An Empirical Analysis of Human Performance and Error in Process Model Development

Interdisciplinary Management Practice of RWTH Aachen University

Alexander Nielen
Denise Költer
Dr. Susanne Mütze-Niewöhner
Dr. Jürgen Karla
Prof. Christopher M. Schlick

Institute of Industrial Engineering and Ergonomics at RWTH Aachen University
Bergdriesch 27
52062 Aachen
Germany

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Agenda

- **Introduction**
- **Methods**
- **Results**
- **Future Work**

Introduction

Human-oriented aspects of process modeling

- Graphical constructs and their meaning (Rosemann et al. 2006)
- Cognitive effectiveness of visual representations (Moody and van Hillegersberg 2008)
- Expressiveness and validity of workflow aspects (van der Aalst 2003)
- Usage of labels and icons as well as activity labeling (Mendling et al. 2009)

- Absence of empirical research on human performance and error in process modeling
- Lack of empirical research on process quality (Moody 2005)

Research Questions

- How do performance and error of novices differ from those of experienced modelers?

- What practical implications can be drawn for a participatory approach in process model development?

Modeling tasks

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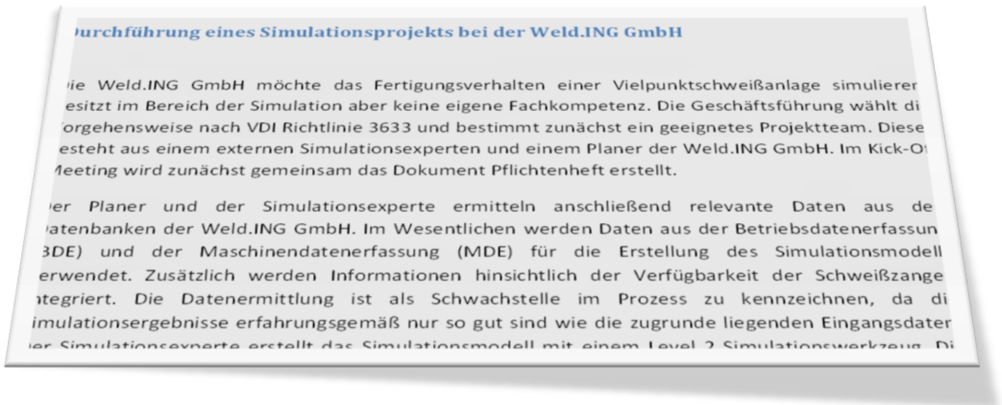
Solving of three text-based modeling tasks by developing a graphical process model

- Easy to understand language
- No specialized knowledge required
- Sample solutions for each modeling task served as a reference baseline against which the elaborated tasks of the subjects were measured

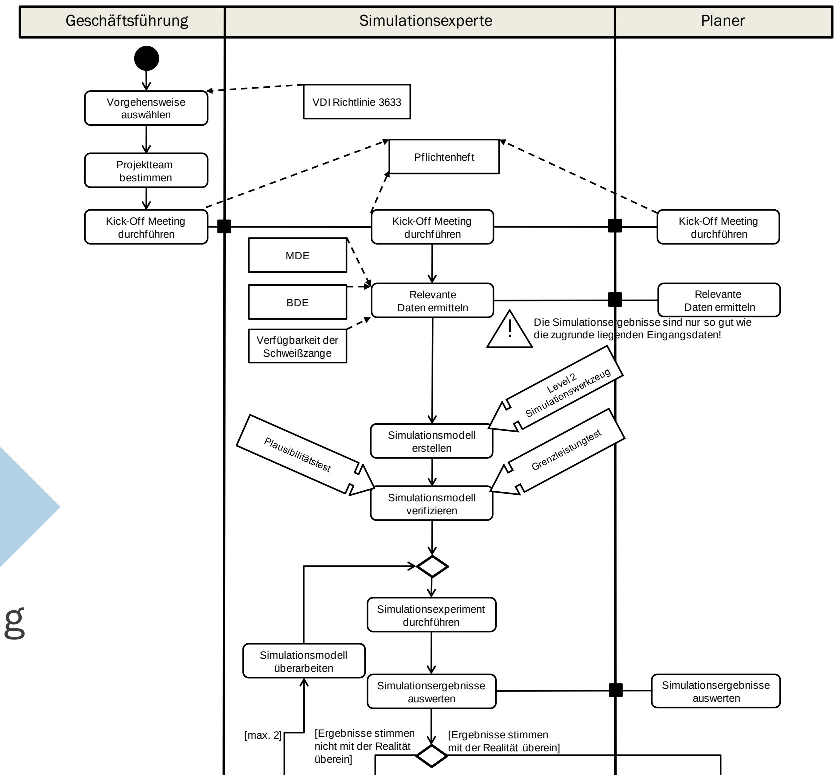


urchführung eines Simulationsprojekts bei der Weld.ING GmbH

ie Weld.ING GmbH möchte das Fertigungsverhalten einer Vielpunktschweißanlage simulierer esitzt im Bereich der Simulation aber keine eigene Fachkompetenz. Die Geschäftsführung wählt di orgehensweise nach VDI Richtlinie 3633 und bestimmt zunächst ein geeignetes Projektteam. Diese esteht aus einem externen Simulationsexperten und einem Planer der Weld.ING GmbH. Im Kick-O leeting wird zunächst gemeinsam das Dokument Pflichtenheft erstellt.

er Planer und der Simulationsexperte ermitteln anschließend relevante Daten aus de atenbanken der Weld.ING GmbH. Im Wesentlichen werden Daten aus der Betriebsdatenerfassun BDE) und der Maschinendatenerfassung (MDE) für die Erstellung des Simulationsmodell erwendet. Zusätzlich werden Informationen hinsichtlich der Verfügbarkeit der Schweißzange ntegriert. Die Datenermittlung ist als Schwachstelle im Prozess zu kennzeichnen, da di imulationsergebnisse erfahrungsgemäß nur so gut sind wie die zugrunde liegenden Eingangsdater

Task solving



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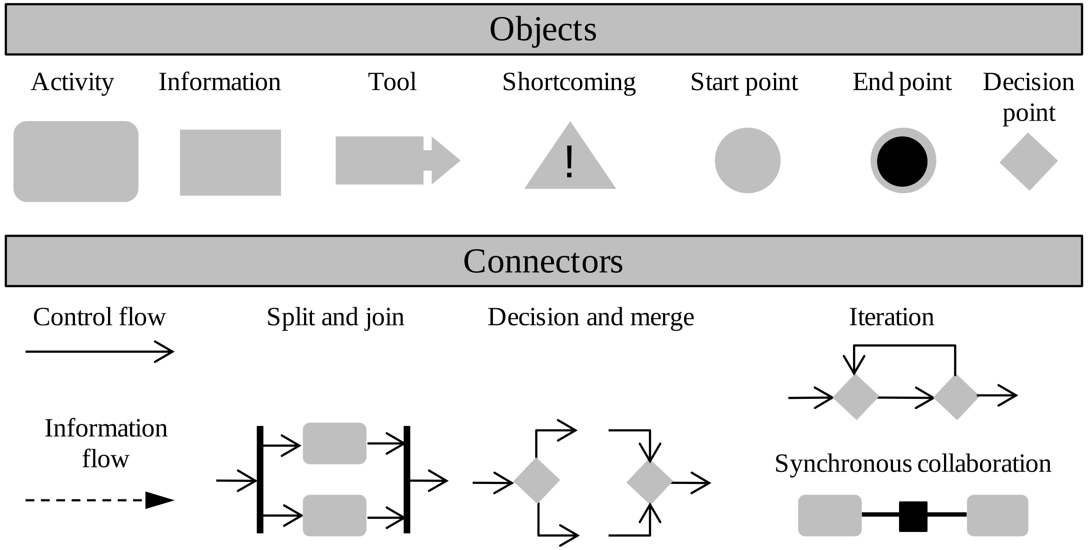
Experimental Design

Modeling tasks

- The task sequence of the modeling tasks was varied.
- The allotted time for each modeling task was not limited.

Modeling language

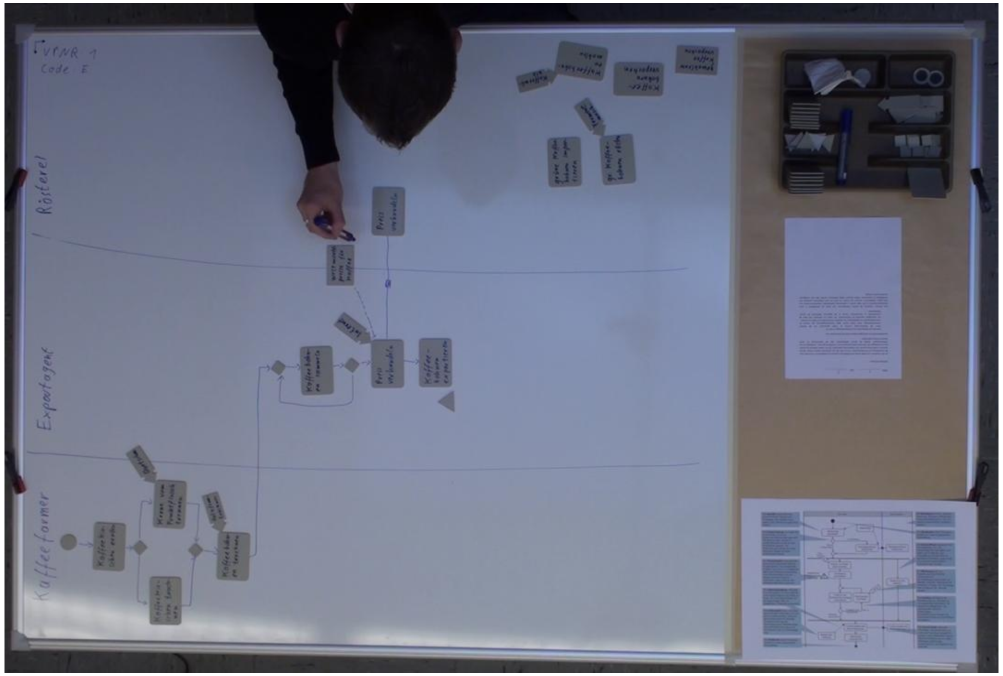
- The modeling language C3—an acronym for coordination, cooperation, and communication—was chosen (Nielen et al. 2010).
- The graphical elements primarily descended from the UML notation in 1999



Apparatus

Working area

- Use of a whiteboard mounted on a height-adjustable table
- Exclude the influence of prior experience with modeling tools



Graphical objects of C3

- Customized magnetic C3-shapes for task solving
- C3 connectors and routing elements had to be drawn on the whiteboard.
- Labeling the C3-shapes and writing on the whiteboard had to be carried out with a board marker.

Subjects

The sample of 39 subjects was divided into experienced modelers and novices (26.4 years, SD = 4.25)

Experienced modelers

- 19 research assistants from industrial engineering, business information systems, and operations research
- Prior work experience in process modeling
- At least one year affiliation to the corresponding research institute
- The subjects held an academic degree in their scientific discipline, three held a doctorate degree.

Novices

- 20 students from from psychology, sociology, and medicine
- No prior experience in process modeling

Procedure

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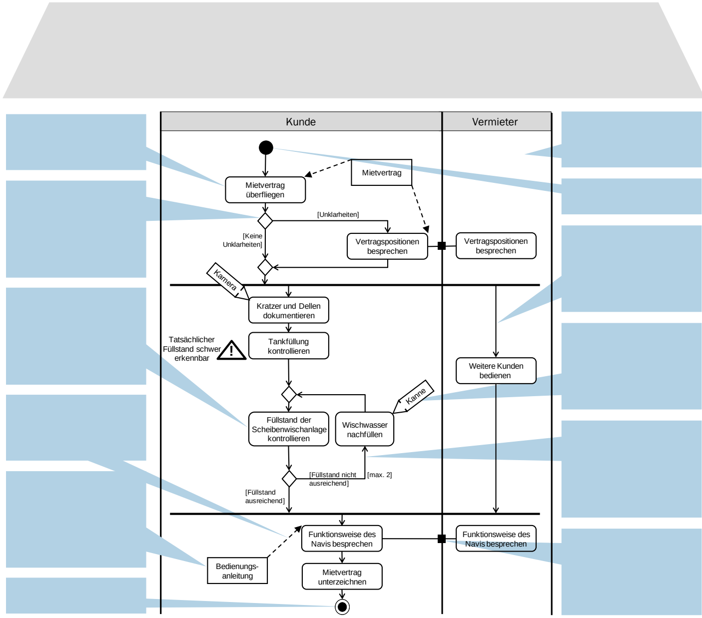
1 Collection of personal data

2 Introduction phase

3 Main experiment

- Age
- Profession
- Affiliation (scientific discipline)
- Prior experience in process modeling (level of expertise)



- Three modeling tasks
- Five minute break after the completion of each modeling task
- Unlimited time for process model development
- Video recording
- Communication with the investigator was not allowed

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Variables and Hypotheses

Independent variable

- The level of expertise of the subjects (experienced modeler versus novice)

Dependent Variables

- Model development time
- Types and frequency of errors
- Types and frequency of activity labeling style

Hypotheses

- Model development time for novices is significantly higher than for experienced modelers (H_1).
- Frequency of errors is significantly higher for novices than for experienced modelers (H_2).
- The task labeling style of experienced modelers does significantly differ from those of novices (H_3).

Statistical analysis

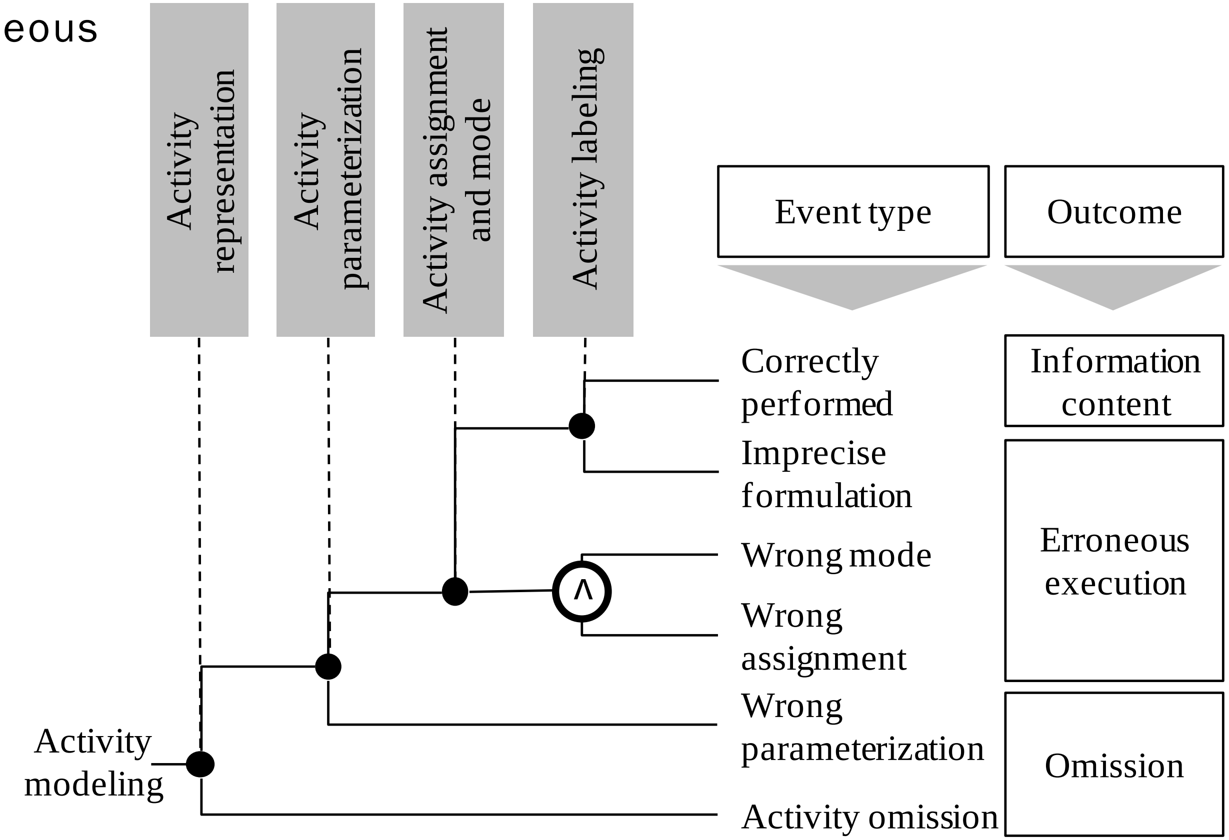
- Use of the statistical software package SPSS Version 18.0.
- The significance level for each analysis was set at $\alpha=0.05$.
- ANOVA
- Bonferroni post-hoc test
- Effect size ω^2 (Field & Hole 2007)
- Chi-square test

Human Error in Process Model Development

Error classification scheme

- Event tree for activity-level error classification
- Division of errors of omission and erroneous execution (Reason 1990)
- Parameterization of activities with:
  - Information
  - Tools
  - Shortcomings

- Assignment and mode
- Division of three activity labeling styles (Mendling et al. 2010) :
  - Object-verb
  - Action-noun
  - Other



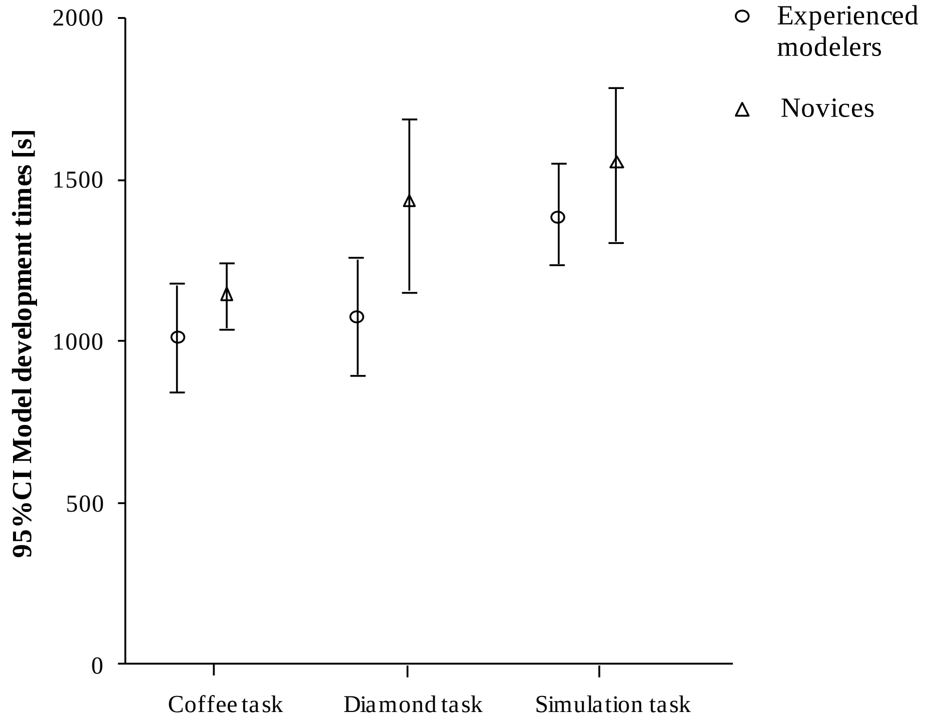
Results I

Model development time

Two-way ANOVA with repeated measures

- Significant main effect of level of expertise on model development time ($F(1,38) = 5.787$, $p = 0.021$)
- Small effect size according to Field and Hole (2007): $\omega^2 = 0{,}1$
- The first hypothesis can be accepted
- The difference is statistically significant with regard to the diamond task ($F(1,38) = 5.135$, $p = 0.029$)

Mean model development times including the 95% confidence intervals

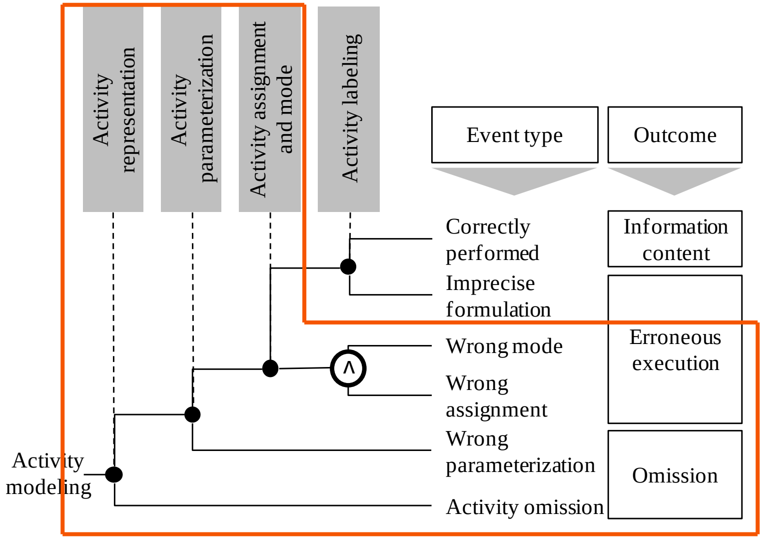


Results II

Frequency of errors

Chi-Square tests

- The statistic analysis shows a significant difference with regard to activity omissions ($\chi^2(2) = 7.080$, $p=0.008$) .
- Significant difference between the two levels of expertise with regard to activity parameterization ($\chi^2(1) = 7.080$, $p = 0.008$).
- Significant difference with regard to activity assignment and activity mode ($\chi^2(1) = 14.931$, $p = 0.000$)
- Hypothesis H_2 can be accepted



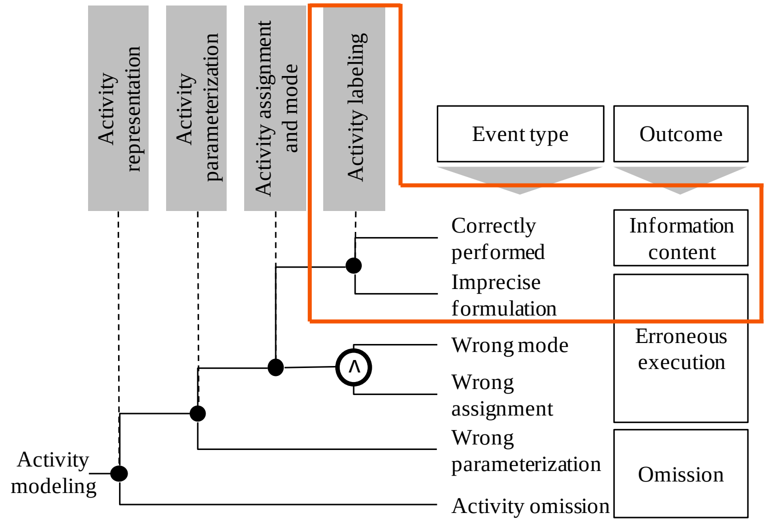
	Activity parameterization		Activity assignment and activity mode		Total number of modeled activities
	Correct execution	Wrong execution	Correct execution	Wrong execution	
Experienced modelers	563 (88.1%)	76 (11.9%)	548 (85.8%)	91 (14.2%)	639
Novices	511 (82.8%)	106 (17.2%)	477 (77.3%)	140 (22.7%)	617

Results III

Activity labeling

Chi-square tests

- Three activity labeling styles were distinguished according to Mendling et al. (2010)
- The statistical analysis shows a statistically significant difference between the two levels of expertise ($\chi^2(2) = 195.285$, $p = 0.000$) .
- H_3 can be accepted



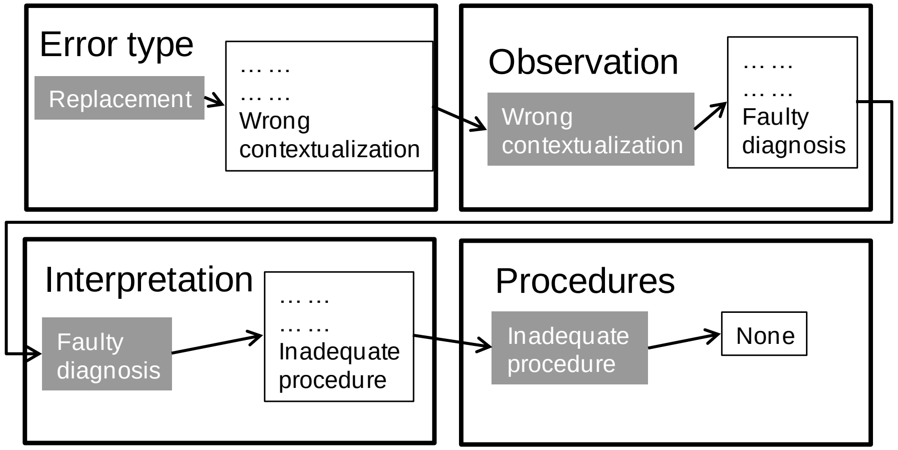
	Activity labeling style			Total number of modeled activities
	Verb-object	Action-noun	Neither	
Experienced modelers	376 (58.8%)	120 (18.8%)	143 (22.4%)	639
Novices	130 (21.1%)	281 (45.5%)	206 (33.4%)	617

Summary

- The overall results indicate that experienced modelers achieve better model quality than novices through higher consistency with the corresponding reality segment.
- The experimental study represents the preparatory work for a participatory approach in process model development
- The study accounted for a defined but limited scope of errors of omission and execution.
- The transformation of more complex work processes from corporate reality into a process model might be prone to a even higher number of errors of omission and erroneous execution.

Future Work

- Application of a second-generation human reliability assessment technique to process modeling to build up a path of possible cause-effect relationships
- Address the issue of human cognition by use of a cognitive user model
- Facilitate the computer-aided development of complex process models
- Development of more complex modeling scenarios



- Revision, update and transfer of the error classification to an empirical setting with practitioners (include peer groups)
- Application of methods and tools from cognitive systems engineering to process modeling

Thank you for your attention!

Dipl.-Wi.-Ing. Alexander Nielen
Phone: +49-241-80-99469
Mail: a.nielen@iaw.rwth-aachen.de

Chair and Institute of Industrial Engineering and Ergonomics
at RWTH Aachen University
Bergdriesch 27
52062 Aachen