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A Case Study Research on Software Cost Estimation Using Experts' Estimates, Wideband Delphi, and Planning Poker Technique

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Abstract

This Article shows a Case Study research that is performed to compare effectiveness of the Planning Poker and Wideband Delphi in two case studies. Although, Wide Band Delphi has been proposed many years ago and has enough supports in both industry and academic area but, Planning Poker is somewhat new. The study showed that applying these techniques in *two companies which were using expert's view for software cost estimation, increased the accuracy of cost estimation*. Also, the results showed that Planning Poker led to better accuracy comparing to Wideband Delphi. However, this accuracy is not too much than Wideband Delphi, it was important that Planning Poker led to reducing financial risks of the projects comparing to Wideband Delphi. The study also showed that both Wideband Delphi and Planning Poker reduced the underestimates significantly.

Keywords: *Software Cost Estimation, Wideband Delphi, Planning Poker, Expert's view, Case Study, Expert's judgment, Agile Software Development*

1. Introduction

Software cost estimation has been a challenge for software industry for software companies for a long time. Accurate cost estimation helps software companies making money and avoiding loss of money[1]. Especially in competitive economy, offering the best price leads to gaining more business benefits and customer's satisfaction. Literature review showed that more projects are doomed from poor cost and schedule estimates than they ever are from technical, political, or development team problems. This reflects the importance of cost estimation in software context. Indeed, it should be considered as a science rather than an art [2].

Primary way to estimate cost of software is estimating the efforts needed to develop and complete that software package [1]. So far, many estimating method have been proposed and many studies have been conducted on effectiveness of them. However, since there are many factors influencing the cost estimation process, none of the methods is perfect or completely accurate. Furthermore, most of the companies prefer to use their historical data in cost estimation than using well-know methods.

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The more popular software cost estimation models are Wideband Delphi, COCOMO, COCOMO II, Function Point, etc. [3]. However, each of them has their own advantages and disadvantages. Generally, in small and medium projects, experts try to estimate the required effort based on their experience. In this case, they review the user requirements carefully and based on the requirements, predict the required effort to develop the software packages.

In this article, software cost estimation in two case studies is discussed. Both of the companies had been used experts' view for cost estimation and they had recorded their estimations for more than 5 years. After that, they are using Wideband Delphi and planning poker. This article has focused on effectiveness on the newly used techniques in these companies.

The rest of this article is organized as: Section 2 presents a brief introduction of experts' judgment for software cost estimation, followed by Section 3 which presents an introduction about Wideband Delphi and Planning Poker. Section 4 presents a detail procedure of the research. Section 5 provides the results of the study. Section 6 presents a discussion on the findings. Section 6 presents limitations of the study, and finally Section 8 concludes the article and suggests the future work.

2. Experts' Cost Estimation

Since inception of software industry software experts or senior software engineers have been responsible for estimation of software size and cost. Their experience in contexts directs them to estimate human effort required for completing of a software package. However, their judgment most often is helpful only in the companies they work in, mainly because such a prediction strongly depends on team experience, project complexity, organizational culture, and so on. Clearly, experts' judgment (experts' view) is prone to bias and strongly is subject to human error. Nonetheless, for small or medium projects is useful, especially in companies that development teams and project domains did not experience significant changes.

3. Wideband Delphi

This method is a team-based software cost estimation technique which required effort is estimated based on the team consensus [1, 4]. This method is widely used when work breakdown structure (WBS) is the basis of the cost estimation. Also, it is used for estimating quality indirectly, as software development effort is encompassed by Cost of quality, Creation, Appraisal, and Cost of poor quality.

The Wideband Delphi in software engineering at the first time was proposed by Barry Boehm and John Farquhar in 1970s. However, the classic Delphi approach was proposed several years ago [1]. The Wideband Delphi put more emphasis on more communication and more interaction between participants comparing to the classic approach[1]. Boehm in his book described the procedure of applying Wideband Delphi in a software project [1]. This procedure can be summarized as below:

- 1- Team selection: Software project manager, called coordinator, is responsible to collect a team involving customer representative and technical team members.
- 2- Kickoff meeting: As the first meeting, team members try to create a WBS and discuss the assumptions.
- 3- Individual preparation: Each team member creates an effort estimate for each task and fills in the required forms.

4- Estimation session: Coordinator distributes the estimates and highest and lowest estimates are asked to justify. Team members can revise their estimates.

5- Assemble tasks: Coordinator assembles the project tasks and their individual estimates into a single master task list and achieve consensus.

6- Review results: As the final step of the estimation process, coordinator along with the other team members review the overall estimate to check whether it makes sense or not and also they discuss about the improvement of the cost estimation procedure.

The most important advantages of this process are: a) simplicity of the process b) All assumptions are discussed, agreed and documented. c) People who would participate in development collaborate on estimation. d) Generally, consensus-based estimates are more reliable and accurate comparing to individual estimates [5].

However, this process is subject to the some disadvantages including: a) Management cooperation is too necessary, while sometimes is not available. b) It requires agreement among the team c) The estimates depend on the team experience.

Focusing on the advantages, it seems that most often this method brings more accurate and reliable estimates than experts' estimates. This fact is laid down in the team consensus on effort estimates[6, 7].

4. Planning Poker Method

Planning Poker, like Wideband Delphi is a consensus-based estimation effort. This method initially was proposed by J. Grenning in 2002 [8] and later was popularized by M. Cohn in his book in 2005 [7]. He, who is a famous author of Scrum, suggested application of Planning Poker in cost estimation in Agile software Development and believed that such a method is completely consistent with people-oriented approach of Agile software development [9]. However, this method can be used in both Agile and disciplined (Waterfall-based) software development methodologies.

Contrary to Wideband Delphi, estimates are limited to specific numbers (each number is written in a card). Each member is holding a deck of Planning Poker cards with values like 0, 1, 2, 3, 5, 8, 13, 20, 40 and 100, which is the sequence that are more popular[7, 10]. However, it is not a standard. Each value represents the number of story points, ideal days, or other units in which the team estimates. Story points refer to customer requirements and describe specific functionalities. Figure 1 shows a sample of card deck of Planning Poker.

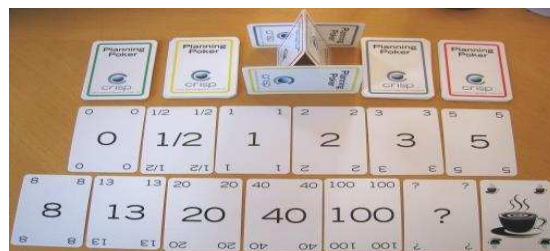


Figure 1. Planning Poker Cards

The estimators discuss the feature, asking questions of the customer representative, called product owner in Agile methods, as needed [11]. When the feature has been fully discussed, each estimator privately selects one card to represent his or her estimate. All cards are then revealed at the same time.

If all estimators selected the same value, that becomes the estimate. If not, the estimators discuss their estimates. The high and low estimators should especially share their reasons. After further discussion, each estimator reselects an estimate card, and all cards are again revealed at the same time [7].

The Planning Poker process is repeated until consensus is achieved or until the estimators decide that agile estimating and planning of a particular item needs to be deferred until additional information can be acquired.

5. Case Studies and Experiments

This study has used the recorded data from two companies, both have more than 15 years experience in software development. Because of confidentiality reasons, we referred to them as 'Case one' and 'Case two'.

Having about 20 years experience in software development, Case one was using RUP as the main development process in more than 10 software teams. Based on the organizational structure of the company, a group of experts involving 4 software experts had been responsible for cost estimation. However, from 2007, cost estimation was predicted using both experts' view and Wideband Delphi method. All the data has been recorded since then. Quotes were based on the Wideband Delphi and not expert's view.

Case two involved 5 development teams using RUP and 3 development teams using Scrum for software development process. They start using Planning Poker for cost estimation from 2009 in the all teams. However, three experts were responsible for this job and they also estimate each project concurrent with Planning Poker. In this company also, Quotes were based on the Planning Poker.

Table 1 and Table 2 show the recorded data in Case one and Case two. Projects are referred to as P1 to Pn and costs of them are estimated based on man-month required to complete them. Actual cost, experts' estimates and Wideband Delphi estimates are presented in these tables. Also, Actual error have been calculated and presented in highlighted columns. Actual error is magnitude of difference between actual and estimated cost.

Based on the Table 1, it seems that generally Wideband Delphi has led to better cost estimation. However, in a few projects like P1, P11 and P14 experts' estimates were better than Wideband Delphi.

Based on the Table 2, using Planning Poker method has led to better cost estimation. However, in a few projects experts predicted the cost more accurately (P1, P2). Since this condition happened in two initial projects, one logical reason can be little experience of team in applying Planning Poker in initial projects.

Table 1. Recorded Data in Case One

Project	Actual cost	Experts' estimates	Actual error	Wideband Delphi	Actual error
P1	32	29	3	37	5
P2	98	89	9	93	6
P3	48	45	3	50	2
P4	38	32	6	40	2
P5	24	18	6	25	1
P6	23	18	5	24	2
P7	38	29	9	33	5
P8	55	50	5	60	5
P9	55	42	13	49	6

P10	38	27	11	34	3
P11	115	120	5	105	10
P12	97	87	10	95	2
P13	48	38	10	50	2
P14	42	41	1	36	7
P15	55	60	5	58	3
P16	62	49	13	59	3
P17	45	40	5	48	3

Table 2. Recorded Data in Case Two

Project	Actual cost	Experts' estimates	Actual error	Planning Poker	Actual error
P1	45	41	4	40	5
P2	25	21	4	20	5
P3	73	80	7	70	3
P4	53	60	7	56	3
P5	25	33	4	28	1
P6	46	51	5	50	4
P7	39	33	6	45	6
P8	44	40	4	48	4
P9	17	12	5	20	5
P10	76	70	6	80	4
P11	41	40	1	41	0
P12	23	18	5	20	3
P13	98	86	12	100	2
P14	33	30	3	35	2
P15	56	52	4	58	2

6. Discussion

The recorded data showed that in both case studies, applying collaborative based estimation techniques (Wideband Delphi and Planning Poker) has led to more accurate estimates. Detail discussion about the real reasons of this fact is beyond the scope of this paper and need a qualitative in-depth research. Meanwhile, focusing on the collected data can highlight the advantages of using aforementioned methods instead of traditional cost estimation way, Experts' view. However, as mentioned previously, sometimes experts had estimated the cost more accurately than mentioned methods.

6.1. Estimation Error

Estimation error is a good measurement for comparing different estimation approaches. Using Magnitude Relative Error (MRE), Table 3 and Table 4 show the percentage of estimation errors in Case one and Case two respectively.

$$MRE = (|actual - estimated|) / actual$$

Based on Table 3, the average estimation error for experts' estimates in terms of MRE was 14.8% that is relatively high. Also, when the company used Wideband Delphi, the mean estimation error was 7.6% that is about half of the error estimation when experts had estimated. This shows that Wideband Delphi is so better than expert's views.

Table 3. Percentage of Relative Error in Case One

Project	Experts' estimates			Wideband Delphi		
	MRE	Over-estimate	Under-estimate	MRE	Over-estimate	Under-estimate
P1	9.4		-9.4	15.6	15.6	
P2	9.2		-9.2	5.1		-5.1
P3	6.3		-6.3	4.2	4.2	
P4	15.8		-15.8	5.3	5.3	
P5	25		-25.0	4.2	4.2	
P6	21.7		-21.7	4.3	4.3	
P7	23.7		-23.7	13.2		-13.2
P8	9.1		-9.1	9.1	9.1	
P9	23.6		-23.6	10.9		-10.9
P10	28.9		-28.9	10.5		-10.5
P11	4.3	4.3		8.7		-8.7
P12	10.3		-10.3	2.1		-2.1
P13	20.8		-20.8	4.2	4.2	
P14	2.4		-2.4	14.3		-14.3
P15	9.1	9.1		5.5	5.5	
P16	21		-21.0	4.8		-4.8
P17	11.1		-11.1	6.7	6.7	

The fact behind this is that, the collaboration of people and discussion between team members and customer representative give a good opportunity for understanding the scope of the functionalities that should be involved in the final software package.

Based on the Table IV, the average of estimation error of experts' view in Case two was 12.4%. This number when using Planning Poker was 7.1% that shows the better performance of Planning Poker comparing to experts' view.

Table 4. Percentage of Relative Error in Case Two

Project	Experts' estimates			Planning Poker		
	MRE	Over-estimate	Under-estimate	MRE	Over-estimate	Under-estimate
P1	8.9		-8.9	11.1		-11.1
P2	16		-16.0	16.0		-16.0
P3	9.6	9.6		4.1		-4.1
P4	13.2	13.2		5.7	5.7	
P5	13.8		-13.8	3.4		-3.4
P6	10.9	10.9		8.7	8.7	
P7	15.4		-15.4	5.1	5.1	
P8	9.1		-9.1	9.1	9.1	
P9	29.4		-29.4	11.8	11.8	
P10	7.9		-7.9	5.3	5.3	
P11	2.4		-2.4	0.0	0.0	
P12	21.7		-21.7	13.0		-13.0

P13	12.2		-12.2	3.1	3.1	
P14	9.1		-9.1	6.1	6.1	
P15	7.1		-7.1	3.6	3.6	

6.2. Overestimate vs. Underestimate

At the previous section, error estimation solely was discussed, while from business approach, the type of the error estimation is so important. Generally, an estimate can be over or under the actual effort needed to develop a software package or complete a software project. Although both overestimate and underestimate are harmful, underestimate leads to financial loss. Overestimate can lead to reducing chance of getting a project; however, if company succeeds in getting project, it leads to more financial benefit. In contrary, underestimate definitely leads to financial loss.

With respect to the above discussion, focusing of type of error estimation is so important. Figure 2 and Figure 3 depicts the comparison of experts' estimation, Wideband Delphi, and Planning Poker. Based on the figures, it seems that both Wideband Delphi and Planning Poker led to more overestimate comparing to experts' estimates. Indeed, these models from business perspective have better financial benefits or at least lead to less financial loss. This is the where managers prefer to use team members estimation rather than experts [12, 13].

Focusing on the above finding, there is significant point that more researches can be done on over and under estimation of the popular estimation methods, especially when the economy economic situation has become more difficult all over the world [14].

Continuing the analysis of this part, Table 3 shows that in Case one, experts had estimated 109 man-month effort less than the actual effort and 10 man-month effort more than the actual effort during the period of the study. In this company, team members using Wideband Delphi have estimated 41 man-month underestimate and 24 man-month overestimate. This reflects the better performance of Wideband Delphi in reducing underestimate cost prediction.

In case two, as identified in Table 4, experts had estimated 58 man-month underestimate and 19 man-month overestimate. At the same time, using Planning Poker, team members had estimated 16 man-month underestimate and 26 man-month overestimate. In this case study also Planning Poker led to less underestimate.

It should be noted that this research cannot judge about negative effect or risks of the Wideband Delphi and Planning Poker, since the only available data was regarded to recorded cost estimation tasks. However, there are some points about the risks and negative effects of the both method [15-17].

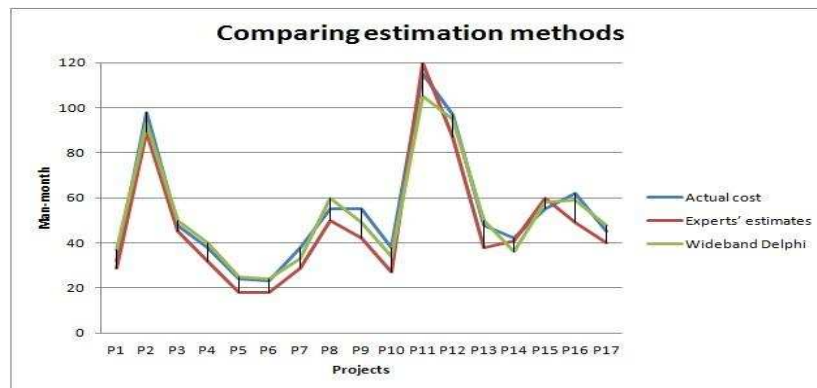


Figure 2. Comparing Estimation Methods in Case One

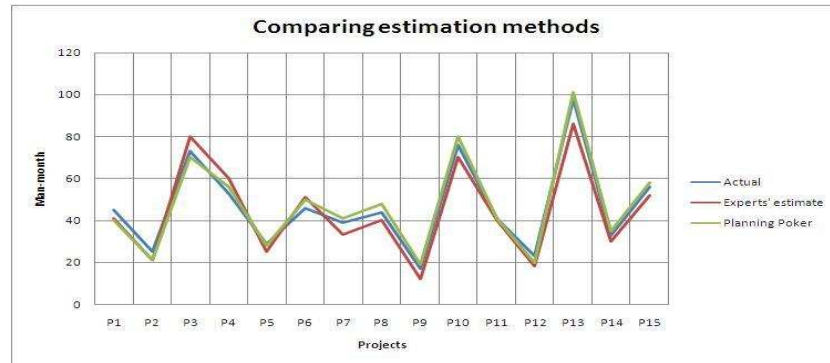


Figure 3. Comparing Estimation Methods in Case Two

6.3. Wideband Delphi vs. Planning Poker

Comparing these methods need enough attention on the environment. There are lots of factors that may affect the comparison of these methods such as team experience, projects complexity, team collaboration, and so forth. Thus, comparing these methods through this study is impossible, since the environments of the two case studies were different, judgment about projects complexity is impossible, and also team experience and collaboration were different in the companies. Nonetheless, comparing the results of Case one and two with each other may help the readers to build a rough perception about comparing two methods.

Table 1 and 3 show that by considering both overestimates and underestimates, Case one experts' estimates were 99 man-month less than the actual man-month (total actual = 913), that means the company could have faced with a 10.8 % loss. But, since they had used Wideband Delphi, their predictions led to 17 man-month underestimates, means 1.9% loss. However, such a small percentages can be compensated during a period of time or by reducing the expected benefit

Similarly, Table 2 and 4 show that in Case two, experts' estimates were 39 man-month less than actual effort (total actual = 698), that means the company could have faced with a 5.6% loss. Similarly they used Planning Poker to contract the projects. Applying Planning Poker led to 10 man-month overestimate that means during the mentioned period, they had 1.4% extra benefit.

7. Limitations

The above discussion shows that both Wideband Delphi and Planning Poker in this Case Study research are better than experts' estimation. However, this generalizing the findings of this article is a debate. Like any other Case Study, generalization is challenge. But, at least the findings can be helpful for both of the aforementioned companies[18].

8. Conclusion and Future Work

Conducting a Case Study involving two software companies, three cost estimation methods were compared. Both companies had used experts to estimate cost of project for a long time, and started to use Wideband Delphi and Planning Poker concurrent with experts' estimates. The recorded data showed that Both Wideband Delphi and Planning Poker had helped companies to estimate the cost of the projects more accurate than experts. Data analysis showed that Wideband Delphi and Planning Poker caused to reducing underestimate

which is a good achievement for companies and could lead to reducing financial risks of estimation.

Furthermore, however comparing Wideband Delphi and Planning Poker based on the case studies is not possible, but evidence showed that Planning Poker led to financial extra benefit comparing to Wideband Delphi.

Extending this study can be applying both Wideband Delphi and Planning Poker simultaneously in a same case study and comparing the results. Only in this way, the researcher can do judgment about comparison of these methods. Also, during a qualitative study and based on the team members' viewpoints Wideband Delphi and Planning Poker can be compared with each other well.

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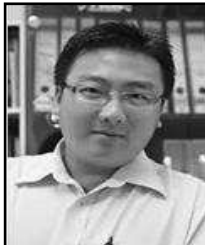
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