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Quality Indicators for Effective Component-Based Software Application Modernization

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ABSTRACT
Application modernization has become a key process in software production due to rapid and continuous technological changes in software production tools and operations which render most applications obsolete shortly after deployment, a situation requiring corresponding quick software process and product delivery to address the obsolesce issues. In dealing with this, component-based modernization is usually adopted because of its advantages like quick product delivery and enhanced product quality. Notably, not all modernized applications are of high quality as the quality of such applications are usually influenced by factors like quality of the reusable components and the process, skillset of the professionals just to mention but a few. Being that, the quality of components to be reused in modernization is key factor in producing quality products, there is need to always assess the quality of reusable components with respect to specific quality indicators before they are selected for reuse. To this effect, this article presents the impact of selected quality indicators of reusable components on modernized application as an outcome of a research undertaken in this regard. From the research findings, 94% of the respondents (software professionals) affirm that reusable components that are stable, reliable, well-structured, extensible and innovative when used in a quality-driven modernization process by experienced professionals are capable of producing high quality modernized applications.

Keywords:- Component-based Modernization, Reusable Components, Quality Attributes, Product Quality

I. INTRODUCTION

Component-based modernization has become a major area of concern to software engineers in recent times with the introduction of Component-based software engineering (CBSE). The modernization of applications along component lines will no doubt enhance quick process and product delivery. Although the need for application modernization is usually prompted by maintenance challenges posed by legacy related attributes like language obsoleteness, lack of relevant skillset in legacy language and tools, incomplete documentation and poor code structure [1], it is very important to ensure that modernized products are highly qualitative and free from maintenance impediments to guarantee their longevity.

As a word of caution, [2] maintains that modernization should only be contemplated and implemented where the product can no longer be evolved otherwise it will be counterproductive. The caution is further emphasized in [3], [4] and [5]. A product with evolving difficulty is already quality challenged. Dealing with such a challenge, implies dealing with quality issues. Therefore, the modernization of such a product should drive quality enhancement by removing impediments that would even mitigate against future modifications.

Some of the key quality attributes necessary in quality assessment of modernized products include reusability, extensibility, reliability, portability, and innovativeness [6]. The extent to which these attributes impact the overall quality of modernized products is worth considering. In [7], [8], [9], and [10], research findings relating to quality of modernized products have been presented with great emphasis on quality components extraction for reuse in modernization.

According to [11], [12], and [13], proper application of assessment and ranking techniques after successful extraction of components, could lead to the identification and selection of highly qualitative components for reuse. Most of these assessment and ranking techniques are based on components stability and reusability [14], whereas according to [15] and [16], not much is done in terms of assessment of the impacts of the quality attributes in the overall quality index of modernized products.

In view of the above, this research was undertaken to investigate the impacts of some selected quality indicators on the overall quality of component-based modernized products.

II. REVIEW OF RELATED RESEARCH WORKS

Success in a research of this magnitude require sound knowledge of achievements of related research works. To this effect, relevant research works presented in this section

were reviewed to gain further understanding of the research area and existing gaps to explore.

The RISE Maturity Model (RISE) in [17], is presented as a practical approach in achieving high quality products with attributes ranging from stability to understandability from software development projects in organizations where it is adopted.

In [18], research reports that list some quality attributes ranging from stability to adaptability as key attributes that influence components reusability in modernization are presented with further calls for more researches in maturity assessment since existing models were inadequate. Also, [16] presents the Reuse Capability Maturity Model (RCMM) that emphasizes proper planning and controlling of reusable components in projects.

In [11], a method that utilizes digraph principle in computing and ranking selected components for reuse is presented whereas [19] provides tips on how to measure the quality of software components selected for reuse in software development projects using selected software metrics necessary in reducing the time and efforts required in reusability process. Also, a technique for components selection for reuse based on cost evaluation of the quality attributes which emphasizes the selection and reuse of cost-effective components in modernization process is presented in [12].

In [14], key issues to consider when using relevant search engine in selecting web-based components for reuse are highlighted as well as a technique for ranking the selected components based on the search results. It also presents some of the key issues involved in enhancing components selection and support for pragmatic reuse together with some metrics useful in addressing such issues with some guides on how best to rank such components from the search results.

III. RESEARCH GAPS

The review of literature undertaken in this research indicates that most of the research work relating to the quality of reusable components and their impacts on the modernized products are mainly set to determine quality indicators for reusable components and how such could be used as guide in selecting quality components for reuse in software projects. Some of the quality indicators for reusable components as reported in relevant research reports include: Reusability attributes like stability, adaptability, completeness, maintainability and understandability [15].

Resulting from these researches, useful methods, models and approaches to assessing and ranking reusable components before they are selected for reuse in software projects have been proposed and even implemented in relevant projects as reported in [6], [16], [17] and [20].

Furthermore, [14] and [21] presents key issues in using relevant search engine to select web-based components for reuse together with a technique for ranking the selected components based on the search results.

In [13], [22] and [23], quality attributes to be considered in assessing the quality of components are presented to include Stability –attribute of a component that continues to function perfectly according to specifications despite modifications over the years from one version to another. Reliability– attribute of a component that makes it robust, fault-tolerant and highly available. Structural Independence – attribute of component that is self-contained which interaction with other components are through well-defined interfaces. Others include, extensibility – attribute of components that supports quick updates and code modifications to meet up with new functional requirements and emerging markets. Lastly, innovativeness – attribute of components that provides supports for new ideas, techniques and methods.

However, it is worth mentioning that, while approaches and methods that utilize these quality indicators have been implemented in relevant modernization projects, their impacts on the quality of the modernized applications have not been investigated to determine how effective they are, the challenges associated with the process and possible areas for improvements. This is a major gap identified which needs to be filled.

To this effect, there should be conscious efforts by researchers to find out the impacts of the different quality attributes of reusable components on modernized applications. Such findings could serve as a guide to professionals on what quality attributes to look out for in reusable components to be selected for reuse in modernization. In doing so, high quality of the modernized application could be guaranteed. This is the major focus of the research reported in this article.

IV. RESEARCH METHODOLOGY

The research work was designed as a survey research with the following processes:

i. Review of relevant documentations made to find out the level of achievements in the research area and to identify the research gaps.
ii. Stating of the Hypothesis based on the identified problems

iii. Design of the research instrument, in this case, questionnaire was used.
iv. Data Collection, Coding and Analysis
v. Results Validation through data triangulation
vi. Results Interpretation and discussions

V. RESEARCH HYPOTHESIS

The hypothesis for the research is given below:

H_0 = The quality of modernized legacy software from component-oriented reengineering technique does not depend on the quality of the legacy components extracted and repackaged for reuse in modernization.

VI. DATA COLLECTION

The views of sixty-one software practitioners were obtained through interview questionnaires to test the stated hypothesis. The snowball sampling method was used to identify practitioners with relevant experience. In this case, twenty-one (21) respondents with relevant experience in the research area were initially identified and asked to nominate other professionals with relevant experience necessary to participation in the research.

To this effect, forty (40) additional professionals were nominated and contacted accordingly making a total of sixty-one (61) respondents. Each respondent was interviewed to confirm their familiarity with the research area and later requested to respond to positivistic statements, which is Question 12 to Question 16 coded as Q12 to Q16 which focuses on the impacts of quality indicators on overall quality of modernized applications. The six multiple choices of linkert scale namely strongly agreed (SA), agreed (A), undecided (UD), dis-agreed (D), or strongly dis-agreed (SD) were used.

In order to validate the analysis results from interview data, survey questionnaires were also sent to another set of professionals via email, of which valid questionnaires from 107 respondents were returned and analyzed accordingly. Data collected through interview and questionnaires are presented in tables 1 and 2 respectively.

Table 1. Interviewees' Response to Impacts of components quality on modernized application

Question No.	Question	SA	A	UD	D	Total
Q12	Component-oriented re-engineering of legacy code that uses stable reusable components produces modernized software that are highly qualitative?	***41***	***20***	***0***	***0***	***61***
Q13	Component-oriented re-engineering of legacy code that uses reliable reusable components produces modernized software that are highly qualitative?	***42***	***16***	***0***	***3***	***61***
Q14	Component-oriented re-engineering of legacy code that uses well-structured reusable components produces modernized software that are highly qualitative?	***37***	***22***	***1***	***1***	***61***
Q15	Component-oriented re-engineering of legacy code that uses extensible reusable components produces modernized software that are	***42***	***16***	***3***	***0***	***61***

	highly qualitative?					
Q16	Component-oriented re-engineering of legacy code that uses innovation-driven components produces modernized software that are highly qualitative?	***31***	***30***	***0***	***0***	***61***
	Total	***193***	***104***	***4***	***4***	***305***

Table 2. Response to Email Survey Questionnaire on Impacts of Components Quality on Modernized Application

Question No.	Question	SA	A	UD	D	Total
Q12	Component-oriented re-engineering of legacy code that uses stable reusable components produces modernized software that are highly qualitative?	**64**	**41**	**2**	**0**	**107**
Q13	Component-oriented re-engineering of legacy code that uses reliable reusable components produces modernized software that are highly qualitative?	**58**	**44**	**3**	**2**	**107**
Q14	Component-oriented re-engineering of legacy code that uses well-structured reusable components produces modernized software that are highly qualitative?	**43**	**58**	**4**	**2**	**107**
Q15	Component-oriented re-engineering of legacy code that uses extensible reusable components produces modernized software that are highly qualitative?	**57**	**48**	**2**	**0**	**107**
Q16	Component-oriented re-engineering of legacy code that uses innovation-driven components produces modernized software that are highly qualitative?	**61**	**43**	**2**	**1**	**107**
	Total	**283**	**234**	**13**	**5**	**535**

VII. DATA ANALYSIS

The quantitative data were analyzed using Chi-squared test with the observed frequency table shown in table 3.

Table 3: Observed Frequency of the collected data

	SA	A	UD	D	Total
Q12	**41**	**20**	**0**	**0**	**61**
Q13	**42**	**16**	**0**	**3**	**61**
Q14	**37**	**22**	**1**	**1**	**61**
Q15	**42**	**16**	**3**	**0**	**61**
Q16	**31**	**30**	**0**	**0**	**61**
Total	**193**	**104**	**4**	**4**	**305**

Expected Frequency

The expected values were obtained using the expression

$$E_{ij} = \frac{r_i \, x \, c_j}{GT}$$

where i= 1 to 5 and j= 1 to 4; for instance

$$E_{11} = \frac{61 \, X \, 193}{305} = 38.6$$

Table 4: Calculated Values based on Collected Data

O_i	E_i	$(O_i - E_i)$	$(O_i - E_i)^2$	$(O_i - E_i)^2/E$

41	38.6	2.4	5.76	0.15
42	38.6	3.4	11.56	0.30
37	38.6	-1.6	2.56	0.07
42	38.6	3.4	11.56	0.30
31	38.6	-7.6	57.76	1.50
20	20.8	-0.8	0.64	0.03
16	20.8	-4.8	23.04	1.11
22	20.8	1.2	1.44	0.07
16	20.8	-4.8	23.04	1.11
30	20.8	9.2	84.64	4.07
0	0.8	-0.8	0.64	0.80
0	0.8	-0.8	0.64	0.80
1	0.8	0.2	0.04	0.05
3	0.8	2.2	4.84	6.05
0	0.8	-0.8	0.64	0.80
0	0.8	-0.8	0.64	0.80
3	0.8	2.2	4.84	6.05
1	0.8	0.2	0.04	0.05
0	0.8	-0.8	0.64	0.80
0	0.8	-0.8	0.64	0.80
χ^2_{cal}				25.70

Chi-squared test

Chi-squared calculated value = 25.7
Degree of freedom (df) = 12
Chi-squared tabulated value = 21.03

Decision

Since the χ^2_{cal} is greater than χ^2_{tab}, we reject the null hypothesis and accept the alternative hypothesis that the quality of a modernized legacy application from component-oriented reengineering technique depends on the quality of the legacy components extracted and repackaged for reuse in modernization.

VIII. RESULTS AND DISCUSSIONS

The results from the analysis and discussions are presented thus:

A) Impacts of Components Quality Indicators on Overall Quality of Modernized Application

The analysis result, where the χ^2_{cal} = 25.7 is greater than χ^2_{tab} = 21.03, implies that the null hypothesis should be rejected and the alternative hypothesis accepted. This clearly indicates that, the quality of a modernized legacy application obtained from component-based modernization depends on the quality of the extracted and repacked components with respective to the quality indicators of the components.

Where the extracted and repackaged components are such that are stable, reliable, structurally independent, extensible and innovative for instance, the resulting product is bound to possess those quality attributes which will result in a highly qualitative product.

Figure 1 which is the graphical representation of the views of the respondents on the impacts of specific quality indicators on the overall quality of the modernized product further confirms this with component stability and extensibility rated highest.

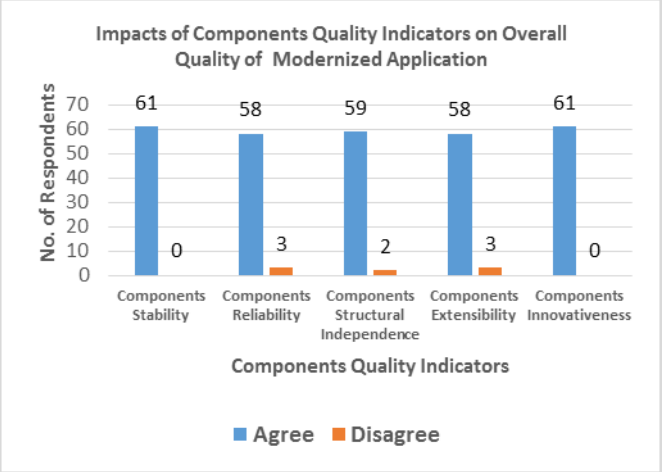

Fig. 1: Graphical Representation of Respondents Views (Interview Data)

The graphical representation of the validation data collected through e-mail survey questionnaire which also confirms interview results is given in figure 2.

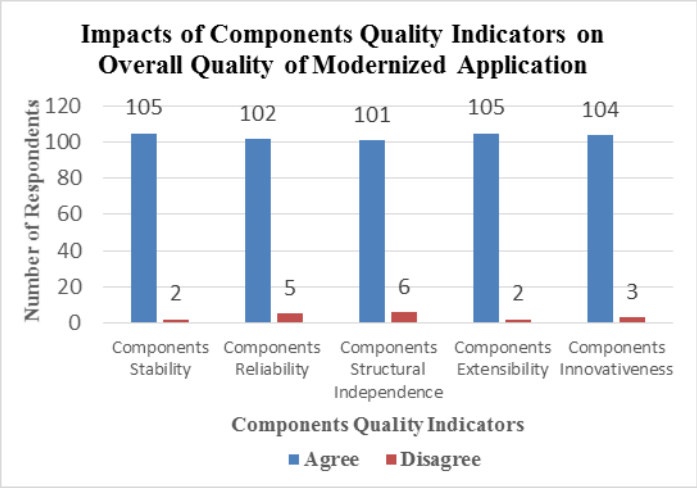

Fig. 2: Graphical Representation of Respondents Views (Results Validation)

A close examination of the graphical representations of the two results in Figures 1 and 2 shows some collaboration which is a confirmatory evidence for the research results.

From the research findings, 95% (i.e. 58 out of 61) of the respondents support the proposition that the quality of a modernized legacy application depends on the quality of the components extracted and repackaged for use in modernization. Also, findings from the results validation indicate that 94% (i.e. 101 out of 107) of the respondents also support the proposition with respect to all five quality indicators examined.

B) Challenges in Producing Quality Modernized Application

As indicated by the research findings, components that are highly qualitative will also produce modernized applications that are highly qualitative. However, the process could be challenged to an extent that the final result is somewhat different from the expected. Some of such major challenges as revealed from the research include:

i. Difficulty in assessing the quality of legacy components with respect to specific quality indicators to determine how qualitative they are, as there are inadequate tools and methods to support such assessment.
ii. Difficulty in extracting and repackaging quality components from legacy applications as most legacy applications are not componentized.
iii. Lack of appropriate off-the-shelf components needed to replace low-quality components in modernization where some are found to be so.
iv. Difficulty in assessing the quality of a modernized application to determine how qualitative it is, as there are inadequate tools and methods to support such assessment.

IX. CONCLUSION

The importance of reusable components in software process particularly in application modernization cannot be over-emphasized. Utilization of reusable components in such processes amongst other things, facilitates quick and timely delivery of products. However, it is important to note that, the quality of the resulting product will depend greatly on the quality of the components that are used in the process. However, some of the quality indicators that determine how qualitative a component or product is include stability, reliability, structural independence, extensibility and innovativeness just to mention a few.

To this effect, this research was designed to examine the impact of these quality indicators on modernized applications using data from interview conducted with 61 professionals and survey questionnaires from 107 respondents accessed via e-mail. From the research findings, 95% (i.e. 58 out of 61) of the respondents support the proposition that the quality of a modernized legacy application depends on the quality of the components extracted and repackaged for reuse in modernization. Also, findings from the results validation indicate that 94% (i.e. 101 out of 107) of the respondents also support the proposition with respect to all five quality indicators examined. This clearly underscores the importance of using quality reusable components in software modernization.

The research further reveals that the major challenge for producing quality products from reusable components include difficulty in assessing the quality of legacy components to determine how qualitative they are, difficulty in extracting and repackaging quality components from legacy applications as most legacy applications are not componentized. Others include, lack of appropriate off-the-shelf components needed to replace low-quality components in modernization where some are found to be so. Lastly, difficulty in assessing the quality of a modernized application to determine how qualitative it is as there are inadequate tools and methods to support such assessment. Dealing with these challenges in an effective manner will further enhance modernization processes and the quality of products obtained from component-based modernization.

X. RECOMMENDATIONS

Based on the research findings, the following recommendations are necessary to further enhance the quality of modernized products:

a) Adequate techniques and methods for effective assessment of the different quality attributes of components are highly recommended. Existence of such will provide a platform for a wide range of quality assessment as no single technique or method does it all.
b) Professionals should consider the development of commercial-off-the-self components that could be used to replace low-quality components of an application where some are found to be so.
c) Professionals should also focus on the development of tools to support product quality assessment with respect to the different quality attributes of application as existing tools are inadequate.

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