,05 | 0,011 |



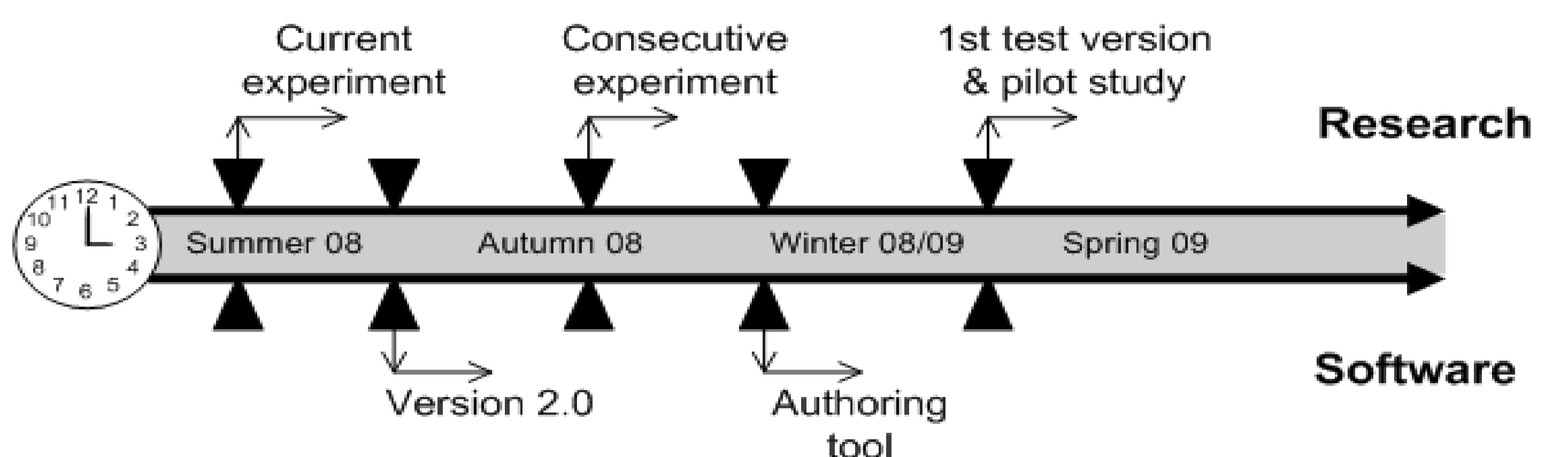
- Quality of effects: strongest main effect; side effects strongly increase difficulty
- Quantity of effects: no main effect; more effects slightly decrease difficulty
- Number of variables: main effect; more variables increase difficulty

C.) Additional results

- Further screening suggests that
 - ...there is some evidence for problems with the dependent var
 - ...correctness of mental model and control performance are only weakly correlated
 - ...subjects have considerable problems detecting side effects
 - ...there are only moderate training effects

5) Perspective

- There is need for a follow up study to learn more about item difficulty in LSE-systems (autumn/winter 2008).
- Subsequently, explorative competence levels can be derived and tested in a pilot study.



Literatur

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