



# Software test process improvement approaches: A systematic literature review and an industrial case study



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## ABSTRACT

Software test process improvement (STPI) approaches are frameworks that guide software development organizations to improve their software testing process. We have identified existing STPI approaches and their characteristics (such as completeness of development, availability of information and assessment instruments, and domain limitations of the approaches) using a systematic literature review (SLR). Furthermore, two selected approaches (TPI NEXT and TMMi) are evaluated with respect to their content and assessment results in industry. As a result of this study, we have identified 18 STPI approaches and their characteristics. A detailed comparison of the content of TPI NEXT and TMMi is done. We found that many of the STPI approaches do not provide sufficient information or the approaches do not include assessment instruments. This makes it difficult to apply many approaches in industry. Greater similarities were found between TPI NEXT and TMMi and fewer differences. We conclude that numerous STPI approaches are available but not all are generally applicable for industry. One major difference between available approaches is their model representation. Even though the applied approaches generally show strong similarities, differences in the assessment results arise due to their different model representations.

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## 1. Introduction

It is a well-known fact that software testing is a resource-consuming activity. Studies show that testing constitutes more than 50% of the overall costs of software development (Harrold, 2000); and with the increasing complexity of software, the proportion of testing costs will continue to rise unless more effective ways of testing are found. One main focus of investigation in industry, for reducing cycle time and development costs, and at the same time increasing software quality, is improving their software testing processes (Collofello et al., 1996). However, state of practice in testing is sometimes ignored or unknown in software development organizations as testing is done in an *ad hoc* way (Bertolino, 2007) without designated testing roles being defined.

In the past, several software test process improvement (STPI) approaches have been developed to help organizations in assessing and improving their testing processes. To improve software testing pro-

cess of a specific organization, an appropriate approach has to be found which suits their specific needs and the methodologies. Obviously, the expectations of the companies differ depending on, e.g., internal goals, maturity awareness and process knowledge. In our understanding, there is a need of consolidating available STPI approaches, along with their specific characteristics, in order to assist organizations in selecting the most appropriate approach.

This paper has an overall goal: to support industry in finding appropriate STPI approaches that fulfill the specific needs of an organization. This goal is fulfilled by two objectives: (1) to identify and evaluate existing STPI approaches and (2) to assist organizations in selecting and comparing the most appropriate STPI approaches. First, a general evaluation is applied to all approaches found by a systematic literature review (SLR). Second, a more specific and detailed evaluation is performed on two approaches using an industrial case study. The first part starts by finding a set of STPI approaches available in literature. Then these approaches are evaluated by a set of criteria. Besides providing information about the identified STPI approaches useful for further research, this evaluation constitutes the basis for the selection of approaches for the second part, i.e., the industrial case study. The second part starts with a pre-selection of applicable approaches based on the results of the first evaluation. A presentation of the pre-selected approaches and results of a voting scheme at

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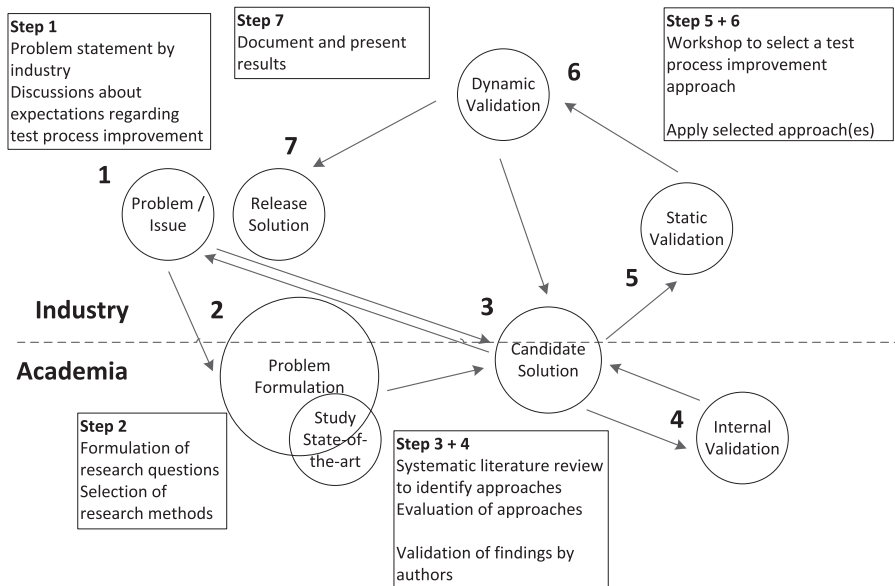


Fig. 1. Technology Transfer Model (originally published in Gorschek et al. (2006)).

the organization resulted in two approaches which are then applied in parallel at the organization. The selected approaches are examined and evaluated in more detail regarding their specific content. Finally, after application of both approaches at the organization, their results have been compared.

The rest of the paper is organized as follows: The next [Section 2](#) describes the overall design of this paper. [Section 3](#) presents the related work. [Section 4](#) discusses the design of the SLR including the research questions, search strategy, study selection and quality assessment, data extraction, evaluation criteria for approaches and validation of results. [Section 5](#) outlines the results of the SLR including the characteristics of 18 STPI approaches and listing approaches that are generally applicable in industry. [Section 6](#) discusses the design of the case study while [Section 7](#) discusses the case study results. The outcomes of this paper are discussed in [Section 8](#) while the validity threats are discussed in [Section 9](#). The major conclusions from this study appear in [Section 10](#).

## 2. Overall study design

The design of this study is based on a model for technology transfer between academia and industry known as the Technology Transfer Model (Gorschek et al., 2006). The underlying theme of this model is that mutual cooperation is beneficial for both academia and industry. Researchers receive the opportunity to study industry relevant issues and validate their research results in a real setting. Practitioners, on the other hand, receive first-hand knowledge about new technology which helps them in optimizing their processes. A graphical overview of our study design based on the Technology Transfer Model is shown in [Fig. 1](#) which has been adapted to the specific needs of our industrial partner.

The different steps in the design of this study based on the Technology Transfer Model are described as follows:

**Step 1 – Problem/issue.** A problem statement given by industry and discussions with company representatives about expectations and needs identify the problem as the unavailability of sufficient knowledge about the practiced testing process and a potential for process improvements.

**Step 2 – Problem formulation.** A preliminary study of the problem indicates the availability of software test process improvement (STPI)

approaches providing frameworks and models to assess the current state of a testing process and to identify improvement suggestions. Based on this knowledge and industrial needs, the research questions along with appropriate research methodologies are identified.

**Step 3 – Candidate solution.** A systematic literature review (SLR) is conducted to identify available STPI approaches. The characteristics of these approaches are identified and an exclusion process provides a selection of generally applicable STPI approaches.

**Step 4 – Internal validation.** The findings from the SLR are partly validated by a number of authors of the primary studies identified by the SLR.

**Step 5 – Static validation.** The preselected generally applicable STPI approaches are presented in industry. The \$100 method, a cumulative voting method (Rinkevics and Torkar, 2013), is used to select approaches to be applied in the organization.

**Step 6 – Dynamic validation.** The selected STPI approaches are applied in the organization. To assess the testing process, interviews are conducted and the data is analyzed based on the instructions given by the STPI approaches. Afterwards, the assessment results are compared based on a prior mapping of the content of the approaches.

**Step 7 – Release solution.** The results of the study are collected, documented and being presented in academia and industry.

Based on this overall design we decided to conduct the study by using two research methods, a systematic literature review (SLR) and a case study. The SLR covers Steps 3 and 4 of the model, candidate solutions and their characteristics are identified by the SLR and the results are internally validated. Steps 5 and 6 of the model, the static and dynamic validation, are explicitly covered by the case study. Moreover, we present in [Table 1](#) the research goal, objectives, associated research questions, research method(s) used and relevant sections of the paper.

## 3. Related work

Software process improvement (SPI) frameworks involve assessment and improvement of software development processes. The need for such frameworks is motivated by the assumption that quality of a product is dependent on the process used to develop it. There

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