

Experience Report: An Industrial Experience Report on Test Outsourcing Practices

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Abstract—Nowadays, many companies contract their testing functionalities out to third-party IT outsourcing companies. This process referred to as test outsourcing is common in the industry, yet it is rarely studied in the research community. In this paper, to bridge the gap, we performed an empirical study on test outsourcing with 10 interviewees and 140 survey respondents. We investigated various research questions such as the types, the process, and the challenges of test outsourcing, and the differences between test outsourcing and in-house testing. We found customer satisfaction, tight project schedule, and domain unfamiliarity are the top-3 challenges faced by the testers. We also found there are substantial differences between test outsourcing and in-house testing. For example, most of the test outsourcing projects focused on functional test, and rarely did unit test. Also, due to privacy policies of client companies, test outsourcing is performed mainly on the binary distributions of the projects, and rarely the testers can touch the source code. Our findings have implications for future research. For instance, as a starting point, researchers can create automated program comprehension tools which work on binary distributions of projects to help testers better design effective test cases.

I. INTRODUCTION

Outsourcing is a practice used by companies which involves transferring part of the work to service providers in order to reduce costs. According to Gartner, outsourcing contributes more than 50% of the worldwide IT services market growth, which is pegged to reach 1.1 trillion in 2018 [5]. Test outsourcing is a type of outsourcing in which software testing is carried out by an independent organization, which can provide benefits such as improving the quality of the applications and reducing risks through rigorous testing. Companies lacking in-house test teams can outsource Quality Assurance (QA) and testing part of their applications to service providers, who have experienced QA engineers, project managers and subject-matter experts who have extensive knowledge of testing techniques and processes.

Several researchers in the past have investigated test outsourcing. Taipale et al. showed that test outsourcing increases the efficiency and reduces the cost of software testing [28]. Kaner et al. specified that product reliability will be better if independent test organizations conduct testing [11]. Unfortunately, despite the growing interest in outsourcing in general and test outsourcing in particular, there has been no study

that comprehensively investigates the types, processes and challenges in test outsourcing.

To address this need, we conducted an empirical study to understand the test practices followed by developers involved in test outsourcing. We want to understand different characteristics of test outsourcing and different tools and techniques frequently used by testers. We conducted in-depth interviews with 10 senior QA managers and team leaders and surveyed 140 testers. These test managers and testers are all from a large IT organization in China and they all work on projects related to test outsourcing. We first performed face-to-face interviews with 10 senior QA managers and team leaders, and used a transcription service to transcribe the audio into text, and grouped the text into different categories (aka. topics) by performing card sort [27]. Then, we extracted some hypotheses from these topics, and designed a 10-15 minute survey which contains a total of 30 statements based on these hypotheses. Finally, we distributed these survey to the testers in the company, and received a total of 140 responses.

The main contributions of this study are as follows:

- We performed a study on a large IT outsourcing organization to understand the types, processes and challenges involved in test outsourcing.
- We conducted one-on-one interviews with 10 senior QA managers and team leaders to get an in-depth understanding of test outsourcing.
- We discuss differences between in-house testing and outsourced testing and also present implications of our result for future research.

The structure of the remainder of this paper is as follows. In Section II, we explain our study methodology which consists of interviews and surveys. We present the results in Section III. We discuss the threats to validity and future tools in Section IV, and related work in Section V. We conclude and discuss future work in Section VI.

II. METHODOLOGY

In this section, we present our study methodology which involves two parts, qualitative interviews (Section II-A) and survey (Section II-B).

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TABLE I. WORKING EXPERIENCE AND ROLES OF THE 10 INTERVIEWEES.

Interviewee	Working Experience	Role
P1	10 Years	Head of the QA department
P2	10 Years	Senior QA manager
P3	8 Years	Senior QA manager
P4	8 Years	Senior QA manager
P5	10 Years	Project manager
P6	3 Years	Project manager
P7	6 Years	Project manager
P8	5 Years	Team Leader
P9	5 Years	Team Leader
P10	5 Years	Team Leader

A. Interviews

1) *Protocol*: For the interviews, we carefully selected senior Quality Assurance (QA) managers and team leaders who can provide relevant information on test outsourcing practices. The first and second authors conducted face-to-face interviews with these senior QA managers and team leaders. Each interview was completed within an hour.

The interview was semi-structured and was divided into three parts. In the first part, we asked some demographic questions such as the experience the interviewee has on test outsourcing. In the second part, we asked some open-ended questions such as challenges faced by test outsourcing teams, and differences between test outsourcing and in-house testing. The purpose of this part is to allow the interviewees to speak freely about test outsourcing without any bias.

In the third part, we picked a list of topics related to test outsourcing, and asked the interviewees to discuss topics that they have not explicitly talked about. The topics were selected from two sources: some of them were selected from topics in the software testing and software quality areas in the Software Engineering Body of Knowledge (SWEBOK), such as test processes, test levels and types, and test tools; while the others were management topics related to test outsourcing, such as training, knowledge transfer, knowledge sharing, communication skills, and tester experience. We discussed all of the above topics with the interviewees. At the end of interviews, we thanked interviewees and briefly introduced what we plan to do with the data.

2) *Participant Selection*: We conducted interviews with senior QA managers and team leaders in Insigma Technology¹. The company is one of the most well-known IT outsourcing company in China; it is the second largest IT outsourcing company in China [10] and has more than 6,000 employees. Insigma Technology was ranked by International Association of Outsourcing Professionals (IAOP) at the #24 position in the “Global Outsourcing 100” list in 2014 [9]. We first discussed our study with the CTO of Insigma Technology, and he recommended 20 senior QA managers and team leaders from two subcompanies of Insigma Technology. Then, we invited these QA managers and team leaders to participate in the interview. A total of ten people accepted the invitation. Six interviewees were from Insigma Hengtian (HT), which is an outsourcing company mainly for client companies from US and Europe. Insigma Hengtian (HT) has more than 1,600 employees. The other four interviewees were from Insigma Global Service (IGS), which is an outsourcing company mainly for client

TABLE II. MULTIPLE CHOICE AND OPEN-ENDED QUESTIONS IN THE SURVEY.

1. How did you test outsourced projects? <i>Checkbox options</i> : Manually, use automated testing, both manually and using automated testing, others
2. Which types of test outsourcing projects have you been assigned to ? <i>Checkbox options</i> : Basic types, intermediate types, advanced types
3. What types of testing did you do on test outsourcing projects? <i>Checkbox options</i> : Unit testing, integration testing, system testing, functional testing, regression testing, acceptance testing, load testing, performance testing, beta testing, others
4. What types of supporting tools did you use on test outsourcing projects? <i>Checkbox options</i> : Code inspection tools, unit test tools, continuous integration tools, functional test tools, issue tracking tools, test management tools, performance test tools
5. What are some of the challenges that you have encountered during test outsourcing projects? <i>Checkbox options</i> : Customer satisfaction, time constraints, poor documentation, lack of experience, steep learning curve, limited tool support, unfamiliar area, Others
6. If there is a test automation tool that researchers can build in the future to support test outsourcing, what kind of tools would that be? <i>Free form text</i> .

companies from within China. Insigma Global Service (IGS) has more than 400 employees. Eight interviewees were male, and two were female. In the remainder of the paper, we denote these 10 interviewee as P1 to P10.

Table I presents the working experience and roles of the 10 interviewees. The average number of years these 10 interviewees has worked on test outsourcing projects is 7 years. Nine of the ten interviewees have worked on test outsourcing projects for more than 5 years. One interviewee has worked on test outsourcing projects for only 3 years, but he has worked on other kinds of software outsourcing projects for more than 6 years. Among the 10 interviewees, one is the head of the QA department, three are senior QA managers, three are project managers, and the remaining three are team leaders. The 10 interviewees have diverse experience on different types of projects. For example, P2 leads a test outsourcing team which works for a well-known US bank for more than 7 years. P3 has 5 years of test outsourcing experience working on projects from some well-known IT companies (e.g., Cisco), and 3 years of test outsourcing experience with a well-known e-commerce company in China. When this study was conducted, P10 led a test team for a Chinese bank. The diversity of the background and experience of the 10 interviewees help improve the generalizability of our results.

3) *Data Analysis*: After the interviews, we used a transcription service to transcribe the audio into text, and grouped the text into different categories by performing card sort [27]. Since we discussed with the interviewees a number of topics, we first extracted some keywords from each of the topics. For example, for test techniques, we extracted keywords such as “unit testing”, “functional testing”, and “automated testing”. Next, for each interviewee, we put sentences into a topic if they contain the corresponding keywords. The process was repeated until all sentences made by the interviewees were covered. We then analyzed these topics and the related sentences, and grouped them into four different categories, i.e., general characteristics, technical aspects of test outsourcing, management aspects of test outsourcing, and differences between test outsourcing and in-house testing. Furthermore, since all of the 10 interviewees were Chinese, we used Chinese as the main language to discuss with them. In the paper, we translated Chinese into English.

¹<http://www.insigmaus.com/>

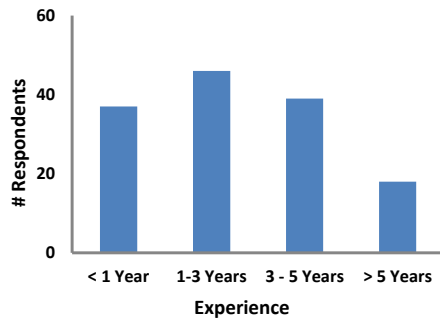


Fig. 1. Distribution of the participants in the survey.

B. Survey

1) *Protocol*: We designed a survey to validate hypotheses that we learned from the interviews. The goal of the survey was to quantify the qualitative results expressed by the 10 interviewees over a range of topics. We first wrote 50 candidate statements each capturing a hypothesis that we learned from the interviews and asked the respondents to rate their agreement/disagreement. Their ratings are given on a 5-point Likert scale, from strongly disagree to strongly agree. For example, we asked the respondents to rate the statement “Understanding domain knowledge and requirements is challenging for test outsourcing, but it is less challenging for in-house testing, since projects tested in-house are in the same/similar domain.”, and “We use manual testing more than automated testing in test outsourcing projects.”. Next, the first and second authors discussed these 50 candidate statements, and removed statements which were ambiguous, were perceived to be difficult for the respondents to rate, or were duplicate of other candidate statements. In the end, we kept 30 statements in the final list².

We also asked respondents to fill in more specific multiple choice and open-ended questions to better understand test outsourcing. Table II presents these questions. We asked respondents about ways to test outsourced projects, test types, types of test outsourcing projects they have participated, test techniques, test support tools, challenges, and also envisioned automated testing tool that can help in test outsourcing projects. Finally, we also collected demographic information from the respondents.

2) *Participant Selection*: We recruited respondents in the QA department of Insigma Hengtian and Insigma Global Service to participate in the survey. Insigma Hengtian and Insigma Global Service have more than 500 and 100 testers. P1 and P2 helped us to forward the survey to testers in these 2 companies. In total, we asked 428 testers to complete the survey, and 140 testers completed the survey. The response rate was 32.7%.

Figure 1 presents the distribution of the participants in the survey. Among the 140 respondents, 37 respondents (26.4%) have worked on test outsourcing projects for less than 1 year, 46 respondents (32.9%) have worked for 1 to 3 years, 39 respondents (27.9%) have worked for 3 to 5 years, and 18 respondents (12.8%) have worked for more than 5 years.

3) *Data Analysis*: We examined the distribution of responses from the respondents. We linked interviewee comments with survey responses by referring to survey statements,

²The details of the 30 statements can be found in Table III.

e.g., [S1]. We numbered statements in the order in which they appeared in the survey, S1 through S30. Since we used a 5-point Likert scale, we annotated each with [\checkmark SX], [\times SX], and [SX], if the number of people who gave 4 or 5 points (i.e., agreement or strong agreement) to the statement is more, less, and equal to than the number of people who gave 1 or 2 points (i.e., strong disagreement or disagreement) to the statement, respectively. If the average score for a statement was more than 4, which means most of respondents gave 4 or 5 points to the statements, we annotated it with [$\checkmark\checkmark$ SX]. If the average score for a statement was less than 2, we annotated it with [$\times\times$ SX].

III. FINDINGS

In this section, we first report the results of our face-to-face interviews with the 10 participants. We augment our interviewee responses with our survey participant answers. We organize the interviewee responses into four categories which correspond to the first four sub-sections of this section, i.e., general characteristics of test outsourcing, technical aspects of test outsourcing, management aspects of test outsourcing, and differences between test outsourcing and in-house testing. Next, we present the detailed survey results in the last sub-section.

A. General Characteristics

1) *Project Types*: We refer to companies that outsource some of their information technology (IT) functions as *client companies*. Test outsourcing can be categorized into several types based on the IT capabilities of the client companies. For example, some companies have strong background in IT (e.g., Cisco), and they outsource testing to relief their internal testing teams. On the other hand, some companies focus on areas other than IT (e.g., some small banks in China), and they always contract their development and testing efforts out to an outsourcing company. According to the interviewees, especially P1 to P4, test outsourcing can be categorized into 3 types:

- 1) **Basic Type**. The client company has a strong test team, the outsourcing projects are well documented, and the test specifications and test cases have been designed. The main task for test outsourcing is to follow the instructions given by the client company, and test the projects according to the descriptions in the test specifications and test cases.
- 2) **Intermediate Type**. The client company has a test team, but the testers in an outsourcing company need to work together with the testers in the client company. They work together to establish the test plan, design the test cases, build the test system, and complete the whole test process [$\checkmark\checkmark$ S3].
- 3) **Advanced Type**. The client company has no test team or even no development team, and all of their IT functions are outsourced. The testers in an outsourcing company need to help the client company to establish the test plan, design the test cases, build the test system, and complete the whole test process.

In Insigma Technology, most of the test outsourcing projects are those of the “intermediate type (around 60%),

followed by basic type (around 20%) and advanced type (around 20%)” (P1). In general, projects of the basic type are “easy to deploy and carry out”, and “requirements for personnel quality are not high, one or two senior testers leading some junior testers are sufficient” (P1) [✓S2].

The projects of the intermediate type require “more senior testers, and since the working styles of the two test teams are different, communication is especially important” (P2), also “since the domains of the projects varied, e.g., some of the projects develop financial systems, while others are e-commerce projects, understanding domain knowledge and requirements, and designing test cases based on project requirements are challenging” (P3).

The projects of the advanced type are the “most challenging” (P1); “help from the client company is really limited, and the client company even does not know how to test the project and measure project success, what they know is that when the project is released to the real users, they should be satisfied” (P4). As P2 noted, the success of test outsourcing projects of advanced type will “depend more on the quality and experience of personnel” [✓✓S4].

In practice, outsourcing companies prefer projects of basic type than advanced type, as P1 stated:

“Although projects of the advanced type are difficult and technically challenging, the benefits from the projects are the lowest among the 3 test outsourcing types since they require a number of senior testers who are also highly paid and an outsourcing company only has a limited number of senior testers which causes high opportunity cost. For projects of the basic type, the human resource cost and the project management risks are low, thus the company can get more benefits.”

In practice, if an outsourcing company always does projects of basic type, it will blunt its competitive edge in the future, and if an outsourcing company always does projects of advanced types, the low benefits may hurt company operations and bottom line. Thus, an outsourcing company often “focuses more on projects of the intermediate type, which balance immediate benefits and future prospects” (P1) [✓S6].

Figure 2 presents the distributions of types of test outsourcing projects that our 140 survey respondents have been assigned to – 45, 112, and 53 respondents have been assigned to basic, intermediate, and advanced test outsourcing projects respectively. Notice that in our survey, one respondent can work on multiple types of test outsourcing projects before.

2) *Test Process:* The test process followed by test outsourcing projects of different types are different. For a project of the basic type, the client company typically sends some senior testers to the test team in the outsourcing company, and they will organize some training sessions for the testers. The training sessions provide “an introduction of domain knowledge, background and basic operations of the projects, and test environment” (P1). They also provide “an explanation of the requirement and test case documents” (P1). After training, the testers begin to test the system according to “the test cases, compare the outputs of the system with the expected outputs of the test cases, and report bugs found” (P4).

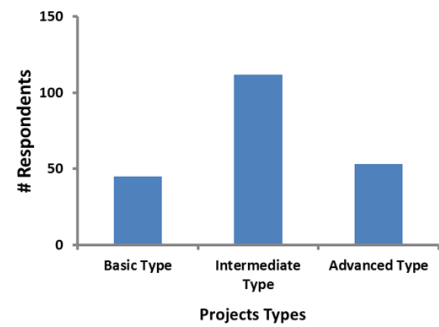


Fig. 2. Distributions of survey respondents according to test outsourcing projects type.

For a project of the intermediate type, testers in the client company and in the outsourcing company work together to design test cases, and complete the whole test process. Similar to projects of the basic type, in the beginning, some senior testers in the client company will train testers in the outsourcing company. Then they “work in a collective way to perform the test process, for example, testers in the outsourcing company may design test cases, and testers in the client company may review the test cases, and then they work together to execute the test cases and report bugs” (P3).

Projects of the advanced type are different from projects of the other two types. “A brainstorm session is commonly held to understand requirements from a client company” (P3). A lot of effort is spent on communication and discussion in the setup phase of the projects. Since the client company has limited experience on testing, testers in the outsourcing company also need to “design a detailed test plan” (P1). These testers need to then “train people in the client company to make the client company understands and accepts what they want to do” (P2). After that, these testers begin to design detailed test cases, and run them to find bugs.

3) *Challenges:* There are various challenges which can affect the success of test outsourcing projects, e.g., customer satisfaction, time constraints, poor documentation, and domain unfamiliarity. All of the ten interviewees agreed that customer satisfaction is one of the biggest challenges for test outsourcing projects (P1 to P10) [✓✓S9]. In detail, the customer satisfaction challenges for different types of test outsourcing projects are different:

- 1) **Basic Type.** Since the client company provides all test documentations to the test team in the outsourcing company, to ensure customer satisfaction the team needs to “follow the test cases and plans provided by the client company, test the system based on the test cases, and complete the project on time” (P6). Sometimes, the test cases and test plans provided by the client company may contain some problems. For example, some test cases may be “unreasonably designed or even wrongly designed and in conflict with the requirement documents” (P6), some test cases “are hard to execute and reproduce (e.g., testing concurrency modules in a system)” (P8), and some test plans “are too packed which makes it hard to complete the project on time” (P9).
- 2) **Intermediate Type.** Since testers in the outsourcing company need to work closely together with testers in the client company, making the latter “recognize

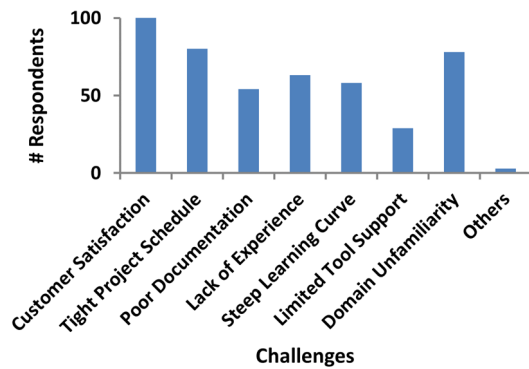


Fig. 3. Challenges faced by testers in test outsourcing projects.

the professional level and ability of testers from the outsourcing company” (P6) is a challenge for projects of the intermediate type, as P6 states: “Testers [from both companies] work much closer for projects of the intermediate type than projects of the other two types. Testers from the client company evaluate the abilities of testers from the outsourcing company. If the client thinks that the service level of the outsourcing company is not good, they will transfer to another outsourcing company. Thus, how to make the customer recognizes the service and professional level of the outsourcing company is important for projects of the intermediate type.”

- 3) **Advanced Type.** For projects of the advanced type, “since the customers have limited knowledge on software testing”, the challenge is that “the testers need to make the customers understand what they want to do, and how they will accomplish it” (P7). To make the client company trusts that the test team can do the work, “testers need to write more detailed documents, and communicate with the customers well” (P8) [✓✓S5].

Eight of the ten interviewees agree that domain unfamiliarity is another major challenge for the success of test outsourcing projects (P1, P2, P3, P4, P5, P7, P8, P10). P10 explained: “Test outsourcing projects cover a wide range of domains, e.g., from finance to manufacturing [✓✓S1]. Whenever we work in a new unfamiliar domain, we always feel nervous since we do not have the domain knowledge and good understanding of the background of the projects [✓S7]. For example, we began to test financial systems in 2004, but we failed on our first project with a US bank. The main reason was that we did not have sufficient background on finance”.

Tight project schedule is also a major challenge that affects the success of the projects (P1, P2, P3, P5, P7, P9). Some projects have strict deadlines, especially for projects of the basic type. There are various factors that may adversely impact on-time delivery of projects, e.g., high turnover rate, frequent requirement changes, etc. P8 states: “A typical outsourcing company has high turnover rate, testers come and go and this will cause project delay [✓S10]. For projects of the basic type, to save cost, some companies will hire many interns from universities, and the interns are less reliable than full-time employees. Another risk to on-time delivery is frequent requirement changes, which is common for some newly setup projects. We need to re-design test cases, and re-execute test cases every time the requirement changes [✓✓S8].”

Figure 3 presents the distributions of challenges that testers whom we have surveyed faced. It is interesting to note that customer satisfaction (104 votes), tight project schedule (80 votes), and domain unfamiliarity (78 votes) are the top 3 major challenges that the testers faced. Notice that the number of votes for “limited tool support” is comparatively low (29 votes). P1 and P2 mentioned that in test outsourcing projects, testers prefer manual testing over automated testing³, thus the need for advanced tool support is not as important as the other challenges.

B. Technical Aspects of Test Outsourcing

1) *Manual vs. Automated Testing:* In test outsourcing projects, “testers prefer manual testing to automated testing” (P1) [✓S13]. Automated testing can help reduce the amount of repetitive work in the testing process. However, automated testing is only used in a limited way in test outsourcing projects. P4 explains: “The learning curve for automated testing can be high, and sometimes testers need to write test scripts. For some projects of the basic type, the expertise of most testers are not high which makes it difficult for them to use automated testing tools. Also, for some complex business logics, such as business logics implemented in a quantitative finance module of a stock trading system, the automated tools cannot work well [✓S16]. On the other hand, manual testing is easy to do and flexible for different systems. Also, testers can focus more on test cases/business logics of the systems rather than complex technical aspects of testing.”

For some outsourcing projects, automated testing is hard to deploy due to frequent requirement changes [✓S15]. P5 who worked for advanced test outsourcing projects explained: “Although we use automated testing tools sometimes, it is mainly for regression testing of code which has stable requirement. In most outsourcing projects, requirements are always changing, and test cases have to change accordingly. Automated testing can not work well in such conditions where the system has no stable requirements. Thus, in most of the projects, we perform manual testing much more than automated testing.”

Also, automated testing tool does not work well for GUI testing. P7 explained: “Changes to GUI are often small; most of the time, people move one control to another place, or increase or decrease the size of controls. However, automated testing tool cannot capture these small changes in the GUI. We need to modify the test scripts every time GUI changes.”

Among the ten interviewees, P8’s team is the one that mainly performs automated testing, he explained: “Our team does regression testing in Inigma. We have stable requirements and test cases. In such a case, we can use automated testing to relief our workload. For some projects, testers will perform both manual testing and automated testing, but automated testing is only performed for modules with stable requirements.”

Figure 4 presents the distribution of survey respondents who performed manual and automated testing in their test outsourcing projects. Among the 140 survey respondents, 88 (62.9%), 8 (5.7%), 41 (29.3%), and 3 (2.1%) respondents perform manual testing, automated testing, both manual and

³For more details, please refer to Section III-B1.

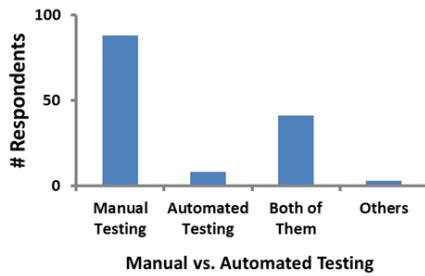


Fig. 4. Distribution of survey respondents who performed manual and automated testing.

automated testing, and no testing (others) in their past test outsourcing projects, respectively. For the 3 respondents who selected others, they are senior managers, and they focused on project management activities and performed no testing.

2) *Test Levels and Types*: There are various test levels, e.g., unit testing, integration testing, and system testing, and test types, e.g., functional testing, and non-functional testing [21]. Not all of these test levels and types are frequently performed in test outsourcing projects.

Unit testing is an important test type. Greiler et al. found unit testing plays an important role in the testing of plug-in systems [7]. However, in test outsourcing projects, unit testing is less often performed unless the customer requires it [✓S11]. Unit testing is often done by developers who wrote the code as they want to get the feedback as quickly as possible. Furthermore, unit testing will “add cost to client company, and also increase testing time which causes delay to project completion” (P4). Since most of the test outsourcing projects have “tight schedule and limited budget” (P4), to ensure projects are completed on time, clients prefer system testing to unit testing. Note that “in some test outsourcing projects such as e-commerce projects, unit testing is still performed especially for interfaces to the payment functions” (P2). For outsourcing projects of the basic type, there are often “no requirement for unit testing, since the client company may also perform unit testing within the company” (P1).

Furthermore, in test outsourcing projects, functional testing is performed more often (P1, P2, P3, P4, P5, P6, P7, P9, P10) [✓✓S12]. P10 stated: “*Compared to other properties of a system such as reliability, security, and performance, the first thing customers care is whether all of the functional requirements are well implemented in the system. They cannot bear a half-implemented system. Thus, functional testing is a must whenever we get a test outsourcing contract.*”

Figure 5 presents the distribution of different test levels and types performed by our survey respondents. A total of 128 and 90 respondents performed functional testing and system testing in their past test outsourcing projects, while only 18 respondents performed unit testing. The results of our survey support what our ten interviewees mentioned. Functional and system testing are performed more often than other test levels and types.

3) *Supporting Tools*: There are various types of supporting tools that can help in a test outsourcing project. For example, code inspection tools such as PMD and FindBugs are often used to identify potential bugs from the source code, issue tracking tools such as JIRA and Bugzilla are often used to

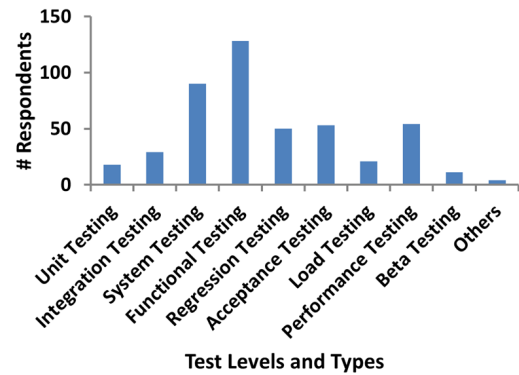


Fig. 5. Distribution of survey respondents who performed different test levels and types.

report and manage bugs detected during the execution of test cases.

All of the ten interviewees agreed that issue tracking tools are the most widely used tools as compared with other tools such as code inspection tools, and functional test tools [✓✓S19]. All of the test teams need to report and manage bugs; the usage of issue tracking tools can help them “analyze bugs, and compute some statistics such as bug density and bug distributions” (P6). From the customer point-of-view, issue tracking tools can “help them to evaluate the quality of the system and better understand the status of the current system” (P8).

Eight of the ten interviewees mentioned that they also use some test management tools such as Rational ClearQuest⁴ to manage the execution of test cases (P1, P2, P4, P6, P7, P8, P9, P10) [✓✓S20]. Different from issue tracking tools, test management tools are used to manage the whole testing process. One reason why test management tools are popular is due to the frequent requirement changes. Test management tools “set up traceability between requirements and test cases” (P2); if a requirement is changed, it is then easy to identify the affected test cases, and re-design the test cases. Also, test management tools can help project manager to monitor project schedule, and evaluate risks in advance.

Functional test tools such as IBM RFT⁵ are also used. P8 stated: “*Functional test tools will be used if the requirements and test cases are stable, and in practice, they are used by a small proportion of test outsourcing projects. Most of the time we still prefer manual testing.*”

Only one of the ten interviewees mentioned that he uses unit test tools in test outsourcing projects (P5), and the reason to use unit test tools is that customers require them to do unit testing. None of the interviewees mentioned code inspection tools or continuous integration tools. P1 explained: “*In test outsourcing projects, often we cannot get the source code from the clients, thus it is impossible for us to use code inspection tools. Also, continuous integration tools are not considered as test tools but development tools, and we rarely use them in practice.*”

Figure 6 presents the distribution of supporting tools used by our survey respondents. In total, 100 and 87 respondents

⁴<http://www-03.ibm.com/software/products/en/clearquest>

⁵<http://www-03.ibm.com/software/products/en/functional>

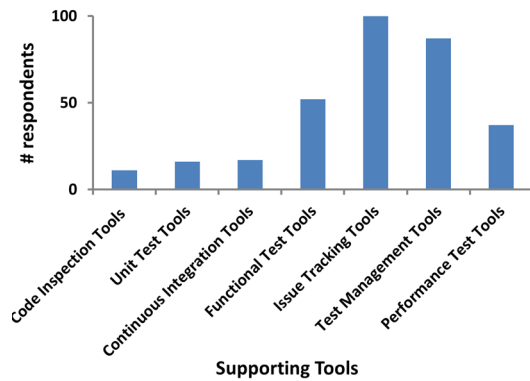


Fig. 6. Distribution of survey respondents who use various supporting tools.

mentioned that they used issue tracking tools and test management tools in their test outsourcing projects respectively, and only 11, 16, and 17 respondents mentioned they used code inspection tools, unit test tools, and continuous integration tools in their test outsourcing projects respectively. The survey results are aligned with the feedback we got from the interviewees.

4) *Test Case Design*: For outsourcing projects of the intermediate and advanced types, testers need to design test cases. Eight out of the ten interviewees agreed that domain knowledge impacts test case design (P1, P3, P5, P6, P7, P8, P9, P10) [✓✓S18]. P9 explained: “For some financial systems, domain knowledge is especially important to design test cases. For example, candlestick chart is very common in stock trading systems, but if we do not understand the meaning of candlestick chart, we cannot design good test cases to evaluate an implementation of the chart. Thus, we believe domain knowledge is one of the most important factors that affect the quality of test cases.”

Previous studies show code coverage is an important metric to evaluate the effectiveness of test cases [2], [6], [8]. However, in test outsourcing projects, often code coverage is not important to evaluate the design of test cases [✓✓S14]. P3 explained: “Although 100% code coverage can help in finding more bugs, in practice, we do not have so much resource and time to design a large number of test cases to achieve a high code coverage. Also, from our experience, high code coverage does not mean high bug detection rate. Thus, in practice, we focus on designing a ‘small’ and yet ‘effective’ set of test cases which can help detect as many bugs as possible.”

In practice, instead of code coverage, client companies care more on “requirement coverage”, i.e., whether the generated test cases have covered all of the requirements [✓✓S17]. P1 stated: “Although requirement coverage is a weak form of coverage, it helps to ensure all the functions are covered, which is useful for functional testing. Also, since some customers do not have strong IT background, they do not understand code coverage, and requirement coverage is easy to explain and present. Thus, for a test outsourcing project, for each unit of requirement, we will design a number of test cases to cover it.”

C. Management Aspects of Test Outsourcing

1) *Training, Knowledge Sharing, and Knowledge Transfer*: In an outsourcing company, the turnover rate is high. Test

teams will be affected if too many testers leave the team. Training, knowledge sharing, and knowledge transfer are three effective ways to reduce the risk due to resignation of people, especially when the project team has a number of new testers [✓✓S22] [✓✓S23] [✓✓S24]. In the beginning of many outsourcing test projects, some senior people in the client company will organize a training session for the testers in the outsourcing company. When the project is progressing, testers in the outsourcing company will organize knowledge sharing meetings for members of the test team, and if some testers leave the team, they will also need to transfer their knowledge to junior testers. When the project is completed, testers also need to share their experience to all of the testers in the outsourcing company.

2) *Communication Skills and Client Relationship Management*: All of the ten interviewees agreed that communication skills are extremely important for an outsourcing company [✓✓S21]. As we have described in the previous section, customer satisfaction is the biggest challenge in test outsourcing, and communication skill can help to reduce the risk of customer dissatisfaction. P1 explained: “Effective communication can help to improve the relationship between our company and the customers. We have a lot of long-term customers, and the reason that these customers are willing to continue to work with us is simply because we set up good communication channels. Thus, in my opinion, besides technical ability, communication skill is the most important factor to the success of a test outsourcing project.”

3) *Tester Experience*: The experience level of testers is another important factor that affects the success of test outsourcing projects [✓✓S25], especially for projects of advanced type. However, in practice, a typical outsourcing company has only a small number of experienced testers, and a large number of unexperienced testers. Thus, most of the time, experienced testers have to work across many different test projects at the same time.

D. Differences Between Test Outsourcing and In-house Testing

For in-house testing, projects are tested by testers within a company. On the other hand, for test outsourcing, projects are tested by testers from an external company. Due to the privacy policy of the client company, and also culture and technical background differences between the two companies, there are several differences between in-house testing and test outsourcing:

- 1) **In test outsourcing, less unit testing is performed** [✓S26]. Most of test outsourcing projects focus on “system testing . . . , and unit testing is rarely performed” (P1). For in-house testing, unit testing plays an important role [7].
- 2) **Understanding domain knowledge, business logics, and requirements is especially challenging for test outsourcing** [✓S27]. There are various types of test outsourcing projects and they are on different domains; for example, some projects are in the finance domain, and some other projects are in the e-commerce domain. Even in the finance domain, there are various kinds of systems, e.g., stock trading systems, fixed income management systems, etc.

Since there are different kinds of systems, unlike in-house testing where testers work in one or two related domains, testers in an outsourcing company always need to test systems from different domains, and they have to continue to “learn new domain knowledge before they can test a new system” (P2). For example, a tester may be required to test a stock trading system in one project, and a manufacturing system in another project.

- 3) **The test setup for test outsourcing and in-house testing is often different.** Due to security and privacy policies in a client company, most of test outsourcing projects work on binary distributions of systems, and rarely testers can touch the source code [✓S28]. Thus, “documents such as requirement and specification documents are important to help testers to understand business logics implemented in the projects” (P4). Also, some client companies will dispatch some senior developers/testers to train testers in the outsourcing company. However, for some complex business logics, “it is often hard to describe them in natural language, and since the testers can not view the related source code, it will be challenging to design suitable test cases to exercise these complex logics and find bugs” (P1). Furthermore, since source code is often unavailable, unit testing is less popular in test outsourcing projects.
- 4) **There are differences in the goal of test outsourcing and in-house testing.** [✓S29]. For in-house testing, since the test team is within the company, the goal is often more specific and testing is often performed more meticulously. For example, the goal can be to achieve zero post-release defects, or at least, to reduce the number of post-release defects below a particular threshold. For test outsourcing, the goal is often less specific and even at times unclear or changing. P5 states: “*In most of the cases, the client company just wants breadth testing which can cover more aspects of the system, and fast testing which can test the system within a short time. But for in-house testing, a company often hopes for deep testing which can find more potential bugs in a system. Of course, some customer companies may require deep testing if they find that breadth and fast testing can not improve the quality of a system. But in general, the goal for test outsourcing is not clear and the test strategy needs to be modified according to changes to the goal.*”
- 5) **Test outsourcing tends to produce more documents than in-house testing.**[✓✓S30]. In test outsourcing projects, documents are also important deliveries to the customers. P7 explained: “*We need to record every thing we do in test outsourcing projects, and we have various types of reports, such as daily/monthly/annually reports, test case design reports, test execution reports, etc. Documentation builds the communication channel between test outsourcing teams and the customers; customer can know the status, problems, and risks of the projects. I know that sometimes writing too many documents is a waste, but it is a culture.*” For in-house testing, the requirement for documentation is not as heavy

as test outsourcing – since the development and test teams are in the same company, the communication between testers and developers is much easier.

E. Detailed Survey Results

Tables III presents our detailed survey results. We show the statements that we send to our survey respondents and the ratings that we received from the respondents to indicate whether they agree or disagree with the statements. The **ID** column presents the identifier of the statements. The **Statement** column presents the detail of the statements that we send to the survey respondents. The **Likert Distribution** column shows the distribution of the rating scores given by the respondents to the statements. The leftmost bar represents strong disagreement, the middle bar represents neutral, and the rightmost bar represents strong agreement. The **Average** column indicates the average rating (i.e., average Likert score) for each of the statements. The higher the average rating, the more the respondents agree with the statement. For example, the average score for S21 is 4.61, which means that most of the respondents “agree” or “strongly agree” with the statement.

From Table III, for all of the statements, we notice that the number of respondents who give 4 or 5 points (i.e., agree or strongly agree) is more than the number of respondents who give 1 or 2 points (i.e., disagree or strongly disagree). Also, there are 17 statements whose average scores are more than 4, which means most respondents express agreement or strong agreement to these statements.

IV. DISCUSSION

A. Threats to Validity

Threats to Internal Validity. Threats to internal validity relates to the reliability of our findings, i.e., whether our findings are in line with our interview and survey participant thoughts. We have recorded our interviews and listened to it several times to ensure the validity of the findings that we report in this paper. After completing our paper, we also sent it to the interviewees, and asked them to validate the results.

Threats to External Validity. Threats to external validity corresponds to threats to the generalizability of our findings. First, the number of participants in our interviews and survey are limited. In total, we interviewed 10 participants. Although the number 10 is on par with other interview-based studies [7], [20], the findings of our interviews have limited generalizability. To improve the generalizability of our study, we also surveyed a large number of respondents (i.e., 140 respondents). Second, we interviewed people and conducted survey only within Insignia Technology, thus it is possible that the results may not generalize elsewhere. Still, we have interviewed and surveyed a large number of respondents from two subcompanies of Insignia Technology, i.e., HT and IGS. These respondents have worked in many other companies before. Insignia Technology is a large IT company and it has successfully completed many test outsourcing projects. Insignia Technology clients include many international companies from various domains. In the future, we plan to reduce the threats to external validity further by interviewing and surveying more people from more companies.

TABLE III. DETAILED SURVEY RESULTS.

ID	Statement	Likert Distribution	Average
S1	Test outsourcing projects cover a wide range of domains, e.g., from finance to manufacturing.		4.45
S2	Outsourcing projects of the basic type are easy to perform, and the requirement for tester expertise is not high.		3.22
S3	For outsourcing projects of the intermediate type, testers in the outsourcing company and in the customer company work together to design test cases, execute test cases, and complete the test process.		4.38
S4	The success of projects of the advanced type depends more on the quality and experience of personnel.		4.39
S5	For outsourcing projects of the advanced type, we will write more documents and also spend more time to communicate with customers compared with projects of the other two types.		4.43
S6	In our company, most of the test outsourcing projects are of the intermediate type, followed by the basic type and the advanced type.		3.81
S7	Understanding the domain knowledge and requirement documents of external systems is a difficult step in a test outsourcing process.		3.76
S8	Frequent requirement changes will increase the risk of a test outsourcing project, since we need to always redesign the test cases and retest the system.		4.22
S9	Customer satisfaction is the biggest challenge.		4.11
S10	Testers often leave test teams which causes project delays.		3.84
S11	In test outsourcing, we perform less unit testing unless the customer requires of it.		3.66
S12	In test outsourcing, most of the time, we mainly perform functional testing.		4.45
S13	We use manual testing more than automated testing in test outsourcing projects.		3.59
S14	Code coverage is not important in evaluating the design of test cases.		3.19
S15	Automated testing tool can not work if the requirement changes are frequent. Thus, automated testing tools are used in a limited way in test outsourcing projects.		3.34
S16	For complex business logic logics, automated testing tools do not work well, since it is hard to simulate them.		3.58
S17	Test cases are often designed to cover all requirements.		4.45
S18	Domain knowledge will affect the design of test cases.		4.49
S19	Issue tracking tools such as Bugzilla and JIRA are most widely used tools as compared with other tools such as code inspection tools and functional test tools.		4.10
S20	Test management tools which track and record execution results are used.		4.01
S21	Being able to communicate with the customers is highly valuable in my job.		4.61
S22	Training is important to me to perform well in a test outsourcing project, especially when I am new in the project team.		4.48
S23	Knowledge transfer is important to me to perform well in a test outsourcing project, especially when I am new in the project team.		4.61
S24	Knowledge sharing is important to me to perform well in a test outsourcing project, especially when I am new in the project team.		4.55
S25	The experience of testers will affect the success of a test outsourcing project.		4.27
S26	In test outsourcing, unit testing is performed less than during in-house testing.		3.64
S27	Understanding domain knowledge and requirements is challenging for test outsourcing, but it is less challenging for in-house testing, since projects tested in-house are in the same/similar domain.		3.84
S28	In test outsourcing projects, testers can not touch the source code of projects, but for in-house testing, testers can touch the source code.		3.94
S29	There is a difference in the goal of test outsourcing and in-house testing. The goal for an in-house test project is specific, while the target for an outsourcing project will be dependent on the requirements of the customers.		3.70
S30	Test outsourcing projects will produce more documents (e.g., daily/monthly/annual reports, test case design reports, execution reports, etc) than in-house testing.		4.00

B. Future Tools

In this subsection, we discuss some future automated tools which can help testers to improve their productivity in test outsourcing projects.

Program Comprehension Tool. In test outsourcing, understanding the domain knowledge and business logics of an external system is challenging, and also most of the time, developers only have the binary distribution of the system. Thus, a tool which can automatically extract business logics from the binary distribution of the system, and display them to testers can help improve tester productivity. P10 stated: “A program comprehension tool is extremely useful for systems with poor documentations.”

Automated Document Generation Tool. Test outsourcing projects will need to produce many documents as deliverables to customers. This increases tester workload. Our interviewees

described that some of these documents are related to one another, and some of them can potentially be automatically generated. For example, test execution report can be automatically compiled by monitoring and summarizing the behaviors and outputs of test cases that were run by the testers, annual reports can be automatically generated from monthly or daily reports, etc. Thus, a tool which mines various test-related data to automatically generate documents can help to relief testers from their heavy documentation workload.

Advanced Automated Testing Tool. One reason why automated testing is not popular in test outsourcing projects is frequent requirement changes. An automated tool which is specially designed to cope with frequent requirement changes will be appreciated.

Automated Test Case Generation Tool. There are a number of studies on automated test case generation which analyzes

source code artifacts to generate tests [1], [4]. In test outsourcing, testers design the test cases based on requirement documents. Thus, if there exists an automated tool which can automatically generate test cases from requirement documents, it will help to save tester time and effort. One possible solution is to combine natural language processing techniques and data mining techniques to generate test cases.

V. RELATED WORK

Greiler et al. conducted a qualitative study which involved interviewing senior practitioners to understand how they test plug-in applications [7]. They reported some of the testing practices currently used, barriers for adopting testing, and how the community can be leveraged to solve issues related to testing. Memon et al. presented their analysis to improve the current testing tools and techniques to create new common collaborative infrastructure where developers can share tools and information repositories, to help reduce the time and effort required to build better software systems [18]. Pham et al. conducted a study to understand what are the enabling and inhibiting factors, perceptions and attitudes of novices towards testing activities and found that collaborative development with senior developers can help overcome these challenges [22].

Mantyla et al. conducted a study to understand the impact of adding individuals and time pressure on manual testing [19]. Their results showed that adding testers to a project increases the chances of finding more defects and a group of individuals subjected to time pressure is able to find more defects as compared to another group not constrained by time. Mantyla et al. conducted a controlled experiment to study the impact of time pressure on requirement review and test case development [16]. Their results showed that time pressure has a medium effect on requirement review and a high effect on test case development.

Shah et al. conducted interviews with vendor-side testing teams to understand the practice of global software testing (GST) [25], [26]. They found that appreciation is important to ensure high quality testing and the organization's structure such as presence of intermediary teams between clients and vendors can increase the pressure on testers. Cohen et al. showed that the intellectual and personal differences between developers and testers can lead to conflicts and suggested managers should use management practices and team building activities to improve testing activities [3]. Rooksby et al. performed an empirical study on four systems and demonstrated that testing should be treated as a socio-technical problem instead of a purely technical problem [23]. Shah et al. found that human and social factors have a significant impact on software testing practices such as attitude of seniors can impact attitude of juniors towards testing [24]. Martin et al. conducted an ethnographic study to understand the pragmatics of software testing such as achieving good test coverage, getting right requirements and automating test scenarios by taking into account factors such as customer relationships, timing of release of software and available resources [17].

Kochhar et al. investigated the degree software testing adopted in open source projects and project development characteristics that correlate to the presence of test cases [12], [13]. In a latter work, they investigated the adequacy of software testing by analyzing the coverage achieved by test

suites in open source projects and identified factors that correlate with coverage [14]. In another study, Kochhar et al. investigated the test automation culture of app developers by surveying open-source and Microsoft developers [15]. Their study highlights the extent app developers use test automation tools and challenges developers face while testing their apps.

VI. CONCLUSION AND FUTURE WORK

Test outsourcing is a popular trend. Many companies outsource their testing efforts to a third party to reduce the burden of their internal test teams and to increase system reliability. Despite its popularity, unfortunately only few empirical studies have been performed to better understand it. In this paper, we perform an industrial study on test outsourcing by interviewing 10 participants and surveying 140 respondents. These participants and respondents are testers that have worked on test outsourcing projects. By analyzing the participant and respondent inputs, we study various characteristics, capturing both technical and managerial aspects of test outsourcing, such as project types, test process, supporting tools, test case design, required "soft skills", etc., and also investigate the differences between test outsourcing and in-house testing. Our paper contributes to a better understanding of the state-of-practice of test outsourcing in the industry.

The following is a summary of our findings:

- 1) There are three types of test outsourcing projects based on the IT capabilities of the client companies: basic type, intermediate type, and advanced type. Most of the test outsourcing projects that our interview participants and survey respondents have participated are of the intermediate type.
- 2) Customer satisfaction is the biggest challenge for the success of test outsourcing projects, followed by tight project schedule, and domain unfamiliarity.
- 3) Testers perform manual testing most of the time, and automated testing is limitedly used. Furthermore, functional testing and system testing are the two most common types of test, while unit testing is rarely performed.
- 4) Training, knowledge sharing, and knowledge transfer are all important to test outsourcing projects, due to the high turnover rate in the outsourcing companies. Besides, communication skills are highly valued.
- 5) There are substantial differences between in-house testing and outsourced testing, e.g., the types of testing, the test setup, the target are all different.

In the future, we plan to investigate more aspects of test outsourcing, and reduce the threats to external validity by interviewing and surveying more people from more test outsourcing companies. We also plan to implement some tools presents in Section IV-B which can help testers in test outsourcing projects to improve their productivity.

Acknowledgment. The authors thank to all the interviewees and survey respondents from Inigma Technology who participated in this study. This research was partially supported by China Knowledge Centre for Engineering Sciences and Technology (No. CKCEST-2014-1-5), and National Key Technology R&D Program of the Ministry of Science and Technology of China (No. 2015BAH17F01).

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