A Systematic Map on Verifying and Validating Software Process Simulation Models

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Introduction

Software Process Model

Static model \[\rightarrow\] Dynamic model

\textit{change over time}

\downarrow \textit{executability}

Software Process Simulation Model (SPSM)

\textit{How to secure the model’s quality and credibility?}
Introduction

**Model Verification**

- ensures that the computerized model and its implementation are correct.

**Model Validation**

- ensures that the domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model.
Introduction

Research Objective

Aims to deliver a mapping between what model aspects need to be verified and validated by using what methods, which can help model developers to check their SPSMs.
Research Questions

• **RQ1**: What methods were ever used in model V&V for SPSM?

• **RQ2**: What aspects of model were verified and/or validated by these V&V methods?

• **RQ3**: How did software process modelers use these methods in their (simulation) modeling?
**Research Method**

**Search process**

- Complementary search — 282
- Forward snowballing — 49
- Selection — 72 papers included
Research Method

Inclusion Criteria
I-1 published until the end of 2015
I-2 written in English
I-3 primary studies on SPSM
I-4 reporting model V&V applied in the primary study

Exclusion Criteria
E-1 short papers (no more than 5 pages).
E-2 editorial, abstract, keynote, poster, and book.
E-3 opinion pieces, comments, corrections, notes, slides alone or position papers.
E-4 secondary studies summarizing the outcomes of the existing research work, e.g., roadmap, review, survey, etc.
Research Method

Data extraction

RQ1

RQ2

RQ3

Model V&V method
Aspect for V&V
Reason
Type of model
Model background
Tools
Research result
Discussion

10 Methods

- Experimental case
- Sensitivity analysis
- Comparison with actual data
- Parameter confirmation test
- Face validity
- Extreme conditions test
- Dimensional consistency test
- Comparison with other model
- Syntax test
- Questionnaire
Discussion

5 Aspects

- Syntactic Quality
- Semantic Quality
- Pragmatic Quality
- Performance
- Value
What have we done?

- Pragmatic Quality
  - Feasible comprehension (audience)
  - Feasible understandability (model)
- Value
  - Fidelity
  - Feasible test coverage
  - Robustness
- Practical utility

- Maintainability
  - Practical maintenance
Discussion

An evidence-based framework

- Syntactic Quality → Syntactic correctness
- Semantic Quality  
  - Feasible validity
  - Feasible completeness
- Pragmatic Quality  
  - Feasible comprehension (audience)
  - Feasible understandability (model)
- Performance  
  - Fidelity
  - Robustness
- Value  
  - Practical utility
Simulation tools have “Syntax check”

Syntax test

Syntactic Quality

Pragmatic Quality

Value

Semantic Quality

Performance
There are adequate real data
Actual simulation process is available
Model may not be free-of-measurement errors

Parameters have a clear range
Experienced people is available in the verification process

Parameter confirmation test
Extreme conditions test
Face validity

The model is developed based on other models
Comparison with other model

Calibration parameters is available

Comparison with actual data

There may be errors in dimensions and units
Equations may be inconsistent

There are adequate real data
Actual simulation process is available

Value

Syntactic Quality
Parameter confirmation test

Pragmatic Quality
Extreme conditions test

Semantic Quality
Dimensional consistency test

Performance

Model may not be free-of-measurement errors

There may be errors in dimensions and units
Equations may be inconsistent
Mapping

- Syntactic Quality
- Pragmatic Quality
- Semantic Quality
- Performance

Questions with ease of use are available

Face validity
Mapping

Value

Syntactic Quality

Pragmatic Quality

Semantic Quality

Performance

Extreme conditions test

Sensitivity analysis

Ensure the rationality of the model

Parameters have a clear range

There are several clear cases

Experimental case

Models may be sensitive

Uncertainties may exist in the model

Execution validity is difficult to assess
There are several clear cases:

- **Experimental case**
- **Questionnaire**

Questionnaire is available to check the satisfaction of users and participants.
## Mapping

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**Threats to Validity**

- To reduce the reviewers’ bias, each paper was reviewed by two researchers independently and we held regular meetings to discuss any disagreements until reach a consensus.
- One possible threat to validity is that the description and definition of the V&V methods vary among studies, which might introduce the reporting bias when distinguishing and classifying the V&V methods since the description and definition in some studies are vague.
- Several studies provide little detail about their V&V processes, which disables us to identify the actual V&V methods used in them.
Conclusions

- A mapping study captures 72 primary studies on SPSM that report model verification and validation.
- We identified 10 model V&V methods that were used to verify and validate 5 aspects of SPSM and how these methods were used in modeling practice.
- A systematic mapping is presented to illustrate the relationships between these V&V methods and the model aspects to be verified and validated.
- The outcomes of this research also provide reference value for verifying and validating other forms of software process models.

Future Work

- to improve the existing frameworks by proposing an updated and integrated version of the framework for model V&V based on the evidence.
- to develop checklist or guidelines of performing model V&V in process modeling and simulation studies that extend the instructive value of the model V&V framework.
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A CBT module with integrated simulation component for software project management education and training

Abstract

Due to increasing demand for software project managers in industry, efforts are needed to develop the management-related knowledge and skills of the current and future software workforce. In particular, university education needs to provide to their computer science and software engineering (SE) students not only technology-related skills but, in addition, a basic understanding of typical phenomena occurring in industrial (and academic) software projects. The objective of this paper is to present concepts of a computer-based training (CBT) module for student education in software project management. The single-learner CBT module can be run using standard web-browsers (e.g. Netscape). The simulation component of the CBT module is implemented using the system dynamics (SD) simulation modelling method. The paper presents the design of the simulation model and the training scenario offered by the existing CBT module prototype. Possibilities for empirical validation of the effectiveness of the CBT module in university education are described, results of a first controlled experiment are presented and discussed, and future extensions of the CBT module towards collaborative learning environments are suggested. © 2001 Elsevier Science Inc. All rights reserved.

Keywords: Computer-based training; Controlled experiment; Empirical study; Process simulation; Software engineering education; Software project management; System dynamics
Research method

An example

For software project management education

It should be noted that alterations of input parameters can be made at any point in time during project simulation, and that compound effects on project behaviour can be created by concurrent multiple-parameter alteration.

3.1.4. Simulation model implementation

For the implementation of the simulation model the SD modelling tool Vensim 3.0 was used (Ventana, An SD model by Vensim 3.0)

has rarely been published. Examples are Drappa and Ludewig (1999) and Madachy and Tarbet (1999).

The objective of this paper is to present concepts of a computer-based training (CBT) module for student education in software project management, to describe the design for its experimental validation, and to present first results of an empirical study. In the next section, the motivation for the research that triggered the work presented in this paper, the associated research objectives, and the current status of related work in the field...
Research Method

An example

For verifying the model accuracy they compare their model with COCOMO estimates.

For validating the model usability they applied the simulation model in several presentations and lectured this on SW project management.

4. Validation

The validation of the CBT module comprises two steps. Step 1 aims at validating the accuracy and usability of the simulation model. The accuracy of the simulation model has been proven through comparison of the simulation results with estimates of the COCOMO model. The usability has been substantiated through successful application in several presentations and lectures on SW project management. Step 2 aims at validating the effectiveness of the CBT module by submitting it to a series of controlled experiments. In the experiments, project management related knowledge

For validating the model effectiveness they realized a experiment case.
Discussion

Generating the Mapping

1. Extracting the data about V&V methods and the reported aspects verified and validated in the 72 primary studies.

2. Synthesizing all the methods mentioned in the studies into several categories.

3. Proposing revision of the frameworks based on the observed evidence.

4. Linking these methods and aspects based on the V&V relationships identified in the primary studies.