

# System and Software Processes in Practice: Insights from Chinese Industry

Peng Zhou<sup>1</sup>, Arif Ali Khan<sup>1\*</sup>, Peng Liang<sup>2</sup>, Sher Badshah<sup>3</sup>

<sup>1</sup>College of Computer Science and Technology, Nanjing University of Aeronautics and Astronautics, Nanjing, China

<sup>2</sup>School of Computer Science, Wuhan University, Wuhan, China

<sup>3</sup>Faculty of Computer Science, Dalhousie University, Nova Scotia, Canada

{daniel666, arif.khan}@nuaa.edu.cn, liangp@whu.edu.cn, sherbadshah46@gmail.com

## ABSTRACT

Software development processes play a key role in the software and system development life cycle. Processes are becoming complex and evolve rapidly due to the modern-day continuous software engineering (CSE) concepts, which are mainly based on continuous integration, continuous delivery, infrastructure-as-code, automation and more. The fast growing Chinese software development industry adopts various processes to achieve potential benefits offered in the international market. This study is conducted with the aim to investigate the trends of processes in practice in the Chinese industry. The survey questionnaire data is collected from 34 practitioners working in software development firms across the China and the results highlight that iterative and agile processes are extensively used in industrial setting. Furthermore, agile and traditional approaches are combined to develop the hybrid processes. Most of the participants are satisfied using the current development processes, however, they show interest to continuously improve the existing process models and methods. Finally, we noticed that majority of the software development organizations used the ISO 9001 standard for process assessment and improvement activities. The given results provide preliminary overview of processes deployed in the Chinese industry.

## CCS CONCEPTS

• **Software and its engineering** → **Software development methods**.

## KEYWORDS

Software processes, Process Improvement Standards, Survey, Chinese industry

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## 1 INTRODUCTION

The proper software development processes and methods significantly increase the business value of the software systems [20]. Software processes are a set of activities that aim to develop the system in a formal and control way. Common software development processes are categorized across traditional and agile approaches. The well know traditional and agile approaches include waterfall, Scrum, Kanban, Extreme Programming (XP), Dynamic Systems Development Method (DSDM), and Feature Driven Development (FDD) [10]. More generally, both approaches are combined (hybrid) to perform large-scale software development [10]. Moreover, software process improvement (SPI) standards and models are used to effectively manage the activities involved in processes. It helps to increase productivity, the development speed, and decrease the total cost [21].

Software development processes are well-explored in literature [1, 24]. Various primary studies are conducted to discuss the significance of processes in different domains, such as large scale agile development [13], industrial assessment of waterfall model [18], scaling agile in globally distributed environment and hybrid processes in various countries [5, 9, 17, 22, 23]. However, industrial investigations of software development process practices in China are still missing. Chinese software development industry makes remarkable improvements in the last decade and play a key role in boosting the country economy [15]. The total number of software development firms in China were more than twofold in 2014 as compared to 2009. In 2017, the Chinese software industry and related businesses made over 687.5 billion dollars revenue [15]. Similarly, more than 6 million people are employed in software industry in the year 2017. Moreover, the number of employees in the software industry increased by over 3% in 2018 and this growing trend is still continue [15].

Industrial studies conducted in different countries [2, 5, 10, 16, 19] motivated this research work to explore software processes in the Chinese industry, which can help to understand the views and opinions of Chinese practitioners regarding the software processes used in the industrial setting. This work provides interesting insights to better understand the trends of software development processes in the Chinese industry. Moreover, the study focus on understanding the SPI models and standards adopted in the Chinese industry. It will shed light on the significance of commonly used SPI models for managing and improving software process activities.

The paper consists of total six sections. Section 2 provides a detail overview of the related work. The research methodology is presented in Section 3. The study findings against the research

questions are presented in Section 4 and the implications are discussed in Section 5. The threats to the validity of the study findings are highlighted in Section 6 and Section 7 concludes this work with future directions.

## 2 RELATED WORK

Software development processes are continuously evolving because of the complex, rapid and iterative development environment.

Marko et al. [3] proposed the practice-driven software development process. They mentioned that practitioners usually do not follow rigorous development processes, because such processes are more part of academic research. They further focus on exploring the software development processes in practice for specific project domain. The study highlighted the significance of research work that investigate the real-world adoption of software development processes and their industrial impact.

David et al. [4] compared the practices of agile software development processes adopted from 2010 and 2012. They mentioned that concepts of agile methods are widely adopted for years before 2010. Since then, the implementations of agile practices are apparently increased and agile development received significant industrial attention.

Similarly, Narendra et al. [12] conducted an industrial survey and assessed the satisfaction level of the practitioners with respect to agile practices. The study findings reveal that most of the practitioners consider agile development processes more effective. They further mentioned that agile methods reduce workload stress and increase user satisfaction. Agile practices gradually replace traditional development processes and become a standard approach.

In recent years, the concept of hybrid development processes emerges and becomes more common in industrial setting. Marco et al. [10] discussed that more generally the hybrid development processes consider traditional software development approaches as a framework, however, agile practices are used in some specific phase of the software development life cycle. Moreover, Jil et al. [9] mentioned that the integration of both agile and traditional processes improve the delivery time, response to change and increase overall productivity.

The hybrid processes in practice are different across the world. Various studies related to the HELENA project are conducted in different countries [2, 5, 10, 16, 19], however, still no study publish that specifically focus on the Chinese industry. China is one of the world-leading software industries and there is a demanding need to explore the significance of software processes in the Chinese industry.

## 3 RESEARCH METHOD

The research method used to conduct this study is thoroughly discussed in this section. Research questions are described in Section 3.1. The structure of the survey instrument is reported in section-3.2. Finally, the data collection and analysis approaches are presented in section-3.3. Figure 1 generalize the research method steps.

### 3.1 Research questions

Software development processes in practice are significantly different in the way they are discussed in the academic research [3].

We targeted the Chinese software industry to investigate and understand the real-world picture of software development processes. The following research questions (RQs) are developed in order to achieve the given objective:

- RQ1 Which software development processes and practices are adopted in the Chinese industry?
- RQ2 Which hybrid processes are used in the Chinese software industry?
- RQ3 Do current development processes satisfy the software development practitioners?
- RQ4 Which SPI models and standards are used in the Chinese industry?

### 3.2 Survey instrument development

The survey questionnaire is developed to collect industrial data and address the given RQs. The data were collected online using the Tencent questionnaire platform <sup>1</sup> and the questionnaire samples both English and Chinese language versions are provided in Appendix A. Moreover, the overview of the survey questions (short version) is also provided in Appendix A. The survey instrument was developed following the HELENA project questionnaire structure [11]. The first and second authors developed the structure and content of the questionnaire. The third and fourth authors evaluated the preliminary survey instrument and updated based on their understanding. Finally, all the authors participated in the consent meeting and finalized the questionnaire based on the mutual discussion and agreement. Moreover, the questionnaire was externally evaluated by inviting three qualitative software engineering research experts. The invited experts thoroughly reviewed the content of the questionnaire and provided their suggestions which are mostly related to the clarity and understandability of the survey questions. Finally, the questionnaire is revised based on their suggestions and developed both Chinese and English language samples (Appendix A).

The estimated time to complete the questionnaire takes 10 to 20 minutes, moreover, it is clearly mentioned in the questionnaire that the collected data will only be used for the research purposes and not be shared with third party under any circumstances.

### 3.3 Data collection and analysis

The survey data were online collected from 5th February to the 2nd of March 2021. The simple random sampling approach [8] is followed to collect online data from multiple software development firms across the China. Random sampling provides an equal opportunity to approach the large targeted population, as in this case the Chinese software industry is one of the world's leading and big industry. The most common social media platforms in China i.e., WeChat and QQ are used to approach the potential population and collect the survey data. We invited 41 practitioners to participate in the survey study. The first and second authors manually reviewed the received responses (i.e., 41) and revealed that 4 are incomplete and 3 participants mentioned that they are not familiar with the software development processes. We excluded total 7 responses and considered the remaining 34 for the final data analysis. Additionally, we publicly provided the dataset of the survey study to

<sup>1</sup><https://wj.qq.com/>

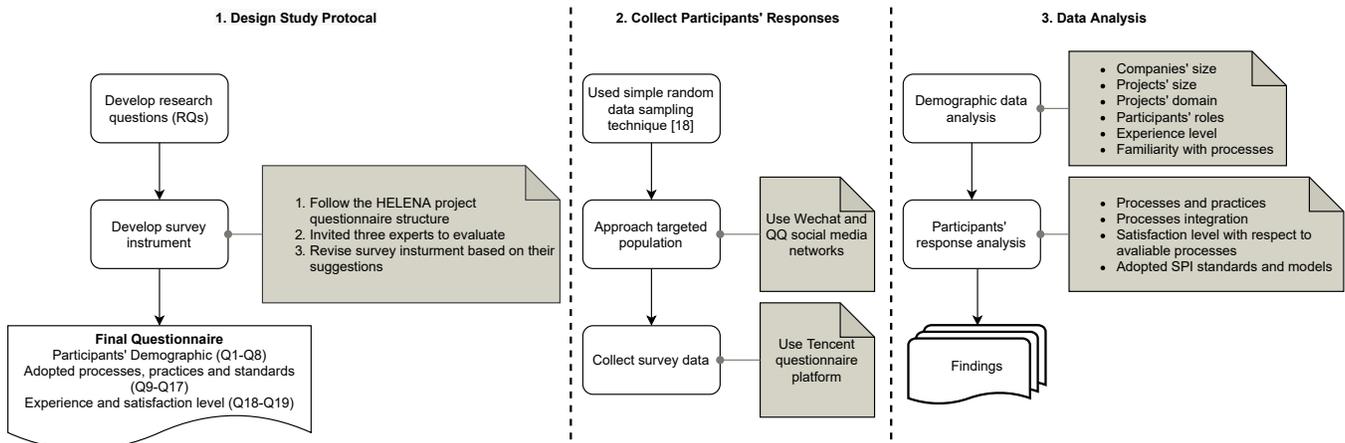


Figure 1: Research method steps

enable others to verify and replicate this research work [25]. The complete research design of this study is provided in 1.

The descriptive analysis approach is used to analyze the survey data. It gives an opportunity to compare the data variables based on the Likert scale [8]. More narrow, the RQ1 data is analyzed by classifying the software processes into three major types, i.e., agile, traditional, and generic. The classification of processes is based on the framework provided by Marco et al. [10]. Agile consists of Scrum, Lean, Nexus, Kanban, ScrumBan, DSDM, Safe, LESS, XP, DevOps, Crystal, and FDD. Similarly, the traditional processes are Waterfall, V-Model, PRINCE2, Spiral Model, RUP, and SSADM. The rest are considered in the generic category, i.e., Iterative Development, Model Driven Architecture (MDA), Personal Software Process (PSP), Domain-Drive Design (DDD), and Team Software Process (TSD). Generic processes are abstractions of the process that can be used to explain different approaches to the software development. They can be adapted and extended to create more specific processes e.g., agile and traditional. The mentioned processes are provided in the questionnaire.

We used the following rules define by Marcelo et al. [14] to define the hybrid methods:

- Agile + Generic = Agile;
- Traditional + Generic = Traditional;
- Agile + Traditional = Hybrid;

Based on the above given combination, the generic process could be either traditional or agile depending on the context. This rule is used to answer RQ2, that specifically focus on hybrid processes. RQ3 has been addressed by evaluating the degree of satisfaction of the survey respondents regarding the current processes used in industrial domain. Finally, the SPI standards and models are evaluated based on the survey responses to answer the RQ4.

## 4 RESULTS

In this section, we summarize the survey study results. Initially, a demographic overview of the findings is provided and then respectively answer the research questions of the study (RQ1-RQ4).

### 4.1 Study population

The survey results are based on the 34 complete and valid responses received from practitioners working in the Chinese software industry. The given data sample might not be strong enough to present the entire population of the industry; however, it provides interesting findings that encourage towards expanding this study in the future and exploring the Chinese industry with a large data sample. Results include 2 micro-sized, 3 small, 13 medium, 4 large, and 12 very large projects. Moreover, the size of the organizations are categorized as micro-sized (3), small (5), medium (7), large (6), and very large (13). The project and organization size classification are based on the criteria given in the HELENA project questionnaire [11]. Most of the projects in the survey study are from very large size organizations. Figure 2 further demonstrates that a large number of projects are from cloud services provision and mobile applications industry. On the other hand, aviation and, logistics and transportation are noticed to be the less frequently mentioned industrial domains.

Further considering the survey population, different roles of the participants are observed. Most of the survey participants are developers (20, 58.8%) in comparison to the others i.e., team manager (4), tester (3), product owner (2), analyst/requirements engineer (2), and quality manager (2). Note that the survey participants do not include C-level management (e.g., CEO, CTO, CIO) and agile coach (e.g., Scrum Master). Additionally, we investigated the experience level (*Software development experience in years*) of the participants. The results shows that the experience level of the respondents mostly range from 3 to 5 years, i.e., 2 participants (5.8%) with less than one year of experience, 5 with 1-2 years (14.7%), 17 respondents (50.0%) with 3-5 years of experience, 8 participants (23.5%) with 6-10 years and 2 participants (5.8%) with more than ten years of professional experience. Furthermore, we summarized the survey participants degree of familiarity with the software processes and found that most of them have good knowledge and understanding except very few.

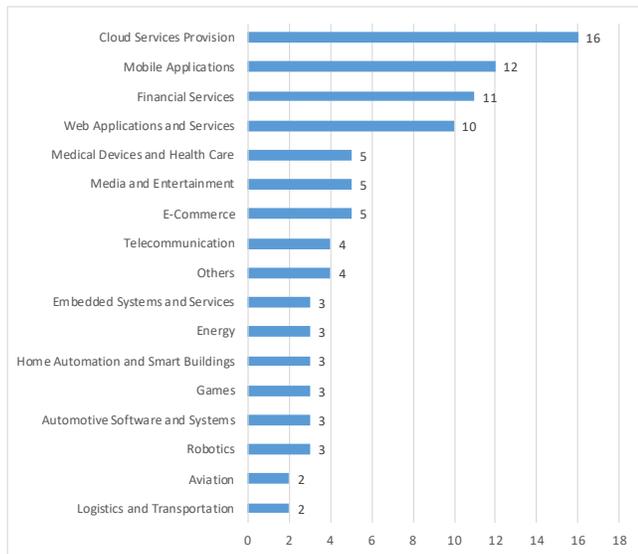


Figure 2: Project type

### 4.2 RQ1: Software processes and practices

The aim of RQ1 is to highlight the current trends of software development processes in Chinese industry. The questions, Q14 and Q15 of the questionnaire are developed to get insights of the participants regarding the software development frameworks and methods used in Chinese industry, as well the adopted development practices. Both Q14 and Q15 are measured against the following scale:

- We do not use it: (do not know it or do not know if we use it or we never use it);
- We use it moderately: (we sometimes use it or we rarely use it);
- We use it extensively: (we always use it or we often use it);

Figure 3 and Figure 4 respectively show the frequency distribution of the survey respondents based on the above given scale. Frameworks and practices listed in Figure 3 and Figure 4 are reference to HELENA project questionnaire [11]. We noticed that Kanban is the most frequently used agile approach in Chinese software industry followed by DevOps (Figure 3). Similarly, PRINCE2 is the most common framework in the traditional software development approaches category. Moreover, the practitioners consider Waterfall model as the second most significant traditional development approach. Finally, the iterative development is highlighted as the most prevalent generic process framework used in the Chinese industry. It has high frequency of occurrence with respect to both agile and traditional methods (Figure 3). The industrial significance of iterative processes are also discussed in different other studies. HELENA project studies [5, 10, 17] reported that iterative development is the most frequently adopted approach.

Similarly, the most significant software development practices used in Chinese industries are: Code Review, Release Planning, Design Review, Coding standards, and Iteration Planning. Automated Unit Testing, Continuous integration (CI) and Continuous deployment (CD) (Figure 4).

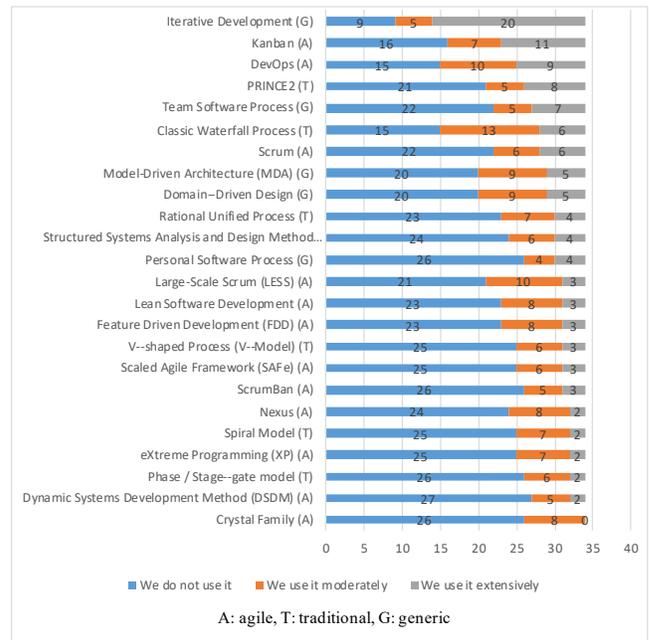


Figure 3: Software development frameworks and methods used in China

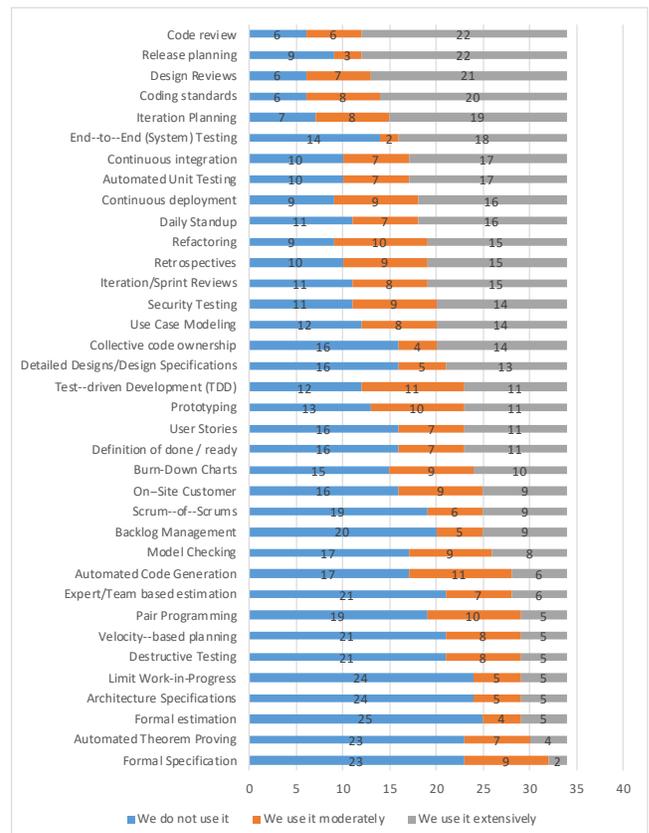


Figure 4: Development practices used in China

## Key Findings of RQ1

**Finding 1:** Iterative development is the most common process and this finding is inline with software processes surveys conducted in other countries [5, 10, 17].

**Finding 2:** Kanban is considered as the most frequently adopted agile approach by the survey participants and PRINCE2 is the most common traditional process method.

**Finding 3:** Code Review, release planning, design review, coding standards, and iteration planning are respectively the top most five significant software development practices (Figure 4).

### 4.3 RQ2: Processes integration

The aim of RQ2 is to study the industrial trends of integrating software development processes. The survey data is analyzed (Table 1) based on the integration concepts discussed in Section 3.3.

**Table 1: Software processes integration**

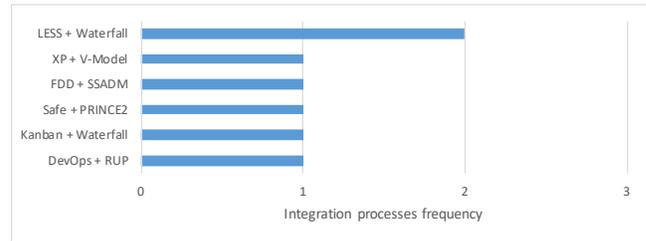
Combination	Definition	n=18	%
Agile	agile + generic	8	44.4
Traditional	traditional + generic	3	16.7
Hybrid	agile + traditional	7	38.9

The results given in Table 1 illustrate that only (18, 52.9%) of the survey respondents consider the combination of development processes. We noticed that agile and generic processes are frequently (8, 44.4%) combined to develop software systems. The second most common processes are hybrid (7, 38.9%), where both agile and traditional models are integrated to perform the software development activities. Finally, only (3, 16.7%) of the survey participants consider the combination of traditional and generic methods. In summary, the given results reveal that the software development firms in China most commonly combine the agile and generic methods to manage the development activities. More specifically, we focus on the combination of agile and traditional approaches used in the hybridization process (Figure 5). From the results, it is evident that two survey respondents consider the integration of LESS and Waterfall approaches to develop the hybrid development processes. The other hybrid processes mentioned by the survey participants are (Xp+V-Model), (FDD+SSADM), (SAFe+PRINCE2), (Kanban+Waterfall) and (DevOps+RUP) (Figure 5).

**Table 2: Causes of integrating different frameworks**

Option	n=18	%
Planned as part of a process improvement program	10	55.6
Evolved from past projects over time	12	66.7

Moreover, the participants were asked the causes of integrating different processes in their respective organizations. The results



**Figure 5: Hybrid processes adopted in China**

shows that 56.6% of the respondents formally integrate the processes as part of a process improvement program, and 66.7% stated that the integration evolved progressively based on the previous projects experience reports (Table 2).

## Key Findings of RQ2

**Finding 4:** More than half (18, 52.9%) of the survey participants integrated different development processes in their projects. Particularly, 7 participants used hybrid processes by combining both agile and traditional approaches. The integration of LESS and Waterfall have highest occurrence (2) in all hybrid processes.

**Finding 5:** (10, 55.6%) participants mentioned that process integration is part of their process improvement program, however, 12 (66.7%) respondents indicated that they scale the development activities towards process integration based on the experience of previous projects.

### 4.4 RQ3: Practitioner Satisfaction level

The aim of RQ3 is to assess the user satisfaction level of existing development processes adopted in the Chinese software industry. To make stronger observations, we developed the survey question (Q18), which consist of seven statements assessment criteria, where each statement is evaluated against the following Likert scale:

- Disagree: (strongly disagree or somewhat disagree);
- Neutral: (neither agree nor disagree);
- Agree: (somewhat agree or strongly agree);

Figure 6 illustrate the survey participants viewpoints regarding the currently deployed processes. More than half of the participants are satisfied with the available processes adopted in the Chinese software industry. The first statement "i.e. available processes provide strong support" given in Figure 6 demonstrates that (21, 66.6%) participants show positive agreement with the support provided by the existing industrial processes, however, 4 participants submitted their feedback with disagreement. Similarly, (21, 66.6%) responses are in agreement with the statement "i.e. existing processes helps to develop the quality product" (Figure 6). Interestingly, the assessment results for statement five reveal that (18, 50.0%) participants are positively interested in updating and improving the current development processes. It opens a call for future research that specifically focus on improving the available software processes and their practices.

**Table 3: Four Survey participants provided disagreement feedback**

Respond Number	Role	Experience	Familiar with software process
41	Developer	1-2 years	moderate
29	Analyst/Requirements Engineer	< 1 year	little
20	Tester	3-5 years	little
14	Project/Team Manager	6-10 years	moderate

Furthermore, we discussed the disagreement responses submitted by the four participants regarding their satisfaction with the existing processes (statement-6). The details of the participants are summaries in Table 3, which reveal that they have not strong understanding of the software processes and lack of processes knowledge might be the reason that they submitted disagreement responses.

Additionally, the open-ended questions are also provided to get additional information from the survey participants regarding the current processes. One of the survey respondents (project manager) mentioned that "*software processes are same poles of magnet to team members, where team members always repel them*". It highlights that still part of industrial practitioners in China are not interested in considering the existing processes for managing software development activities. Moreover, two participants mentioned that the current processes consist of formal activities, however, the real-world implementation of these processes brings no significant benefits.

Overall, the survey results indicate that majority of the participants satisfied with the current processes no matter the role or experience level.

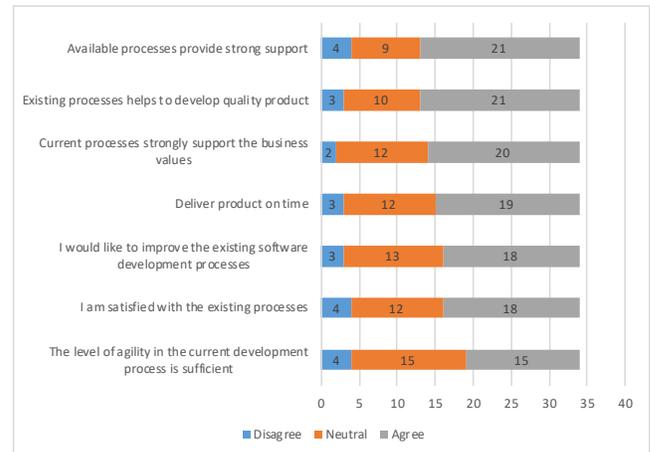
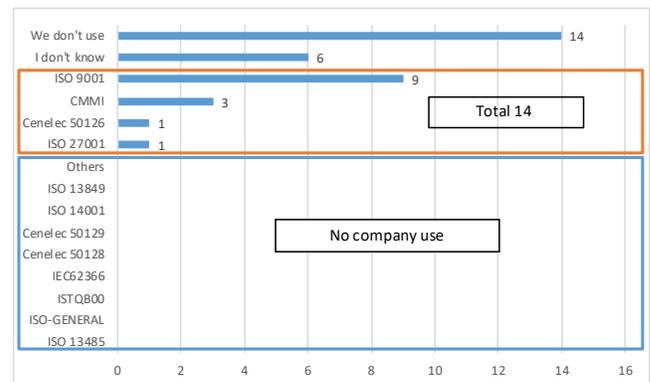
#### Key Findings of RQ3

**Finding 6:** Most of the participants are satisfied using the existing software development processes with respect to support, quality, delivery, business values and agility (Figure 6).

**Finding 7:** 18 (53.9%) of the survey respondents indicated that they are interested to add further improvement in the available processes. This is in line with the general understanding that continuous improvement should be part of development processes and this concept is considered in various process assessment standards and models.

#### 4.5 RQ4: Software process improvement (SPI) standards and models

A list of most common SPI standards and models are provided to the survey participants for selecting the one they used in their respective organizations. The results reveal that 14 (41.2%) of the participants do not use SPI standards and models. Similarly, 6 (18%) participants have no knowledge of the standards they used. Moreover, only 14 (41.2%) respondents selected the specific SPI standards and models (Figure 7). We noticed that ISO 9001 is the most commonly and frequently adopted standard in Chinese industry.

**Figure 6: User satisfaction level****Figure 7: Software Process Improvement (SPI) standards and models used in China**

Similarly, the second most significant model is CMMI, which is selected by 3 (21%) participants. ISO 9001 is a family of quality management standards; however, ISO 9001 could be used by any type of organization (i.e., small, medium, large) irrespective to the domain [7]. It consider the very core quality management principles, including customer focus, top management motivation, process and continuous improvement. Based on the above discussion, we could conclude that the strong quality management features provided by ISO 9001 make it best choice for all kind of organizations regardless of size and application domains.

## Key Findings of RQ4

**Finding 8:** ISO 9001 is the most common process assessment and improvement standard.

**Finding 9:** We noticed that 14 (41.2%) of the survey participants did not use any process improvement standard or model. This finding uncovers an interesting research gap to answer the question: Why SPI standards and models are not common in major part of the Chinese software industry?

## 5 INDUSTRIAL AND ACADEMIC IMPLICATIONS

This study is conducted to encapsulate the insights and perceptions of practitioners regarding software processes in China. The survey participants provided the understanding of processes in practice in their respective organizations. The findings of the study uncover the most common process methods, frameworks, practices, hybrid processes, and SPI standards. The study results provide a future roadmap to the software development organizations planning to deploy formal processes.

Moreover, the available literature is explored to understand software processes discussed in industrial setting. We noticed that, previously no studies are published that discuss various software processes aspects in the domain of Chinese industry. This study portrays a clear picture of existing software processes trends, limitations and demands. The findings provide a preliminary knowledge base of processes for future research in Chinese industry.

## 6 THREATS TO VALIDITY

Following are the potential threats to the validity of the study findings.

### 6.1 Construct validity threats

Construct validity refers to the relation between the concepts behind the experimentation and observations [6]. The observed results based on our experimentation might not correspond to the effect we think we are measuring [6]. The structure and content of the survey instrument could be potential threats to the construct validity of the study. The construct validity threats are mitigated by discussing the pilot questionnaire with software engineering research experts (Section 3.2). Moreover, the most relevant HELENA project [11] questionnaire sample was used as guidelines to finalize the survey instrument of this study. Additionally, all the authors continuously participated in the development of the questionnaire.

### 6.2 Internal validity threats

Internal validity threats refer to the factors that cause the outcomes but are not in control or measurable [6]. In this study, the factors that affect the internal validity of study findings include coverage bias (i.e., the job level distribution of the survey participants may not be balance), and item errors (i.e., survey respondents may not consider some questions intentionally or unintentionally). We improved the internal validity by manually filtering the responses containing the above given factors.

### 6.3 External validity threats

External validity refers to the generalization of the study findings [6]. The study results are only based on a data sample of 34 survey participants and the given sample size might not be big enough to generalise the study findings. However, we plan to extend the study by conducting industrial survey with a larger data sample. Moreover, it is worth mentioning that several relevant software process management studies are conducted in the similar sample size range e.g., [5, 17].

## 7 CONCLUSIONS AND FUTURE WORK

The aim of the study is to explore the practice of the existing software processes and SPI standards in Chinese industry. The industrial data is collected from 34 practitioners working across China. We would like to highlight that the given data sample is not big enough to generalise the study findings for the entire Chinese software industry. However, the results provide some interesting insights in comparison to previously conducted relevant studies in the range of similar data sample [5, 17, 23].

Based on the survey data and analysis, we noted that iterative development (generic), Kanban (agile), and DevOps (agile) are respectively the three most common processes adopted in Chinese industry. The findings shed light on the significance of agile approaches and reveal that one of the world's leading software industries (i.e., Chinese) are moving from traditional process towards agile. Agile methods are the modern-day industrial demand.

The agile methods further reveal that more than fifty percent participants followed the processes integration concepts. Based on the integration criteria discussed in Table 1, we noticed that majority of the firms combine agile and generic processes (agile + generic) to perform development activities. The second most common integration approach is hybridization, where agile and traditional processes are integrated based on the project nature. In general, we could conclude that agile is the most significant industrial approach even in the integration environment.

Moreover, the survey results reveal that ISO 9001 is the most common software process improvement (SPI) standard. Importantly, 41.2% of the respondents mentioned that they do not use any process improvement standard or model. These results illustrate that using SPI standards is not a common trend in Chinese industry. Moreover, it uncovers a novel gap to further explore SPI practices in Chinese industry.

In the next step, we plan to extend this study and collect data from a large sample of the targeted population. The large data sample will provide a clear picture and more generalizable findings of software processes and practices adopted in the Chinese industry. Moreover, we will conduct a survey study to know what academia deliver to students regarding software processes. The long-term plan is to comparatively analyze the results of both industrial and academic survey and identify their differences and commonalities. These results will address the question: what industry really demand from academia?

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## Appendix A SURVEY QUESTIONNAIRE

- Browse the following link to access the overview of survey questionnaire (short version) sample: <https://tinyurl.com/2jx6c7c9>;
- Browse the following link to access the full version of the questionnaire in English: <https://tinyurl.com/9p3632ym>;
- Browse the following link to access the Chinese version of the questionnaire: <https://tinyurl.com/nj4ewpa8>;