SPI is Dead, isn't it? Clear the Stage for Continuous Learning!

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***Abstract*—Software process improvement (SPI) is around for decades, but it is a critically discussed topic. In several waves, different aspects of SPI have been discussed in the past, e.g., large-scale company-level SPI programs, maturity models, success factors, and in-project SPI. It is hard to find new streams or a consensus in the community, but there is a trend coming along with agile and lean software development. Apparently, practitioners reject extensive and prescriptive maturity models and move towards smaller, faster and continuous project-integrated SPI. Based on data from two survey studies conducted in Germany (2012) and Europe (2016), we analyze the process customization for projects and practices for implementing SPI in the participating companies. Our findings indicate that, even in regulated industry sectors, companies increasingly adopt in-project SPI activities, primarily with the goal to continuously optimize specific processes. Therefore, with this paper, we want to stimulate a discussion on how to evolve traditional SPI towards a continuous learning environment.**

***Index Terms*—SPI, software process improvement, continuous learning, survey research**

I. Introduction

Software process improvement (SPI) includes a number of tasks, e.g., process scoping, assessment, design, realization, and continuous improvement [1], [2]. For decades, companies are on the quest for ways to implement SPI right. Prescriptive SPI models, like CMMI [3] and ISO/IEC 15504 [4] were introduced to determine a company's capability and maturity. On the one hand, these models were criticized [5]–[7]; but on the other hand, Horvat et al. [8] found SPI relevant to companies of all sizes. Much effort was spent on developing smaller SPI models, e.g., [9], [10], and the ISO/IEC 29110 [11] targeting small and very small companies was also devised. With the rise of the agile methods, *agile maturity models* appeared, e.g., [12], [13], and in [14], we found that "new", yet barely evaluated, SPI models are constantly proposed.

In a nutshell: SPI is not new and many SPI models are available to help companies improve their processes. The number of SPI models is increasing and, still, many SPI initiatives fail for several reasons, like shortage in resources or organizational "immune reactions" [15]–[17]. With the methods for agile and lean software development, new instruments to reflect on and improve a process just-in-time have become available.

In this paper, we review two studies, which were conducted in 2012 (Germany; [18]) and in 2016 (Europe; [19]) for the practitioners' perception on SPI and the different implementations they use. As these studies span four years, we also study if there is a trend away from "classic" SPI. We hypothesize that classic SPI is increasingly pushed into the background while the emerging agile and lean practices around the *continuous learning* paradigm gradually change SPI into a more project-integrated activity.

The rest of this paper is organized as follows: In Section II we briefly discuss related work and Section III outlines the research design. In Section IV present the results and we discuss our findings and conclude the paper in Section V.

II. Related Work

SPI is subject to research for years. Numerous studies have been published, e.g., on motivators and de-motivators of SPI-implementing companies [17], [20], SPI success factors [21]–[24], and a multitude of different SPI models [9], [10]. However, according to [14], most of the SPI-related studies (approx. 38%) propose new SPI models and few papers only (three out of 769 reviewed papers) provide replication studies, while 174 papers report on a single cases only and another 136 report on multi-case studies. Besides those papers criticizing (prescriptive) SPI models, a critical discussion on SPI and the change of SPI in times of agile and lean software development is to the best of our knowledge not available. Hence, with this paper, we aim to stimulate a discussion on SPI and what SPI will look like in future.

III. Research Design

Our research is based on two previously conducted studies [18], [19], which serve as data sources. In this section, we briefly introduce these two studies and we describe how we re-analyzed the two datasets and aggregated the results. The overall research design is illustrated in Fig. 1.

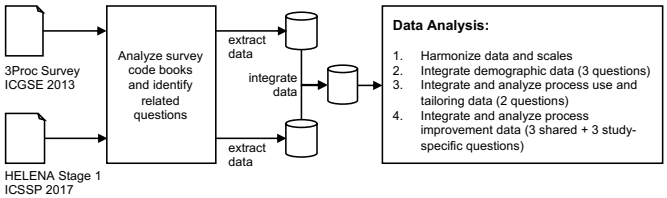

Fig. 1. Overview of the research design

A. The Two Studies from Germany & Europe

This study uses the *3Proc-Survey* (conducted in Germany, 2012) and the first stage of the *HELENA Study* (conducted in

Europe, 2016). Both studies aimed at collecting data about process use in general and further related aspects. Among other things, both studies include questions about SPI.

a) 3Proc-Survey: The *3Proc-Survey* [18] consisted of 33 questions (six for metadata, nine on expectations, 13 on the state of practice, and five on SPI). The goal of this study was to determine the current state of practice in development and test processes, and in SPI. The state of practice was compared to the expectations practitioners had regarding these three process types. Data was collected from October 2012 to January 2013, and the study yielded 51 data points.

b) HELENA Stage 1: The first stage of the *HELENA* study [19] consisted of 25 questions (seven for metadata, seven on process use, four on process and standards use, four on SPI, and three on experience). Parts of the HELENA questionnaire are based on the 3Proc-Survey. The goal of this study was to determine the use of *hybrid development methods*, and if such methods emerge from external standards or explicit SPI programs. Data was collected from May to June 2016, and the study yielded 69 data points.

B. Objective & Research Questions

The overall goal of this study is to understand the role of SPI and its implementation in today's software business. By re-analyzing and comparing data from two previously conducted studies, we aim to answer our guiding research question: *Has classic SPI been replaced by project-integrated SPI activities based on the continuous learning paradigm?*

C. Data Collection & Analysis

For both studies, raw data is publicly available. We used these datasets and, together with the codebooks that describe the questionnaires' structure, we selected in total 11 questions to analyze demographics, the general process use (specifically the process tailoring practices), and the SPI practices implemented by the surveys' participants (Fig. 1). We used all data points of the two studies, i.e., 120 data points in total (3Proc: n=51, HELENA: n=69).

Since the two populations are relatively small and are not expected to be representative (region-specific data collection), we only use descriptive statistics in the data analysis. As the HELENA study "inherited" some questions from the 3Proc-Survey, for this study, we selected those questions dealing with process tailoring and SPI, i.e., questions concerned with process adaptation. Nevertheless, we had to harmonize the data, e.g., harmonization of the categories for company sizes and industry sectors, answers for tailoring behavior, and the use of SPI programs. Furthermore, to make ratings comparable, we normalized the 6-point Likert scales used in the 3Proc-Survey to the 5-point Likert scales as used in HELENA.

D. Threats to Validity

The study at hand is scoped to one specific region: Germany and Central Europe. Therefore, and as we aim to stimulate a discussion, we use this study as a starting point, but we *do not* claim any generalizability of the study results. Nevertheless, while conducting the study, we tried to mitigate the different threat to validity. *Construct Validity:* Both datasets are based on personal opinion online surveys. Hence, there is a risk that the participants misunderstood the questions and, furthermore, in both studies, only subsets of development and SPI methods were subject to study. *Internal Validity:* We reuse publicly available data from studies. We had to select and integrate questions and data. To mitigate risks regarding the data selection and integration, one researcher did the selection, integration and the initial analysis, while the second researcher checked all these steps, confirmed the raw findings and provided an initial interpretation. *External Validity:* Our results *are not*, and *are not meant to be*, generalizable. However, we hope to stimulate a discussion such that future research can provide generalizable findings.

IV. Results

We present the results of our study by providing an overview of the studied populations in Section IV-A, providing isights about the customization of processes in projects (Section IV-B, before we study the ways of implementing SPI initiatives in the participating companies in Section IV-C.

A. Study Population

For both studies, the majority of the participants is located in Germany (3Proc: 64.7%, HELENA: 34.8%) or in Europe (3Proc: 100%, HELENA: 79.7%). Figure 2 provides an overview of the countries from which we have data points available in the dataset.

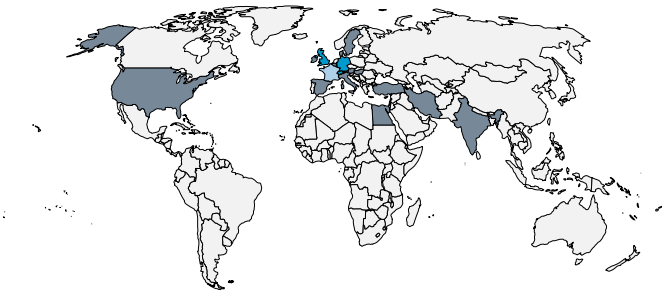

Fig. 2. Overview of the countries from which participants provided data (light blue: 3Proc only, blue: 3Proc and HELENA, dark grey: HELENA only; note: for the 3Proc survey, only 38 out of 51 participants provided a country)

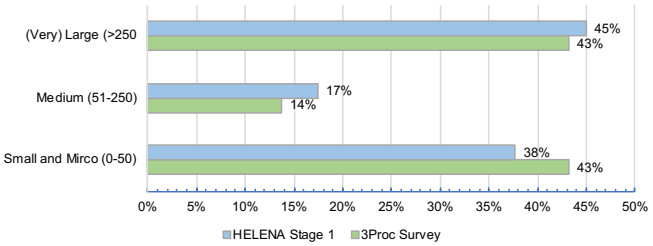

Fig. 3. Summary of the company sizes of the study participants (by study, harmonized categories for company size)

TABLE I
HARMONIZED OVERVIEW OF THE PARTICIPANTS' INDUSTRY SECTORS

Industry Sector	**3Proc** n=51	**HELENA-1** n=69
Software Development	31.4	68.1
System Development (HW/SW)	7.8	23.2
Consulting (Project Management)	51.0	18.8
Consulting (Process Management)	66.7	15.9
IT Consulting, Training & Services	3.9	17.4
Research and Development	3.9	18.8
Logistics, Telecommunications, Automotive, Insurance, Public Sector, Finances	≤ 2.0	≤ 1.5
Other	3.9	2.9

Across both studies, participants came from companies of similar size as shown in Fig. 3. Most participants were affiliated with large/very large companies, followed by micro and small companies and, finally, medium-sized companies. Figure 3 shows, that the distributions regarding the company size are comparable. Table I provides an overview of the participants' industry sectors (based on a harmonized presentation resulting from multiple-choice questions). The table shows that the majority of the HELENA study participants is active in the software and system development domain (68.1% and 23.2%) while the majority of the 3Proc-Survey participants comes from different consulting domains.

B. Process Customization in Projects

The first aspect of interest is the way software processes are used in the participants' companies, specifically if there are standard processes/standard process portfolios used or if participants are free to select any process. Table II provides an overview showing an indifferent picture: while 52.2% of the HELENA participants have standardized processes, 44.1% of the 3Proc participants have the freedom to select their individual process on a per-project basis.

TABLE II
DOES YOUR COMPANY DEFINE A COMPANY-WIDE STANDARD PROCESS FOR SOFTWARE AND SYSTEM DEVELOPMENT?

Answer	**3Proc** n=34	**HELENA-1** n=69
Yes, all projects are operated according to the same (potentially customized) standard process (portfolio)	35.3	52.2
Each business unit has its own approaches/ standards, which all projects of this unit have to follow	20.6	20.3
Each project can individually select the process to be used	44.1	27.5

The second aspect is the way the project processes are selected, i.e., how the process is selected, when and by whom? Table III provides a consolidated view. In the 3Proc-Survey, more than a half of the participants (56.8%) state that a project manager tailors a process in the beginning of a project, but 29.7% also mention that the process is adapted in response to the project situation if necessary. The results from HELENA are slightly different: only 33.9% of the participants state that the process is selected at the beginning and 35.7% state to have specific rules how to conduct a tailoring. However, more than a half[1] (53.6%) of the HELENA participants state that the process is adapted on-the-fly if necessary, and 25% state that such a adaptation happens in response to customer demands.

TABLE III
HOW IS THE PROJECT-SPECIFIC DEVELOPMENT APPROACH SELECTED?

Answer	**3Proc** n=37	**HELENA-1** n=56
A project manager tailors the process in the beginning of a project	56.8	33.9
Project-specific process selection and tailoring follows defined rules	32.4	35.7
Project-specific process selection and tailoring is supported by tools	5.4	23.2
Specific practices and methods are selected during the project (if necessary)	29.7	–
Specific practices and methods are selected in the project on demand	–	53.6
Specific practices and methods are selected according to customer demands	–	25.0
The process is not tailored at all	16.2	21.4
Other	0.0	5.4

TABLE IV
IS YOUR DEVELOPMENT APPROACH CONTINUOUSLY IMPROVED?

Answer	**3Proc** n=37	**HELENA-1** n=69
Yes, we implement an explicit improvement program based on standards, such as CMMI, ISO/IEC 15504 and/or a non-standardized descriptive approach	18.9	29.0
Yes, we sporadically conduct improvement activities, but do not implement a continuous improvement program	27.0	13.0
No, we do not implement any process improvement program	27.0	18.8
Yes, process improvement is part of the development process (process-integrated improvement, independent from project management)	27.0	37.7

Another interesting observation in Table III is the share of participants stating that they do not tailor their processes at all. The table shows an even increasing share of participants selecting this option (3Proc: 16.2% and HELENA: 21.4%).

C. SPI Program Implementation

Asking the participants if and how they implement an SPI program, the first notable outcome is that 27% (3Proc) and 18.8% (HELENA) of the participants state to not implement any SPI program (Table IV). A prescriptive SPI model is implemented by 18.9% and 29%. The most interesting finding is that in the 3Proc-Survey, 27% of the participants state to follow a project-integrated SPI approach and, for HELENA, even 37.7% state to implement SPI as part of the development

[1]To allow for a better differentiation, we kept these answer option separated as in the HELENA study the reason for on-the-fly adaptations is also available.

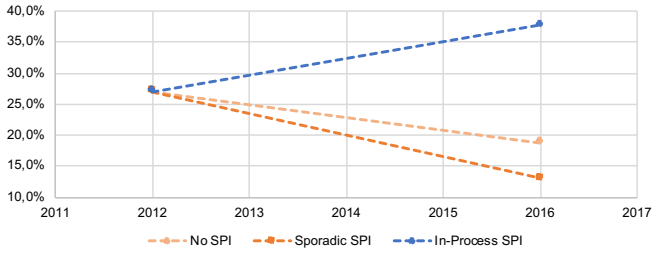

Fig. 4. Aggregated perspective of SPI practices for both studies (2012 and 2016) focussing on no SPI at all, sporadic SPI only and in-process SPI

process. Figure 4 focusses on this finding. The figure shows that, in the 3Proc-Survey, about a quarter of the participants each implemented SPI sporadically only, as project-integrated SPI or not all. In the HELENA survey, we observe a change: the number of participants implementing SPI only sporadically or not at all is decreasing while the number of participants that implement SPI as project-integrated activity increases, which indicates a more continuous learning-based SPI approach.

TABLE V
HOW IS THE COMPLIANCE OF THE DEVELOPMENT PROCESS ASSESSED?

Answer	**3Proc** n=35	**HELENA-1** n=40
Internal/external project assessments	25.71	77.50
Constructive measures	57.14	40.00
Analytical measures	48.57	30.00
Compliance is not controlled	22.85	7.50

Table V summarizes the assessment practices as reported in the two studies. Remarkable is the shift towards internal and external assessments, whereas this shift might also be caused by the different study populations and their respective main industry sectors (Table I). Remarkable, in the 3Proc-Survey, 51.4% of the participants stated to not collect data at all and another 34.3% collected and analyzed data manually [18].

Finally, we investigate drivers for implementing an SPI program. At this point, both studies have incompatible data structures. The 3Proc-Survey asked the participants for their *expectations regarding a continuous improvement programm* while the participants of the HELENA study were explicitly asked for their *improvement goals*. The data on the SPI-related expectations is given in Table VI. Agreement regarding a statement is expressed using a 5-point Likert scale (1=no agreement to 5=full agreement). Table VI shows that the 3Proc-Survey participants expected support for *learning about strengths and weaknesses*. They agreed that an SPI model can help improving the product quality, but, they also expected the implementation of a prescriptive SPI model too demanding.

The HELENA data in Table VII shows the participants expecting support for different optimization tasks when implementing SPI, e.g., improved flexibility, efficiency, and effectiveness. Also, participants considered improved capabilities in terms of the different planning dimensions, e.g., time and cost, relevant. Knowledge transfer across projects, that is, *learning*

TABLE VI
EVALUATE THE FOLLOWING STATEMENTS (3PROC SURVEY, VALUES ARE RE-SCALED TO A 5-POINT LIKERT SCALE)

Statements to be evaluated:	**n**	**Median**	**Mean**	**MAD**
An improvement process significantly improves the product quality	37	3.33	3.26	0.79
Deploying and implementing an improvement process is very time consuming and cost intensive	37	2.50	2.85	1.11
Implementing an improvement process on the basis of a maturity model is very demanding	37	3.33	3.38	0.72
Maturity models are easy to tailor according to company needs	36	3.33	3.07	1.19
Maturity models that we know are not easy to tailor acc. to our company needs	36	3.33	3.12	1.34
An improvement process helps us to learn about our strengths and weaknesses	37	3.33	3.59	0.62
An improvement process is an important argument for sales	37	2.50	2.52	0.87

TABLE VII
WHAT ARE THE GOALS OF YOUR IMPROVEMENT PROGRAM? ($n = 56$, VALUES ARE GIVEN AT A 5-POINT LIKERT SCALE)

Goal	**Median**	**Mean**	**MAD**
Better client involvement	4.00	3.73	0.77
Better knowledge transfer across projects	4.00	3.95	0.62
Better planability (e.g., cost, time)	4.00	4.33	0.66
Better reuse of project artifacts	4.00	3.69	0.84
Better tool support	4.00	3.71	0.97
Certifying the company	3.00	2.98	1.19
Compliance with a standard	4.00	3.29	1.26
Increased effectiveness	5.00	4.31	0.78
Increased efficiency	5.00	4.36	0.74
Increased flexibility	4.00	4.00	0.76
Increased product quality	4.00	4.27	0.71
Increased project speed	4.00	3.93	0.79

across projects, found a relatively high agreement, yet, was not among the top-5 ranked SPI goals. That is, learning activities are important, but they are focused on the current project.

V. DISCUSSION, CONCLUSION & FURTURE RESEARCH

In this paper, we reviewed two previously conducted studies [18], [19] for the purpose of investigating the current role of SPI. Our findings indicate a shift in the way SPI is conducted towards a project-integrated SPI based on continuous learning.

Discussion: comparing the two datasets, the most remarkable finding is illustrated in Fig. 4. While the "sporadic SPI" and "no SPI at all" numbers decrease, the number of practitioners implementing a *project-integrated SPI* increases. This is also reflected by an increasing number of participants stating to assess their process through (internal) project assessments (Table V). Furthermore, we see an increased interest into the different in-project learning activities (Table VII). Table IV shows that also the number of participants implementing the "classic" prescriptive SPI models has been increased—if this results from the different industry sectors represented in the different studies, however, requires further

research. Table IV also shows the increasing number of in-project SPI activities. Data suggests that both styles of implementing SPI go hand in hand, i.e., classic SPI frameworks seem to be enriched by continuous learning practices. Hence, we argue that "classic" SPI is not (yet) dead, but is increasingly complemented with continuous learning activities. Other than described in higher CMMI-levels, we argue that the (continuous) learning does not emerge from a specific SPI requirement, but is introduced through the increasing number of agile and lean development methods [25]. Furthermore, we argue that notably the project-integrated SPI activities help solving project-specific problems fast. However, such problems are connected to specific project characteristics, i.e., an improvement goal can be literally everything, and, thus, a transfer to the organization level is often not reasonable. Also, organizational changes happen quickly. Hence, classic organization-focused SPI, which often focuses on measurement instruments and common process frameworks, could be considered too slow and too abstract to solve specific problems. Still, there are company-wide SPI programs, e.g., in the context of regulation and standardization. Yet, such initiatives are rather compliance programs rather than improvement programs.

Conclusion: We conclude that SPI has changed. Classic SPI is still present and relevant, but the two reviewed studies indicate a trend towards project-integrated SPI activities emerging from the increasing number of agile and lean methods that bring *continuous learning* to the table.

Furture Research Directions: Our findings show that more research is required and we motivate the community to revisit SPI. Instead of criticizing prescriptive SPI models and continuously "discovering" new success factors and spawning "new" SPI models [14], we suggest to put more effort into studying *continuous learning*. Such studies should not be limited to core development activities only. Rather, it should be discussed how "formal" SPI models and continuous learning can be (better) balanced, notably in times of hybrid methods [19], [25] as used for rapid application development and in industry sectors becoming digitalization targets. For instance: How can continuous learning as part of agility integrated with dependable system development in regulated domains? How can findings from continuous learning be integrated in larger SPI initiatives? How can project-specific learnings be transferred to other projects? What are proper metrics and how to collect metrics efficiently and effectively? What is the role of standards and how can standards contribute to implementing continuous learning strategies?

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