Software Certification Implementation: Case Studies Analysis And Findings

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Abstract

Continuous improvement in software quality is an essential concern in software industry. One way to guarantee this continuous improvement is through imposing certification environment. Current studies show that certification of software products are feasible and demonstrate the practicality of the implementation in real situation. Two main models were developed based on end product and process development approach of certification. These models have been tested in three real case studies involving three large organizations in Malaysia. The result of the studies shows that the proposed models and underlying attributes and metrics are appropriate to be gathered and collected during assessment and certification exercises. By having a successful applicable of the case studies show that the models are feasible and practical in the real world environment. Favourable evaluations from the organisations via the software owners enrich the validity and integrity of the model. This paper focuses on implementation of certification model by end product quality approach.

1. Introduction

In recent years, there has been an increasing interest in software development and quality. One of the reasons is because ICT and software have become a central focus for survival. At the same time users and practitioners in this industry are addressing issues regarding software quality. Among them are: (i) determining the quality of software product; (ii) defining mechanism for assessing software product quality; (iii) ensuring and offering software quality guarantee; and (iv) ensuring the continuous improvement of quality of software product. Users concern with the quality of software delivered to them and they expect software are in good quality that meet certain standard. Based on studies conducted in Malaysia, software quality issues are considered as important and critical because on the uncertainties situation among stakeholders, users and suppliers to guarantee and assure the status of the software products [8][9]. Therefore, a standard mechanism for assessment and certification is required to resolve these uncertainties. The development of software certification model is beneficial not only to the users but also to the vendor and stakeholders as well.

Certification of software product can be implemented in three approaches, which by means of process, product and personnel. This is also known as certification triangle [10]. Our certification research focuses on two perspectives viz process and product approaches. This paper presents the research effort in application and evaluation of the certification model to real case studies based on product quality approach. The case studies were launched collaboratively with three large public sector organizations in Malaysia, and named as Case X, Case Y and Case Z respectively.

The objectives of these studies are to test the feasibility, practicality and integrity of certification model in the real environment. In terms of feasibility and practicality, the quality metrics adopted in the certification model named as SCM_*prod* model should be understandable and answerable by the responsible assessor. The metrics should be capable to be gathered and collected during assessment exercise. By having a successful applicable of the case studies show that the model is feasible and practical in the real world environment. Furthermore, by looking at analysis and results provided by the application, users are able to assess and evaluate the model to justify whether the model reflects the real quality picture of the software.

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Favourable evaluation from the organisation via the software owners enriches the validity and integrity of the model.

2. Software Product Certification Model (SCfM_*Prod* Model)

The software certification model based on end product quality approach or SCfM_*prod* model proposed in this research consists of pragmatic quality factor (PQF), assessment team, weighted scoring method (WSM), decision process, repository and certification representation method. PQF is the quality assessment guidelines that consists of several software quality attributes. Undertaking quality attributes defined in ISO9126 model as the based line of the assessment metrics, we define two sets of attributes, which by means of the behavioural and the impact attributes. The behavioural attributes consist of high level software quality characteristics, which include usability, functionality, maintainability, portability, integrity and reliability. Previous study shows that quality attributes can be classified into different levels and weight [2][3]. The impact attributes indicate the conformance in user requirements, expectation and perception. These two groups of attributes are important to balance the assessment between the technical aspects of quality and human factors.

Another aspects of this model are the assessment team that involve in the assessment exercise and the certification representation method. The certification representation method explains how the certification will be implemented and consists of algorithms and methods for certification. In this method there are two main certification approaches. First approach is to assess and certify based on individual attributes defined in PQF while second approach is to assess and certify product as a whole. Figure 1 illustrates the model. The detail of this model can also be referred in [1][2][3][4].

3. Case Study: Assessment on Software Product X, Y and Z

3.1 Case Studies Profile

In this research, Case X is categorized as a large public sector organization in Malaysia. Organisation X is operated in Kuala Lumpur and connected to branches in other cities throughout the country. Software product X was selected by organisation X based on the stability and being used comprehensively by the users from various departments in the organization. It was developed jointly with a private sector software company. Product X was operated for six months in the environment at the time of assessment. The selected product X is a human resource system (HRS) that consists of eight main modules. The modules are: services and personnel, payroll, leave, medical, training and career, loan, internal affairs and others.

The second case study, Case Y, was conducted in collaboration with a government hospital in Selangor, Malaysia. It is a reference centre for the whole country. The hospital provides up-to-date and advanced medical services and capable of providing excellent medical services. Hospital Information System or software product Y was developed by an internal team in the Information Technology Centre with collaboration and support from domain expert users from various departments of the hospital. It was developed in 2004. The first phase of this software was ready to be assessed and ENT Clinic was the pioneer user of this software. The software was only a month in operation during the assessment period. Product Y is a web based application and able to be assessed by users at any location in the hospital. Modules included in the first phase are as follows : - 1) Registration & ED Module: For patient registration, 2) Appointment module: For handling information on patient's appointment and accommodating appointment slots, 3) Admission, Transfer and Discharge (ADT) module. This module is used to handle information on bed ordering, ward admission and transfer. 4) OT Scheduling Module: This module functions to manage operation theatres reservation by doctors, 5) Medical Record Module: It functions to handle and manage patients file movement in the hospital.

Case Z is a semi-government organization that operates in higher learning educational sector. Software product Z was developed in-house by a team in ICT center of Case Z. It incorporates most of the organization's specific requirements of the software. Software Z is a staff information system with complex functions and tasks to meet specific requirements of organization Z including services, personnel, management and training.

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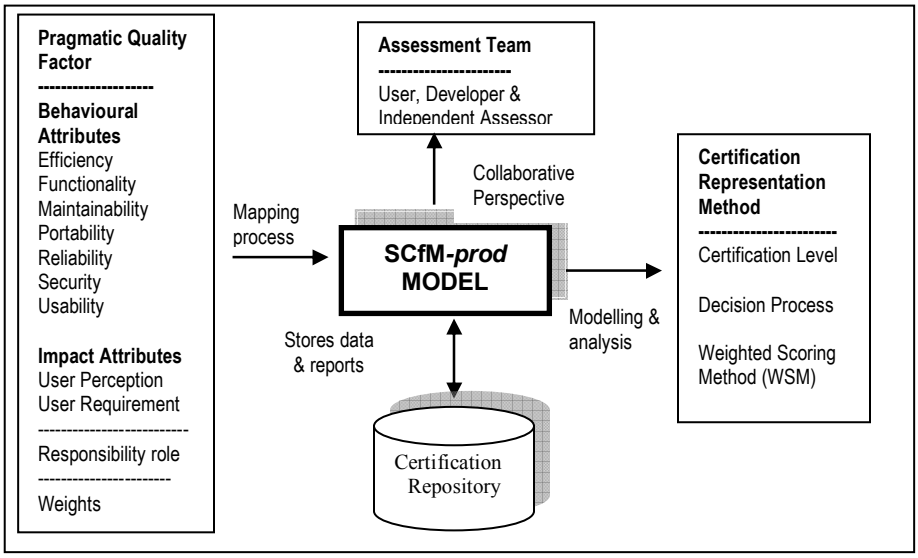

Figure 1. SCfM_Prod : Certification Model by Product Quality Approach

3.2 Translation on Case Study

The case study applied several series of interviews, discussions, demonstrations and on-line testing. These activities were done collaboratively among independent assessor, users and developers. The case studies were conducted in three main phases.

a) Phase 1: Prior to Assessment

In this phase, candidate product was chosen as the target software product by the owner and approved by the management and stakeholder. Main users and developers were identified and the independent assessor led the team of the assessment. The first meeting was held with all team members to explain the activities, tasks and responsibilities in this exercise. In this phase, weight factors of each attribute were identified and assigned by the product owners. The weight factors are shown in Table 1.

b) Phase 2: During Assessment

Table 1. Attribute's weight factor

Attributes	Range of Weight Factor	Case X	Case Y	Case Z
Portability	1 to 4	1	4	3
Efficiency	5 to 7	7	7	7
Maintainability		5	7	7
Usability		5	7	7
Functionality	8 to 10	10	9	10
Reliability		8	9	10
Integrity		9	10	10

Interviews were conducted 'face-to-face' to gather information and data regarding of the quality of products. The setup items in this interview were based on the proposed model and were discussed in separate document [1]. System demonstration and on-line testing were conducted with the presence of direct users and the owner of products. This is to ensure and to protect privacy and confidentiality of the data. Document checking was another important task in this phase which involved two main documents; user manual and design specification.

c) Phase 3: Post Assessment

Once gathered and collected in phase two, data was analysed, prepared and presented in reports and graphical representations. The graphical representations are encouraged and required to illustrate readable and understandable results to clients. Such graphical representations are kiviat graph, line chart and etc.

3.3 Analysis

This section explains the analysis and findings from data analysis. The finding from the analysis of quality attributes is shown in kiviat graphs in Figure 2. Each

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attribute is represented by axis and scores are plotted at the limits between 0-100%. Kiviat graph can be used to easily identify attributes that need attention in this process. Attribute that fall on the limit's outer layer is considered better quality compares to attributes at inner layers of this graph.

In Case X, efficiency and integrity fall in better quality level compared with maintainability, usability and portability. In Case Y, efficiency, functionality, integrity, portability and user conformity fall in better quality level compared to maintainability, reliability and usability. In Case Z, functionality, efficiency, reliability, portability and the impact attribute, user conformity fall in better quality level compared to maintainability, portability, and usability.

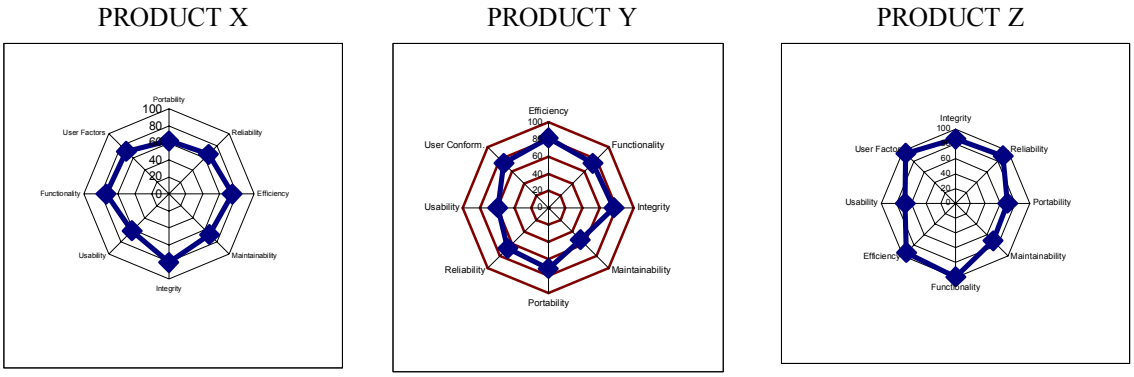

Figure 2. Kiviat graphs show the scores of attributes.

The line chart in Figure 3 demonstrates scores obtained by each attribute, which is broken down into several sub-attributes. The chart shows that some of the sub-attributes require consideration for future improvement of the system. This analysis demonstrates the actual score obtained by each attributes. Each quality attributes has a possibility to obtain score between 1 to 5 according to Likert scale. For example, maintainability attribute consists of sub-attributes analysability, changeability, and testability. Unlike testability, analysability and changeability obtained lower scores, which are less than 3.00/5.00, thus require more attention and consideration for better quality software.

Table 2 shows the final analysis and result of Case Y. This analysis is to obtain certification level of this software as one product. Column 1 refers to the maximum value of each score by respondents. Column 2 refers to the weight values given by the owner of the software or any appointed individual, Column 3 is the average score obtained by this assessment. Based on the weight assigned, scores are calculated (see [1] for detail) as shown in column 4. Final values (column 5) are the computed values of quality score obtained according to attributes. In this case, the score for behavioural attributes is 69.4% and the total quality score of this product is 71.3%.

Similar calculation is carried out for Case X and Case Z. The following section discuses the findings of these case studies.

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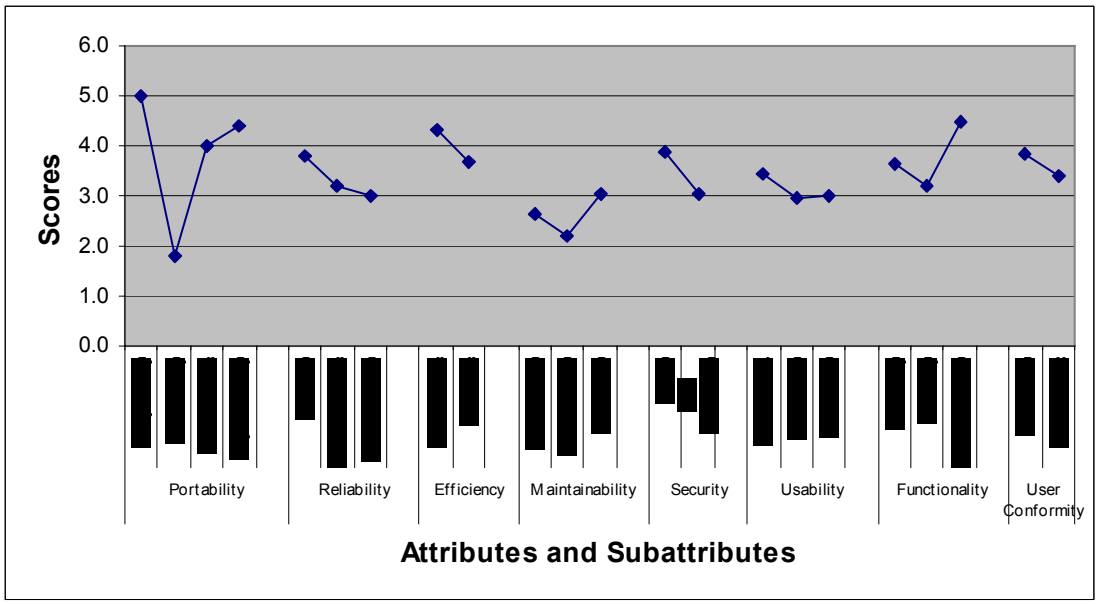

Figure 3. Line chart of scores and attributes and subattributes of product Y

Table 2. Assessment Analysis of Product Y

Behavioural Attributes	Max Value	Weight	Score Obtained	Score	Quality Score (%)
	(1)	(2)	(3)	(4)	(5)
Efficiency	5	7	4.08	0.539	10.8
Functionality	5	9	3.69	0.627	12.5
Maintainability	5	7	2.66	0.351	7.0
Portability	5	4	3.55	0.268	5.4
Reliability	5	9	3.36	0.571	11.4
Usability	5	7	2.95	0.390	7.8
Integrity	5	10	3.83	0.723	14.5
TOTAL		53		3.469	69.4
The Impact					
User Conformity					73.3
Total Product					**71.3**

4 Discussion

Previous sections discussed the application of the model in three real case studies. This section draws upon the discussion of the results by comparing the three case studies.

4.1 Software Product X, Y and Z

The first discussion is dealing with the comparison of the results of software products. It is useful to tabulate the results in the previous sections into a summary table for clarity. The summary of all the results is shown in Table 3.

Product X of Case X was six months old during the assessment period. This product was developed thru out-sourcing and jointly with another software company. The result shows that product X achieved level 2 of certification with score of 70.08/100, which refers to *basic and acceptable*. Product Y of Case Y was only one month old during assessment period. It was developed in house by internal IT professionals with collaboration and supported by domain expert users from various departments in the organization. The result shows that product Y achieved level 2 of certification with score of 71.3/100, which refers to *basic and acceptable*. Whereas product Z of Case Z

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has been operated for more than ten years in the environment. Product Z was developed by in-house professionals and experts within the organisation. The result shows that this product achieved level 4 of certification with score of 90.1/100, which refers to *excellent*.

There are at least two factors to be considered that influenced the certification level of a software product candidate. The two factors are the operation period in the environment of the candidate and second, the weight factors of attributes assigned by the owner of the candidate product. The studies show that the longer the operating period of the software the better result of quality and certification level can be achieved. Clearly, this is true because the software has been updated and corrected accordingly and necessarily by the developers. This relates to the issue of maturity of the software. On the other hand, if the certification exercise is conducted periodically over some time intervals, an unexpected result may be seen because of the aging of the software [7].

The second aspect that influences the result is the weight factors of the product. Without assigning weights factors to quality attributes, the results may indicate different level of certification. Thus, this model accommodates weight factors for all attributes with different level of importance to reflect individual business requirements [6]. It is important that the weight factors are identified and assigned accordingly by the owner of the product to reflect the actual quality status of the software based on the organization requirements and constraints.

4.2 Individual Quality Attributes

In order to explore the individual quality attributes for three case studies, the results are tabulated in the summary table as displayed in Table 4.

From the analysis above, it shows that in these three separate cases, developers are less concerned and concentrated on the aspects of maintainability, portability and usability. These behavioural attributes obtain the lowest scores among other attributes and common for these three products.

4.3 Evaluation of the Model

The applications of the case studies have demonstrated the feasibility and practicality of the model. Upon completion of the assessment and certification exercise, the owner of the product was requested to evaluate the model by filling the evaluation and feedback form. The evaluation was to verify the integrity of the model. The owner of the product who was the representative of the organization gave feedback of the assessment and certification results. This feedback and evaluation form was meant to ensure that the owner of the product accepted the results and to verify that the results reflected the actual standing of the software product. If the owner of the software product disagreed with the results, they might give comments and suggestions in the form. In these case studies, all cases agreed with the certification and assessment results and therefore they verified the integrity and validity of this model.

5 Lesson Learned

Several lessons have been learned from the case studies as they were implemented and applied. In general, several aspects of the model requirements were found to be either inadequate or not feasible. Among those aspects which are significant are:

- The issues of data confidentiality and privacy are essential to consider. The owner of the product usually does not permit independent assessor to access the system and data alone. The direct and valid user must do the testing and this is a common phenomenon at any organizations.
- Secondly, some of the metrics defined in the model are not answerable by users alone thus require involvement from developers as well. Therefore, a collaborative perspective approach was introduced in this model.
- The studies witness that when evaluating software, the assessment does not deal with just extending and refining metrics but also faced with additional challenges in assigning weight for each attributes. This requirement is essential as not all attributes are of equal importance in real situations.
- In handling massive data on quality and involving rules and decisions, a support tool is required to assist in these tasks. Measuring and computing scores on quality for all attributes and sub-attributes using semi-automated system reveal errors and mistakes.
- The studies reveal that the overall model and mechanism of software product certification proposed in this research is feasible and practical to be implemented in real environment. The model is valid and of integrity through the evaluation by the case studies.

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Table 3. Comparisons of Cases X, Y and Z

Criteria	CASE X	CASE Y	CASE Z
Sector	Business	Health	Education/Higher Learning Institution
Software	Human Resource System	Hospital Information System	Staff Information System
Development Approach	Out-Source & Joint Development	In-house	In-house
Duration of Use	6 months	1 month	> 10 years
RESULTS OF ASSESSMENT AND CERTIFICATION			
Quality Score	70.08/100	71.3/100	90.1/100
Certification Level	2	2	4
Certification Status	Basic and Acceptable	Basic and Acceptable	Excellent

Table 4. Comparison of Quality Score obtained by Case X, Y and Z

		Case X	Case Y	Case Z
	Quality Attribute	**Score/5.00**	**Score/5.00**	**Score/5.00**
1	Efficiency	3.73(*74.6%*)	4.08 (*81.6%*)	4.70 (94.0%)
	Time behaviour	*3.56*	4.33	4.50
	Resource utilization	*4.00*	3.70	5.00
2	Functionality	3.62 (*72.4%*)	3.69 (*73.8%*)	4.96 (99.3%)
	Suitability	*3.83*	3.65	4.88
	Accuracy	*3.33*	3.20	5.00
	Interoperability	*3.63*	4.50	5.00
3	Maintainability	3.34 (*67.8%*)	2.66 (*53.2%*)	3.58 (71.6%)
	Analysability	*3.61*	2.63	3.05
	Changeability	*3.13*	2.20	3.25
	Testability	*2.83*	3.06	2.00
4	Portability	3.20 (*64.0%*)	3.55 (*71.0%*)	3.50 (70.0%)
	Adaptability	*3.56*	5.00	4.75
	Installability	*2.77*	1.80	2.60
	Conformance	*4.00*	4.80	5.00
	Replacebility	*3.33*	4.40	5.00
5	Reliability	3.30 (*66.0%*)	3.36 (*67.2%*)	4.50 (90.0%)
	Maturity	*3.83*	3.80	4.75
	Fault Tolerance	*3.00*	3.20	4.38
	Recoverability	*3.00*	3.00	4.33
6	Integrity	3.67 (*73.4%*)	3.83 (*76.6%*)	4.33 (86.7%)
	Security	*4.00*	3.87	4.33
	Data Protection	*3.33*	3.06	3.00
7	Usability	3.20 (*64.0%*)	2.95 (*59.0%*)	3.41 (68.2%)
	Understandability	*2.56*	3.44	2.72
	Learnability	*2.76*	2.93	3.40
	Operability	*3.70*	3.01	4.61
8	User Conformity	3.53 (*70.6%*)	3.67 (*73.4%*)	4.73 (94.7%)
	User's Perception	*3.56*	3.84	4.67
	User Requirement	*3.50*	3.40	4.83

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6 Conclusion

The proposed software certification model has been discussed and applied in the real case studies. This paper demonstrated the application of the model in three case studies viz Case X, Case Y and Case Z. The model has been refined and improved by incorporating the contributing factors associated with assessment technique and quality attributes and metrics. The measurement of quality attributes formulated during the design phase and subsequently applied during assessment phase support the model. The application on case studies has illustrated the practicality and feasibility of the proposed process steps and its conceptual model. The evaluation of the model by the software product's owner verified the integrity of the model. It is worth pointing out that the model is definitive, as the results from the application and evaluation process have confirmed and verified the model.

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