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REUSABILITY: A MAJOR ASPECT TO MAINTAINABILITY

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ABSTRACT- This paper focuses on Reusability. Reusability is one of the most significant software quality indicator its correct quantification directs to the prospects of facilitating as well as improving software maintenance process. Reusability is strongly related to maintainability and constantly plays a key role to deliver high class maintainable and trustworthy software within time and budget. In this paper an endeavor has been made to establish a correlation between object oriented design constructs and Reusability. A Reusability Quantification Model (RQM^{OOD}) has been proposed for Object Oriented Design by using multiple linear regression. Finally, the proposed model has been validated using experimental tryout.

KEYWORDS- Maintainability, Modularity, Reusability, Testability, Design phase, Object Oriented Design.

I. INTRODUCTION

As discussed in literature review [3, 5, 6, 7, 8] Modularity and Reusability are two important key contributors for maintainability quantification at design phase. Emphasis on Reusability in early phase of software development cycle leads to significant improvement of Reusability and decline in development and maintenance costs. Building programs and components with good Reusability constantly improves and simplifies maintenance process during maintenance phase and after implementation [14, 15, 21]. It facilitates the creation of better quality software in time and resources. system development cycle it is poorly managed [19, 20, 22].

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The quantification of Reusability using design properties is more relevant and its justification indicates the valid influence of functional and structural information of object oriented design and development. Regardless of the fact Reusability is vital and extremely noteworthy aspect for

II. MAPPING BETWEEN REUSABILITY AND OBJECT ORIENTED DESIGN PROPERTIES

An extensive analysis of object oriented design and development was showed in Paper [1, 2,4,9,10,11,12,13,16,17,18, 23] to develop a foundation for diagramming design properties to quality attribute Reusability. In view of this truth, we established a correlation amongst object oriented design properties and Reusability as shown in Fig. 1. The diagramming establishes an appropriate influence association amongst Reusability and object oriented design properties and the related design metrics.

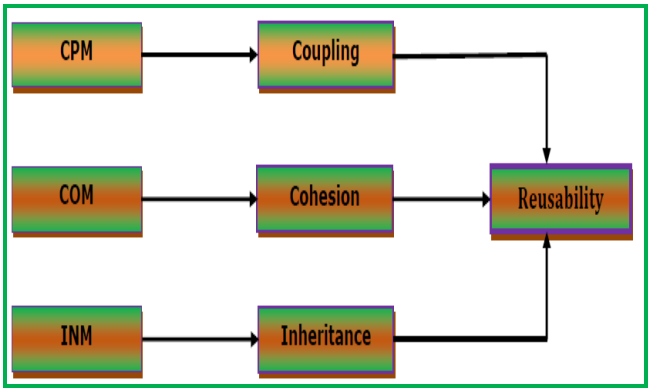

Fig. 1: Relation among Reusability and object oriented design properties and metrics

III. REUSABILITY QUANTIFICATION MODEL (RQMOOD)

In order to set up a model for Reusability, multiple linear regression process has been used.

Reusability = ß + A1 × Coupling + A2 × Cohesion + A3 × Inheritance Eq. (1)

The respective coefficients value are calculated via SPSS and a Reusability model is developed.

Reusability = -.462+ 1.202× Coupling -1.363× Cohesion + 2.297× Inheritance Eq. (2)

The data values for developing Reusability model and validating the developed model is acquired from [20, 24] that have been together from the class diagrams. It contains a group of twenty (20) class diagrams (designated from Project No. 1 up to Projects 20) laterally with the values of metrices of each of these. Along with this, we have the real mean value of different rating by experts of Software Reusability for these projects respectively [25]. These are called "Known Values" here in this research work. Equation (2) signifies the relations amongst Reusability and the object-oriented design properties as evaluated.

Table 1 shows the coefficients for Reusability quantification model. The unstandardized coefficients part of the output gives us the values that we need in order to write the regression Eq. (2). The Standardized Beta Coefficients give a measure of the contribution of each variable to the Reusability model. The experimental quantification of Reusability is very encouraging to obtain maintainability index of software design for low cost testing and maintenance.

Table 1: Coefficients for Reusability Quantification Model

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-.462	2.001		-.231	.832	-6.830	5.905
	Coupling	1.202	.405	1.061	2.971	.059	-.086	2.490
	Cohesion	-1.363	.422	-.983	-3.233	.048	-2.705	-.021
	Inheritance	2.297	.631	1.009	3.643	.036	.290	4.304
a. Dependent Variable: Reusability								

The Model Summary Table 2 output is most valuable when performing multiple regression. Capital R is the multiple correlation coefficient that tell us how powerfully the multiple independent variables are related to the dependent variable. R Square is very supportive as it gives us the coefficient of determination.

Table 2: Reusability Quantification Model Summary

Model Summary									
					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.925[a]	.856	.712	.51903	.856	5.940	3	3	.089
a. Predictors: (Constant), Inheritance, Cohesion, Coupling									

IV. STATISTICAL SIGNIFICANCE BETWEEN REUSABILITY AND OBJECT ORIENTED DESIGN PROPERTIES

To justify the correlation of Reusability with object oriented design properties, statistical test are performed.

The applications that are used to perform statistical test have been taken from [20]. We labeled the applications as: System X, System Y and System Z. All the systems are commercial software applications implemented using object oriented technology with the number of classes as shown in Table 3.

Table 3: Group and Projects for Proposed REM^{OOD}

Group Name	Projects Detail
System X	4(11,12,17,18)
System Y	4-11,1,2,14,15
System Z	4-11-12-13-16

Table 4: Descriptive Statistics for System X

	Mean	Std. Deviation
Reusability	7.6750	.84212
Coupling	1.9750	.60759
Cohesion	4.1500	2.00749
Inheritance	.8000	.18257

Table 5: Correlation Analysis for System X

	Reusability	Coupling	Cohesion	Inheritance
Reusability	1	.917	.683	.954*
Coupling	.917	1	.892	.992**
Cohesion	.683	.892	1	.828
Inheritance	.954*	.992**	.828	1

Table 6: Descriptive Statistics for System Y

	Mean	Std. Deviation
Reusability	7.8250	.75000
Coupling	1.7500	.38730
Cohesion	3.2000	.47610
Inheritance	.7250	.15000

Table 7: Correlation Analysis for System Y

	Reusability	Coupling	Cohesion	Inheritance
Reusability	1	.878	.850	.881
Coupling	.878	1	.868	.947
Cohesion	.850	.868	1	.700
Inheritance	.881	.947	.700	1

Table 8: Descriptive Statistics for System Z

	Mean	Std. Deviation
Reusability	7.8500	1.17331
Coupling	3.8000	.31623
Cohesion	2.2750	1.14419
Inheritance	.6750	.17078

Table 9: Correlation Analysis for System Z

	Reusability	Coupling	Cohesion	Inheritance
Reusability	1	.979*	.932	.973*
Coupling	.979*	1	.967*	.926
Cohesion	.932	.967*	1	.917
Inheritance	.973*	.926	.917	1

Table 10: Correlation Analysis summary

	Reusability x Coupling	**Reusability x Cohesion**	**Reusability x Inheritance**
System D	.917	.683	.954*
System E	.878	.850	.881
System F	.979	.932	.973

Table 10 précises the outcome of the correlation analysis for Reusability quantification model, which shows that for all the System, cohesion, coupling and inheritance are highly correlated with Reusability. The correlation value of 'r' lies between ±1, positive value of 'r' in Table 10, designates positive correlation between the two variables given by Gupta & Gupta (2014). The value of 'r' close to +1 specifies high degree of correlation between the two variables in above Table.

V EMPIRICAL VALIDATION OF REUSABILITY QUANTIFICATION MODEL

This part of study paying concentration how the above planned model is capable to conclude the Reusability of object oriented design at design phase. No substance, how influential a hypothetical outcome may be, it has to be empirical validated, if it is successful to be of any applied usage. This is correct in all, 'engineering disciplines' including "software engineering" also. Consequently, in adding to the hypothetical validation, a mathematical test is equally important in order to make the claim more acceptable and adaptable. In view of above fact, an experimental validation of the developed Reusability quantification model RQM^{OOD} (equation 2) has been carried out with the Appendix I-Table I.1.

In order to validate the, proposed Reusability quantification Model the projects viz. P8 to P17 were taken from [20]. The known Reusability value and rank for the given projects class diagram is publicized in Tables 11 and 12.

Table 11. Known Reusability Value

P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17
7.4	8.6	7.9	7.0	6.9	6.8	8.3	6.7	9.3	7.2

Table 12. Known Reusability Rank

P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17
6	9	7	4	3	2	8	1	10	5

Using the similar group of data for the given project class diagram Reusability was calculated using developed Reusability quantification model and the results are publicized in Table 13.

Table 13. Calculated Reusability Value Using Proposed Model SEM^{OOD}

P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17
1.1	1.3	0.8	0.7	0.8	0.3	1.1	0.2	1.2	0.9

Table 14. Calculated Reusability Rank Using Proposed Model SEM^{OOD}

P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17
7	10	5	3	4	2	8	1	9	6

Table 15: Computed Rank, Actual Rank and their Relation

Projects➔	P0	P1	P3	P9	P15	P16	P19	P23	P24	P27
Computed Ranks	7	10	5	3	4	2	8	1	9	6
Known Ranks	6	9	7	4	3	2	8	1	10	5
d^2	1	1	4	1	1	0	0	0	1	1
∑d2	10									
r_s	**0.939393939**									
r_s > **0.7818**	✓									

(Charles Spearman's) Rank relations "rs" was used to assess the importance of correlations amongst "calculated Ranks of Reusability" via proposed model and it's "Known Ranks". The 'rs' was calculated via the formulation specified asunder:

Spearman's- Coefficient of Correlation (rs) –

$$rs = 1 - \frac{6\Sigma d2}{n(n2-1)} \qquad -1.0 \leq rs \leq +1.0 \qquad \text{Eq.(3)}$$

'd'=difference amongst "Calculated Rank" and "Known Rank" of Reusability.

'n' = Total Project used in the research.

The correlation value amongst calculated "Reusability ranks" using developed model SEMOOD and "known ranks" are publicized in Table 15. Correlation value rs unquestionably show that the Reusability model is very important and highly significant. The correlation is up to high standard with highest degree of confidence; i.e. at the 95%. Therefore we can conclude without any loss of generality that proposed Reusability quantification model estimates are extremely trustworthy, important and applicable in the perspective.

VI. CONCLUSION

This paper shows the significance of Reusability and its relationship with object oriented design properties viz. cohesion, inheritance and coupling. Reusability is one of the most noteworthy factors for evaluating maintainability of object oriented design. This paper proved the significances of Reusability and its relationship with various object oriented design properties. Further, study developed a Reusability quantification model with correlation establishment among Reusability and object oriented design properties. Subsequently, developed model was validated empirically by means of investigational tryout. The applied authentication on the Reusability model accomplishes that the Reusability model is most highly significant. The work concludes that there is a high correlation between Reusability and design properties.

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