

Effort Estimation in Agile Software Development: An Empirical Study in the Sri Lankan Context

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Abstract - In responding to the dynamic business environments, most software development organizations have shifted towards the practice of agile methodologies, due to their capability in undertaking change in requirements. Accurate and reliable effort estimates usually assist effective project planning. Effort estimation in agile software development differs from traditional approaches due its iterative nature. In this survey-based study, the main objective is to assess the status of effort estimation by agile software development teams in Sri Lanka. Hence, the investigation focuses on finding out the widely adopted agile effort estimation techniques, effort predictors, accuracy level of each technique, and the factors affecting estimation accuracy. The data was collected from software industry professionals using an online questionnaire and was statistically analysed. According to the results obtained, “Expert Judgment”, “Planning poker”, and “Use Case point” are the most used effort estimation techniques among Sri Lankan agile teams, and it was evident that “Expert Judgment” is the most accurate effort estimation technique among them. Further, a conceptual model on the effect of cost drivers on the accuracy of the effort estimation was proposed based on the results of correlation and linear regression analysis.

Keywords: *agile software development, software estimation, effort estimation, effort estimation techniques*

I. INTRODUCTION

The software engineering industry has been continuously affected by the extreme changes brought by the globalization to the world economies in the 21st century (Britto, Usman and

Mendes, 2014). Software development teams are faced with frequent change in requirements caused due to the highly dynamic nature of the business environments. As a result, lots of software development teams have now shifted towards agile software development approaches. In ASD, software development happens in an incremental manner as small iterations by incorporating the feedback of customers at the end of each iteration (Darrin and Devereux, 2017) (K.R, 2017)(Kim, 2007).

During the planning phase of a software project, a schedule estimate is prepared based on the effort required to complete the project. Usually, effective planning requires accurate and reliable estimates as inputs. Thus, if the project can have a more accurate effort estimate, it will eventually lead to high customer satisfaction. Hence, effort estimation can be considered as an integral step of software project management (Usman et al., 2014)(Nazir, Hasteer and Bansal, 2016). But in contrast to the plan driven software development approaches, estimations and planning in agile approaches happens progressively due to its iterative nature (Canedo et al., 2018). Therefore, in ASD, project planning happens iteratively as three steps: release planning, iteration planning and the current day planning (Cohn, 2005)(Tuli et al., 2014). Accordingly, estimation techniques used in ASD differs from the techniques used in the traditional software development. Expert Opinion, Analogy, Disaggregation, and Planning Poker are some of the common techniques for estimation in ASD (R. Popli and N. Chauhan, 2013).

With the growing number of ASD teams, agile estimation is still an active research area. The objective of this research study is to investigate the status of the practice of agile effort estimation in the Sri Lankan software engineering industry. Hence, for obtaining an in-depth understating of how effort estimation is being performed by ASD teams and the accuracy of estimation techniques used, a survey questionnaire was designed and executed. Further based on the results obtained, factor affecting estimation accuracy was identified and a conceptual model for effort estimation accuracy was proposed.

The remainder of the paper is organized as follows: section 2 summarises the existing works; the methodology and experimental design is presented in section 3 and results are presented in section 4. Finally, discussion and conclusions are given in section 5.

II. RELATED WORKS

With the popularity of agile, many research studies on different aspects of ASD has been conducted and among them we could identify a few research works conducted on effort estimation practices of ASD.

In the study by (Usman et al., 2014), a literature review has been done, studying total of 25 primary studies on agile effort estimation. Expert Judgment, Planning poker and Use case points estimation techniques identified as most frequently applied techniques in ASD. Use case points and story points has been identified as most frequently used size metrics while MMEE and MRE have been identified as frequently used accuracy metrics. Team skills, prior experience and task size has been cited as three important cost drivers and Extreme Programming and SCRUM identified as only the two agile methods used.

In the research work of (Usman, Mendes and Böstler, 2015), a survey has been carried focusing on a wide range of aspects such as the estimation techniques and effort predictors used in a global context. Among the findings, Planning Poker (63%), analogy (47%) and expert judgment (38%) identified as frequently practiced estimation techniques in ASD. Story point has been identified as most frequently (62%) employed size metric. Team's expertise

level and prior experience has been identified as most used cost drivers.

In the study by (Canedo et al., 2018), a literature review has been done, studying total of 27 primary studies on agile effort estimation. This study's result shows that Planning Poker is the most popular technique for agile teams in the planning phase, Story Point and Point of Function are the most used metrics in agile projects for estimating size, time, effort, productivity and cost.

(Usman et al., 2018), has performed an exploratory longitudinal case study through archival research and semi-structured interviews. As key findings they have suggested that a two-stage effort estimation process can improve effort estimation accuracy and seems to address some of the challenges in large-scale agile software development. Also, it has been found that team maturity, team distribution, requirement size and requirement priorities play a vital role in improving the accuracy of effort estimates.

With respect to the existing literature, it is evident that no study has conducted on the practice of agile effort estimation in Sri Lankan ASD teams. Thus, this study narrows the aforesaid gap through carrying a survey-based study among Sri Lankan agile software development teams.

III. METHODOLOGY

A survey-based research methodology was followed in the study conducted. This section describes on formulation of research questions, design of survey questionnaire, and execution of survey.

A. Research Questions

In achieving the objectives of study, four research questions were formulated.

Research question 1 (RQ1) – What are the most used effort estimation techniques in agile software development teams?

Research question 2 (RQ2) – How accurate is the effort estimations done using the above techniques?

Research question 3 (RQ3) – Which effort predictors are used within the aforesaid

techniques for effort estimation? **Research question 4 (RQ4)** – What are the factors that have an impact on the accuracy of the effort estimations?

B. Survey Design

A survey is a most effective and trustworthy form of investigation that targets at collecting data from a wider and most related population (Orel, 2020). It is mandatory to define its purpose, the unit of analysis to be used and a representative population sample related to the research problem in order to perform surveys. The survey was defined as follows:

- 1) *The purpose:* Collecting data on the state of the practice on effort estimation in ASD in Sri Lankan context.
- 2) *The analysis Unit:* Elements of the effort estimation process such as effort estimation techniques, cost drivers, size metrics.
- 3) *The target population:* Practitioners who have worked with effort estimation in agile teams
- 4) *The sampling unit:* Practitioner responsible for performing effort estimation in an organization.

This study was conducted in the form of an online questionnaire which was shared among the target responder group. The use of the e-form helped to maximize the number of respondents. The survey questionnaire encompassed with thirty-eight closed-ended questions and two open-ended questions. For the coverage all the research questions formulated, questionnaire was structured in to three sub sections: Demographic information, ASD practices, and Effort estimation practices. The aim of the obtaining the demographic information is to understand the background of the responders. ASD practices section includes questions related to the application of agile methodologies in software development. Effort estimation practices section includes questions related to the application of effort estimation techniques.

Some of questions in the survey has been combined and denoted as a single question for the ease of presentation. In the survey, Questions 1 to 12 were compulsory and designed as

categorical measurement scales. Question 13 is an open-ended question which is not compulsory. Question 6 is a multiple answer question, and all others are with a single answer. Respondents were given the chance to be anonymous with their feedback, but they could provide contact details willingly for a follow up interview.

1) Demographic Questions:

Question 1 - Is your organization, project base, productbase or both?

Question 2 – What is your age?

Question 3 – What is your job title?

Question 4 – What is your experience in agile softwaredevelopment (in years)?

Question 5 – What is the size of your project team?

2) ASD Methodology Questions

Question 6 – Which agile methods are used by your team?

Question 7 – What is the length of iteration (ex: Sprint)?

3) Effort Estimation Questions

Question 8 – What is the effort estimation technique employed in your ASD project?

Question 9 – What is the size metric utilized in effort estimation?

Question 10 – This is a multi-part question focusing on the accuracy of effort estimation technique employed. Here the impact of the chosen effort estimation technique to estimate accuracy and accuracy of each technique is assessed.

Question 11 - This is a multi-part question focusing on the effect of cost drivers to the accuracy of effort estimation. According to literature, factors affecting the accuracy of the effort estimates can be categorized as communication, team expertise and social factors. Communication factors includes strength of communication among team members, linguistic diversity of team members, and involvement of the client in estimation tasks. Team expertise factors include prior experience in ASD, agile estimation, project domain, and technology stack. Social factors include team members' cultural diversity, geolocation, familiarity, and

unity.

Question 12 – This is a multi-part question focusing on general project factors that can impact to the accuracy of effort estimation apart from above cost drivers. Factors include scope of the project, type of the software developed, size of the task breakdown, quality of requirement specification, effort estimation team constitution.

Question 13 – This is a non-compulsory open-ended question for obtaining responders’ suggestions on increasing the accuracy of effort estimates in ASD.

C. Survey Execution

As the initial step, a pilot survey was conducted with the help of few industrial experts. Based on the feedback received, questionnaire was modified and improved. Then in collecting responses, online questionnaire survey was shared to the responders mainly through the LinkedIn social media platform, so that eligible responders for the study could be reach more comfortably. Further some other respondents were invited through emails by contacting few reputed software development organizations. The survey questionnaire was available online from 1st of August 2020 to 30th November 2020 and there were 111 total responses.

IV. RESULTS

A. Demographic Questions

As per the Question 1, 47.3% of the respondents work in an organization which has both products and services base projects. Among the rest, 28.1% works in purely product base organizations while 24.6% are in purely service base organizations.

Question 2 assessed the age range of the respondents, and the results show that 56.1% of respondents were age between 25 and 30, 28.1% of respondents between 30-40, 14% of respondents were age below 25 and only 8.0% of respondents were age above 40.

Question 3 captured the respondent’s job title. Respondents were playing diverse roles associated with ASD. Among respondents 50% of respondents were developers and there were also roles such as “Team Lead”, “Tester”, “Project Manager”, “Software Architect”, “Business Analyst”, “QA Lead”, “DevOps Support Engineer”,

“SCRUM Master”, “QA Manager” and “Project Coordinator” etc. These results suggest that developers also play an important role in effort estimation ASD same as the higher-level project leadership or management roles such as project managers, architects, team leads etc.

Question 4 assessed the respondent’s experience in agile software development. The results show that 40.4% of respondents have 1 to 3 years’ experience and 37.8% of respondents have more than three years’ experience in agile software development environment. Among them 24.6% of respondents have 3 to 5 years’ experience and 12.3% of respondents have 5 to 10 years’ experience.

Question 5 assessed the project team size of respondents. As per the results half of respondents (50%) were in teams of 3 to 9 members. Further, 25.4% were working in teams of 10 and 15 members. It is evident that ASD is more popular with small size teams.

B. ASD Methodology Questions

Question 6 captured the agile methods employed by the respondents’ project teams. As per the results, most popular agile methodology is “Scrum” (66.7%) followed by “ScrumBan” (20.2%). Table 1 shows the status of adopting ASD methodologies including hybrid approaches. Further in Question 7, length of an iteration (in weeks) practiced in respective development methodology was assessed. It was obvious that most teams have adopted an iteration two weeks. Proceedings of 14th International Research Conference of KDU. You can use this document either as a set of instructions or as a template into which you can type your own text directly. The template has adopted the main good-practices used in scientific publications, which are also compatible with those of Social Sciences and Humanities.

Table 1: Employed agile method in respondent’s teams

Agile Method	Percentage
Scrum	66.7%
ScrumBan	20.2%
Kanban	5.3%
XP	1.8%
Lean	1.8%
Scrum, XP	1.8%
XP, Kanban	0.9%

Scrum, lean, kanban	0.9%
Scrum, Kanban, FDD	0.9%

C. Effort Estimation Questions

In achieving one of the objectives of the study, Question 8 captured the effort estimation techniques that are practiced by ASD teams. The results suggest that “Expert judgment” is the mostly used effort estimation technique (33.3%) followed by “Planning Poker” (31.6%) and “Use Case Points” (28.1%). Table 2 shows the usage of different effort estimation techniques. Moreover, this result is a significant deviation from the results of existing studies in literature (Britto, Mendes and Borstler, 2015) (Usman, Mendes and Börstler, 2015) where “Planning poker” was resulted as the mostly used effort estimation technique. Table 2 shows the status of adopting different effort estimation techniques.

Table 2. Effort estimation technique used by respondents’ agile teams

Effort Estimation Technique	Percentage
Expert Judgment	33.3%
Planning Poker	31.6%
Use Case Points	28.1%
COCOMO	4.4%
Delphi	1.8%
Disaggregation	0.9%

Question 09 captured the size metrics used upon estimating the effort by ASD teams. Results shows that ‘Story point’ is the mostly used (57.9%) size metric followed by ‘Use Case points’ which have 31.6% of usage percentage.

Question 10 which is a multipart question that captured the accuracy level of each effort estimation technique according to the opinion of the responders. Estimation accuracy is the most important feature expected from an effort estimation technique. If estimations are erroneous by a huge margin, there is no point of conducting an estimation. Around half of the responders (52.3%) agreed that the adopted estimation techniques have an effect towards the effort estimation accuracy, while 24.6% had a neutral response and 20.1% disagreed. When considering the accuracy of the estimations received by each technique, there was an

accuracy of 89.5% for “Expert Judgement” while 86.1% for “Planning Poker” and 56.3% for ‘Use case Point’ technique.

Question 11 is also a multipart question that captures the effect of cost drivers effect to the effort estimation accuracy. When considering all factors under three categories, communication between team members, client involvement in effort estimation process, team members with prior experience in ASD, effort estimation technique used, and familiarity among team members usually effect the effort estimation accuracy in positive manner. Lack of expertise on project domain and lack of technological knowledge, and lack of team unity seems to affect the effort estimation accuracy in a negative manner.

Question 12 is focused on the project related factors which can impact to the accuracy of effort estimation except above mentioned size metrics. As per the results, scope of the project, type of the software system developed were main factors affecting the accuracy. Further, following deductions could be made based on the results obtained.

- Estimating relative effort is accurate more than estimating absolute effort.
- Unclear, unstable, and miss-documented requirements decrease the accuracy of the effort estimation.
- Estimations conducted as smaller tasks provides more accuracy than large tasks.
- Estimations are more accurate when estimation is done by the same team who are also responsible for development.

After the analysis of the feedback obtained for Question 13, few of commonly received suggestions were summarized as follows.

- It is important to involve the assigned person(s) for
- the task during estimation.
- Considering of the performance of employees assigned for the task is important.

- It is important to have clear requirements and client involvement.
- It is important to create and use planning documents, such as specifications and project plans.

Further an advanced statistical analysis was conducted with the objective of finding any available relationships between the identified factors and estimation accuracy, and estimation techniques. Thus, a correlation analysis and a multiple linear regression analysis were conducted. For the correlation analysis average value of responses for the communication factors, team expertise factors, and social factors were used to compared with Expert Judgment, Planning poker, and Use Case points techniques. Result of the analysis showed that all the three types of factors have a high correlation with "Planning Poker" technique. But when considering the "Expert Judgment" and "Use Case Points" techniques only communication and team expertise factors have a high correlation and social factors do not affect hugely for effort estimation accuracy. With the integration of results of correlation analysis and the results of the linear regression analysis, a conceptual model for effort estimation was constructed illustrated as in Figure 1.

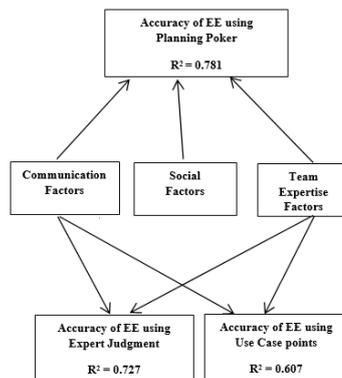


Figure 1: Proposed conceptual model for effort estimation

V. DISCUSSION AND CONCLUSION

In response to the dynamic business environments, most of the software development organizations have now shifted to ASD from traditional plan driven development approaches. Estimations and planning in agile approaches happens progressively due to its iterative nature. Effective planning requires accurate and reliable

estimates. The objective of this research study was to investigate the status of the practice of agile effort estimation in the Sri Lankan context. In this study a survey-based research methodology was adopted. Thus, feedback to online questionnaire survey was obtained from industrial professionals with an exposure to ASD. Collected data were analyzed using several advanced statistical methods. As per the results SCRUM is most widely adopted ASD methodology while Expert Judgment is the most used and most accurate effort estimation technique followed by Planning Poker and Use Case Points. Accuracy of all above techniques highly depends on the team's communication strength and the team's expertise in ASD and additionally, social factors also affect in the Planning Poker technique. Finally, a conceptual model for agile effort estimation was proposed. Also based on the suggestions of responders, new set of factors affecting estimation accuracy could be identified. In future works we are planning to integrate the newly identified factors to this conceptual model and validate it through industrial application.

REFERENCES

- Britto, R., Usman, M. and Mendes, E. (2014) 'Effort estimation in agile global software development context', Lecture Notes in Business Information Processing, 199, pp. 182-192. doi: 10.1007/978-3-319-14358-3_15.
- Canedo, E. D. et al. (2018) 'Methods for estimating agile software projects: Systematic literature review', Proceedings of the International Conference on Software Engineering and Knowledge Engineering, SEKE, 2018-July(July), pp. 34-39. doi: 10.18293/SEKE2018-031.
- Cohn, M. (2005) 'Agile Estimating and Planning', Pearson Education.
- Darrin, M. A. G. and Devereux, W. S. (2017) 'The Agile Manifesto, design thinking and systems engineering', 11th Annual IEEE International Systems Conference, SysCon 2017 - Proceedings. doi: 10.1109/SYSCON.2017.7934765.
- K.R (2017) 'Know all about Sprint Planning Agile Estimation under 6 minutes', [Online]. Available: <https://www.youtube.com/watch?v=cR63BbmyUpk>.
- Kim, Y. S. (2007) 'Analyzing scrum agile software development with development process, social factor,

and project management lenses', Association for Information Systems - 13th Americas Conference on Information Systems, AMCIS 2007: Reaching New Heights, 3, pp. 1937–1945.

Nazir, N., Hasteer, N. and Bansal, A. (2016) 'A survey on agile practices in the Indian IT industry', Proceedings of the 2016 6th International Conference - Cloud System and Big Data Engineering, Confluence 2016, pp. 635–640. doi: 10.1109/CONFLUENCE.2016.7508196.

Orel, M. (2020) 'Supporting work–life balance with the use of coworking spaces', Equality, Diversity and Inclusion, 39(5), pp. 549–565. doi: 10.1108/EDI-01-2019-0038.

R. Popli and N. Chauhan (2013) 'A sprint-point based estimation technique in scrum', Proc. 2013 Int. Conf. Inf. Syst. Comput. Networks, ISCON 2013, pp. 98–103, 2013, doi: 10.1109/ICISCON.2013.6524182

Tuli, A. et al. (2014) 'Empirical investigation of agile software development', ACM SIGSOFT Software Engineering Notes, 39(4), pp. 1–6. doi: 10.1145/2632434.2632447

Usman, M. et al. (2014) 'Effort estimation in Agile Software Development: A systematic literature review', ACM International Conference Proceeding Series, pp. 82–91. doi: 10.1145/2639490.2639503.

Usman, M. et al. (2018) 'Effort estimation in large-scale software development: An industrial case study', Information and Software Technology, 99, pp. 21–40. doi: 10.1016/j.infsof.2018.02.009.

Usman, M., Mendes, E. and Börstler, J. (2015) 'Effort estimation in Agile software development: A survey on the state of the practice', ACM International Conference Proceeding Series, 27- 29-April. doi: 10.1145/2745802.2745813.

ABBREVIATIONS AND SPECIFIC SYMBOLS

ASD – “Agile Software Development” FDD – “Feature Driven Development” XP – “Xtreme Programming”

EE – “Effort Estimation”

MREE – “Mean Magnitude of Relative Error” MRE – “Magnitude Relative Error”

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