Validating Utility of TEIM: A Comparative Analysis

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***Abstract*— Concrete efforts to integrate Software Engineering and Human Computer Interaction exist in the form of models by many researchers. An unconventional model called TEIM (The Evolved Integrated Model) of Software Engineering and Human Computer Interaction was proposed by us. There is a need to establish correlation with prior models as well validate utility of TEIM. In this paper product PS designed using SE-HCI integration model TEIM is evaluated by making a comparative analysis. For evaluation UGAM and IOI tools designed by DR.Anirudha Joshi are used. Our analysis showed that correlation of TEIM exists with prior models. Regression analysis showed that high correlation exists between TEIM and prior model.**

Keywords- SE; HCI; UGAM; IOI; PS; TEIM.

I. INTRODUCTION

Better user experience is an oft expressed quality of the products designed nowadays. Many efforts in this regard lead to various proposals of smooth integration of SE(software engineering) processes with HCI(human computer integration) for product development were done [1], [3], [4], [5], [8], [10], [11], [12]. We got inspired by these and designed a product application by name PS(Personal Secretary) using SE-HCI integration model of [1] and adding empathy map [7], [9] to it. The steps used for designing PS evolved into a new SE-HCI integration model by name TEIM [2].

II. VALIDATING UTILITY OF TEIM

Dr.Anirudha Joshi in [1] had proposed UGAM (Usability Goals Achievement Metric) to measure user experience goals and IOI (Index of Integration) to measure extent of integration of HCI activities in SE processes.

We used UGAM and IOI to evaluate PS in this paper. Section III explains UGAM score calculation for PS, section IV explains IOI score calculation for PS and section V explains mathematical and comparative analysis of PS vis-à-vis TEIM.

For mathematical and comparative analysis statistical methods of regression, Pearson's coefficient, ANOVA are used.

III. USABILITY GOALS ACHIEVEMENT METRIC

Usability Goals Achievement Metric (UGAM) proposed by [1] is a product metric that measures the quality of user experience.

A. UGAM components [1]

- Goals: High level user experience goals.
- Goal parameters: Goals divided in to goal parameters.
- Weight: Weights are in the range 0-5 indicating least relevant to most relevant.
- Score: Scores are in the range 0 to 100 broken down to four categories 0- worst user experience, 25- bad, 50- undecided state, 75- good and 100- best.

UGAM calculation for TEIM Model is in Table 1.UGAM parameter labels are in Figure 1.The average weight assigned is 2.8 which is in the range 2.4 to 3.4.As per UGT (Usability Goal Setting Tool) the weight assigned is balanced.UGAM tool proposed by Joshi. A. et al., [1] is used to measure user experience of PS designed by us.

PS was designed using TEIM model [2] (refer Figure 5). TEIM [2] evolved as an unconventional model of integrating software development process with usability aspects [1][3] wherein we were trying to understand SE-HCI integration efforts of Joshi .A [1] , Ferre[3][4], Seffah[5], designed PS using their techniques of integration and adding our beliefs.

PS was evaluated on teaching staff of Computer Engineering dept. of BSCOER, Pune by us and scores were assigned. UGAM was calculated [1] using the formula $\sum (W_p X S_p)/ \sum W_p$ where Wp is the weight of the goal parameter p and S_p is the score of the goal parameter p.

IV. UGAM AND IOI RELATIONSHIP

In [1] data from industry projects was available in the form of 61 industry projects UGAM and IOI scores .We could not get access to such data so our reference data were the UGAM and IOI scores of Joshi. A. et al. [1].

Using this reference data and extended waterfall model[8] we used the same techniques [1] of evaluation for establishing relationship between UGAM and IOI as well relationship between our UGAM + IOI scores vs. [1] scores .Methods used to establish correlation between and their results are as followed:

- Pearson's Correlation: Refer Table III for Pearson Coefficient calculation and A for the results.
- Linear Regression: Refer Table IV, V for Linear Regression calculation and B, C for results.
- ANOVA: Refer Table VI, VII and D for ANOVA calculations and results respectively.

A. Pearson's Interpretation

Interpretation of Pearson's Correlation results: a positive Coefficient indicates values of variable A vary in the same direction as variable B. Characterizations of Pearson r:

- .9 to 1 very high correlation
- .7 to .9 high correlation
- .5 to .7 moderate correlation
- .3 to .5 low correlation

Very high positive correlation exists between the Variation of UGAM and the variation of IOI.There is a significant positive correlation (r= 0.99, p < 0.0005 two-tailed) between UGAM and IOI $r_{xy} = 1$, adjusted $r_{xy} = 0.99$.

All the above techniques including the plot drawn for UGAM vs. IOI (refer Figure 3, 4 and F) validate linear correlation between UGAM and IOI. Also Table VIII, F and E establish a linear correlation between TEIM and [1].

A: learn ability: A1: find ability: easy to find option, A2: take less time to learn, A3: able to learn on their own, A4: product: internally consistent, A5: consistent with other products, A6: consistent with earlier version, A7: retain critical/infrequent tasks
B: speed of user: B1: ability to do tasks easily all times, B2: ability to navigate quickly/easily, B3: not load user user's memory, B4: flexibility: control seq of tasks, B5: complete tasks in less effort, B6: automatic personalization, B7: localized for specific market, B8: user ability to customize,
C: Ease of Use, C1: interface communicate model, C2: predict next step intuitively, C3: No entry barrier: complete tasks, C4: No unnecessary tasks, C5: automate routine tasks, C6: product: always on/accessible
D: Ease of Communication, D1: Information Architecture well categorized, D2: clear understanding of text/visuals,
E: Error-free use, E1: should give good feedback/status, E2: Should not induce errors, E3: Errors: tolerate/forgive/prevent, E4: Help to recover from errors
F: Subjective Satisfaction, F1: Feel in control/behavioral appeal, F2: Emotional engagement/fun/appeal, F3: Aesthetical/Visceral appeal, F4: Average weight

Figure 1. UGAM PARAMETER LABELS

B. Regression Coefficient

$R^2 = ((1/N)*\sum [(X1-\bar{x}) *(Y1-\bar{Y})]/(\sigma_x * \sigma_y))^2 = 1$

$\sigma_x = \text{sqrt} [\sum(X1-\bar{x})^2/N] = 11.83$

$\sigma_y = \text{sqrt}[\sum (Y1-\bar{Y})^2/N) = 8.72$

Adjusted $R^2 = 0.99$

IOI significantly determines the scores of UGAM with predictor IOI accounting for 99% of the variance in UGAM (adjusted $R^2 = 0.99$)

C. Linear Regression

TABLE I. UGAM CALCULATION FOR TEIM MODEL

	goals and goal parameters	weights	goal para meter score	goal score	UGAM score
A	A1	3	75	52.5	
	A2	4	75		
	A3	3	50		
	A4	3	75		
	A5	3	50		
	A6	0	0		
	A7	4	0		
B	B1	2	75	50	43.15
	B2	2	50		
	B3	3	75		
	B4	2	50		
	B5	2	75		
	B6	3	0		
	B7	3	75		
	B8	2	0		
C	C1	3	25	25	
	C2	2	75		
	C3	3	0		
	C4	3	75		
	C5	2	0		
	C6	5	0		
D	D1	3	25	25	
	D2	4	25		
E	E1	3	50	40	
	E2	3	50		
	E3	2	25		
	E4	2	25		
F	F1	3	50	60	
	F2	3	50		
	F3	4	75		
	F4	2.8			

Regression equation form $\bar{Y} = b0 + b1*x$

$$b1 = \sum ((X1- \bar{x})*(Y1-\bar{Y}))/\sum(X1- \bar{x})$$
$$b0 = \bar{Y} - b1* \bar{x}$$
$$\bar{Y} = b0 + b1*x$$

$$\bar{Y} = 14.95 + 0.74 * x$$

D. Anova Results

According to F Sig/Probability table with df(2,1) F must be at least 19.000 to reach p< 0.05. So F score is statistically significant. Hence our hypothesis is supported.

E. RK VS AJ Correlation

The range of correlation coefficient is -1 to 1. Since our result is 0.99 or 99%, it means the variables have a high positive correlation.

TABLE II. IOI CALCULATION FOR TEIM MODEL

Phases	HCI activities	Recommended weights	weights	Activity Score	Phase Score	IOI Score
A	A1	3 to 4	3	75	54.55	46.74
	A2	2	4	50		
	A3	1 to 3	3	50		
	A4	1 to 3	1	25		
B	B1	4 to 5	4	50	25	
	B2	4 to 5	4	25		
C. Construction	C1	3	3	75	68.75	

A. Communication: A1.Contextual User Studies/modeling, A2: Ideation with multidisciplinary team, A3.Product definition/Information Architecture/Wireframes, A4. Usability evaluation, refinement
B. Modeling: B1.Detailed UI prototyping, B2.Usability Evaluation, refinement
C. Construction: C1: Development Support reviews by Usability team, C2: Usability Evaluation (Summative)

Figure 2. IOI parameter labels

TABLE III. PEARSON'S COEFFICEINT

	X	Y			
group	ugamscore	ioiscore	XY	X^2	Y^2
rk	43.15	46.74	2016.83	1861.92	2184.63
aj	66.81	64.17	4287.208	4463.58	4117.79
SUM	109.96	110.91	6304.02	6325.50	6302.42
n	2				

TABLE IV. LINEAR REGRESSION

		X1	Y1
srno	entity	ugam	ioi
1	RK	43.15	46.74
2	AJ	66.81	64.17
	SUM	109.96	110.91
	MEAN	54.98	55.455

F. UGAM Vs IOI Calculation

The closer the points come to straight line stronger the relationship. We will express the strength of the relationship between 0 and 1.

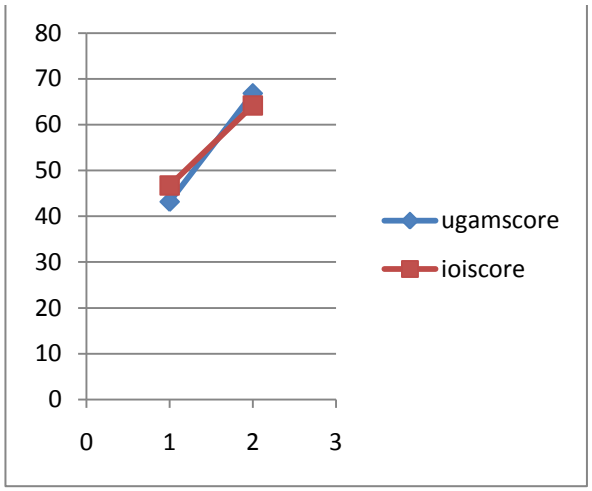

Figure 3. UGAM VS IOI CORRELATION

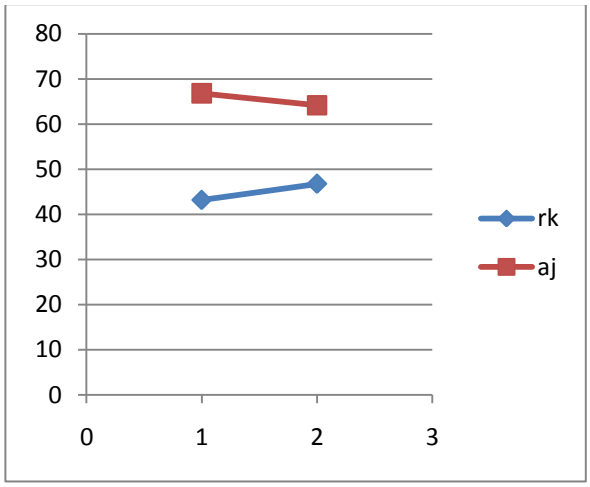

Figure 4. VS AJ RK

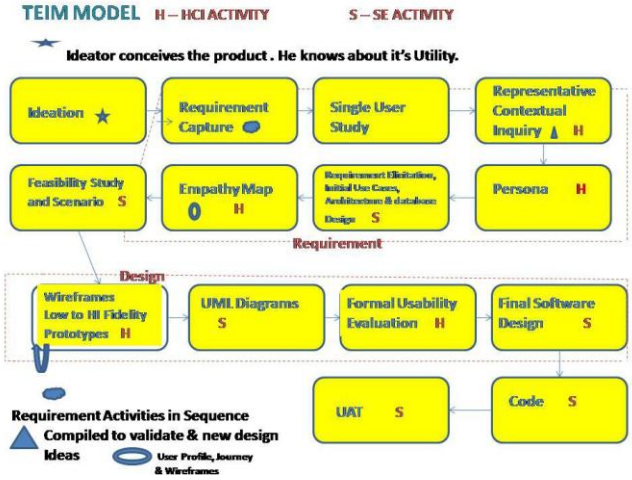

Figure 5. TEIM MODEL

TABLE V. LINEAR REGRESSION

srno	$X1-\bar{x}$	$Y1-\bar{Y}$	$(X1-\bar{x})^2$	$(Y1-\bar{Y})^2$		
	A	B	C	D	A*B	C*D
1	-11.83	-8.72	139.95	75.95	103.10	10629.29
2	11.83	8.72	139.95	75.95	103.10	10629.29
sum			279.90	151.90	206.20	

TABLE VI. ANOVA CALCULATION

SOURCE	SS	DF	MS	F
AMONG	422.10	2	211.05	21.26
WITHIN	9.93	1	9.93	

SSTOTAL	432.03
R^2	0.98

TABLE VII. ANOVA CALCULATION

	X_1	X_2	$(X_1)^2$	$(X_2)^2$
	43.15	66.81	1861.92	4463.58
	46.74	64.17	2184.63	4117.79
$\sum$	89.89	130.98	4046.55	8581.37
$(\sum x)^2$	8080.212	17155.76		
M	44.945	65.49		

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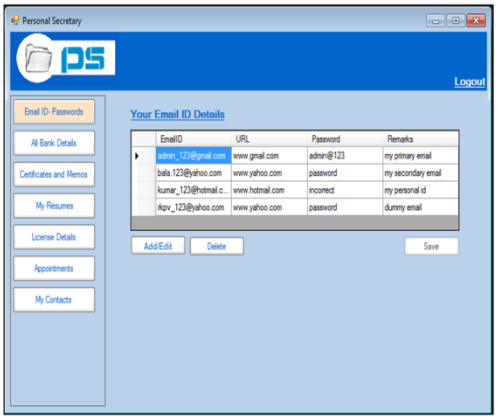

Figure 6. PS Product Screen

V. CONCLUSION

We designed product PS (refer Figure 6) getting inspired from prior work of integration of Human Computer Interaction and Software Engineering processes also adding our own beliefs such as empathy map [7], [9]. Whatever design steps we applied we compiled them together as a new integration model of SE and HCI and called it as TEIM- The Evolved Integration Model of SE and HCI [2]. Dr. Anirudha Joshi's work in this area is here [8]. Dr. Anirudha Joshi's tools UGAM and IOI were used to calculate UGAM score (43.15) and IOI score (46.74) respectively for the product PS. Though scores were on lower side as compared to [1] (beta version of PS was tested) they showed linearity and strong correlation.

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