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Technology adoption: A study on post-implementation perceptions and acceptance of computerised maintenance management systems

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ABSTRACT

Information and communications systems are increasingly being used to capture, record, store, transmit and retrieve data to manage the maintenance of equipment and physical infrastructure. The justification for the costs incurred in implementing computerised information systems subsumes that acceptance of the associated technology by the users will provide the desired future benefits to the business organisation. The study assumes that the respective organisations were ready for the implied change, and thus applied the premise that *perception* influences *acceptance* to assess the implementation of computerised maintenance management software systems in a number of user organisations. Respondents to the study indicated that *ease of use*, *usefulness* and *system characteristics* were strongly dependent on the level of training of the user during the implementation of the computerised maintenance management software system, thus reiterating that user training influences perception which, in turn, influences user acceptance of technology. A model to predict user perception is developed based on data arising from respondent feedback.

***Keywords*:** *Technology Perception, Technology Implementation, Technology Acceptance.*

I. Introduction

Many organisations implement information and communications technology (ICT) systems to improve their business processes and operations, as well as to provide better products and services. Computerised information systems are typically deployed and utilised in business operations to facilitate reporting and decision making. In many business organisations, so called *c*omputerised *m*aintenance *m*anagement systems (CMMS) are used to capture, store, retrieve and transmit data and information related to maintenance procedures for equipment, plant and infrastructure. According to Throop (2000), a CMMS is a 'software package used to track, schedule, organize and facilitate maintenance activities'. Bagadia (2006) and Kullolli (2008) both make the point that current versions of CMMSs are particularly used to prompt scheduled preventative maintenance actions, as well as to manage data related to the condition of equipment.

In their examination of the role of software in the management of engineering assets, Mehul and Littlefield (2010) argue that computerised information systems that are properly deployed to automate business processes can improve overall firm performance. Although the consensus from vendors, suppliers and consultants, as articulated by Kullolli (2008), Crain (2003), and reference [7] suggests that a well-implemented CMMS should provide operational and cost benefits to a business, however, Bagadia (2006, 2007) indicates that among other factors, user perception and acceptance strongly determine the extent of utilization of the CMMS after implementation. This provokes the question as to how to measure user perception and acceptance of technology encapsulated in the form of computerised maintenance management software systems.

This paper briefly describes a study designed to examine post-implementation perception and acceptance of CMMS by users. The primary assumptions are that plausible definitions for user perception and acceptance exist, and that these two factors can be measured. The study which was conducted from the viewpoint of a CMMS implementation vendor was not longitudinal. Furthermore, the study did not consider or examine the issue of readiness of the client/user organisations. User clients were contacted to respond once-off to a survey, while the focus was on the reflexive user attitudes to CMMSs already implemented.

II. Acceptance and User Perception of Information Systems Technology

Technology acceptance

The acquisition of information systems is often a strategic investment for an organisation, and the implementation of the information system correspondingly induces changes in attitudes and behaviours within the organisation's internal structures, as well as the external linkages to the organisation. The implementation of ICT systems invariably involves and induces change. Abdinnour-Helm et al (2003), and Kwahk and Lee (2008) discuss attitudes that prevail in organisations during the pre-implementation phase of enterprise resource planning systems. Raymond, Riyard and Jutras (2006) developed a framework for readiness assessment but, often, both organisational and staff readiness for the impending change tends to be assumed *apriori*. Extrapolating from Timmor and Zif (2010), change readiness demonstrates the capacity of an organisation to respond effectively to a new culture that may be induced by the implementation of an information system, and the capacity is embedded in the attitudes and behaviours within the organisation. Staff readiness may be described in terms of employee acumen, attitudes, and motivation, while organizational readiness may be described in terms of awareness, competence, culture, predisposition for accepting changes, and resources devoted to the implementation. In essence, the real success of any CMMS manifests in how the system is utilized post-implementation.

Although information systems provide potential to improve the performance of any organisation (Davis, 1989), however, the opportunities for success are often scuffled by:

i. apathetic attitudes during the pre-implementation phase,
ii. intransigent perceptions during implementation, and
iii. post-implementation reluctance to accept and utilise the associated technologies.

User perception

Alben (1996) defines user perception in terms of 'quality of experience', while Colbert (2005) discusses user perception in terms of 'impairment of experience'. Whereas Preece et al (2002), Al-Hammad (2006), McNamara and Kirakowski (2006), and Garrett (2010) provide various definitions of user perception, however, we have adopted the definition (cf: [20]) of user perception as "…the process by which human beings translate sensory impressions into a coherent and unified view of…" computerised systems installed and deployed to facilitate how people perform tasks. Lucas (1975) points out that the tendency for users to remain apathetic to seemingly useful computerised systems does not abate, despite the increased deployment of highly functional information technology in business operations. The reasoning from Fishbein and Ajzen (1975) suggests that attitudes are often rooted in a person's beliefs, behavioural preferences, cognition, motivation, and thinking styles, and these determine how a person may perceive and/or accept technology necessary to perform a task. Although Venkatesh (1999) believes that positive user perception significantly impacts the adoption and continued deployment and utilisation of information systems, however, Dillion (2001) expresses the latent concern that it is difficult to isolate and exclusively determine the benefits provided by computerised information systems.

The following ontologies derived from Rogers (1995) summarise issues which affect user perception of technology viz:

i. relative advantage - i.e., the superseding technology should be perceived as better;
ii. compatibility - i.e., the technology should be consistent with present standards, past experiences and requirements of users;
iii. complexity – i.e., the technology should be easily understood, learned and used;
iv. trialability – i.e., extent of testing of the technology by the eventual users;
v. observability – i.e., appreciation of the value of the technology.

The link between the perception of technology and its acceptance (see, Davis (1989), 1993; and Bagozzi et al (1992),) is summarised in the technology acceptance model (TAM) illustrated Figure 1.

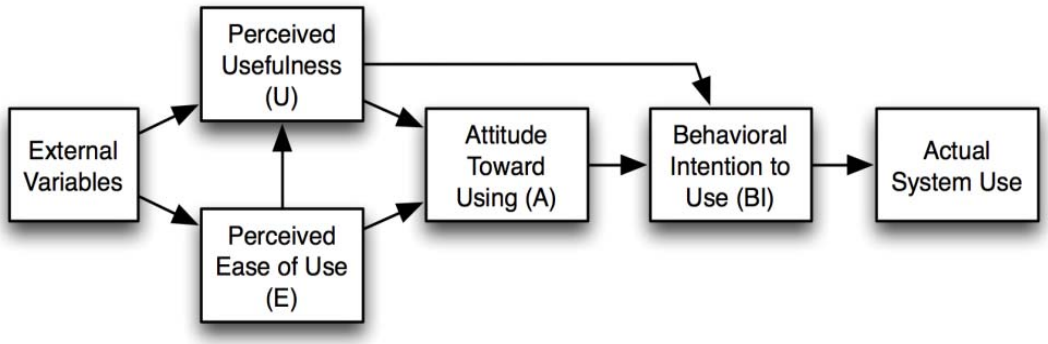


Figure 1 - Technology Acceptance Model (TAM) *Source*: Davis (1989)

According to Davis (1989) and Venkatesh (1999), the model essentially depicts that user perception of technology comprises two related constructs:

i. perceived *ease of use*, and
ii. perceived *usefulness*.

Davis (1993) makes the point that, although the perceived *ease of use* of technology may have a direct effect on the perceived *usefulness* of the corresponding information system, however, the reverse is not true, meaning that technology that is perceived as useful may not necessarily be easy to use. With regard to utilisation of technology, perceived *usefulness* has a greater influence than perceived *ease of use* as surmised Dillion (2001). Bhattacherjee (2001) also confirms that acceptance is influenced by the perceived *ease of use* of a system, while Thong et al (2004) concur that perceived *ease of use* and perceived *usefulness* both have significant impact on user acceptance of technology.

According to Al-Gahtani and King (1999), and Firesmith (2010), perceived *ease of use* perceived *usefulness* and work in cohort with *system characteristics* to influence user acceptance of technology. In comparison to the assertion by Rogers (1995), Firesmith (2010) further explains that a technology may be characterised by the following grouping of ontological constructs:

i. systems (e.g., complexity, size, distribution, heterogeneity, and variability)
ii. quality (e.g., reliability, availability, maintainability, and usability)
iii. programmability (e.g., flexibility, and customisability)

Sternard and Bobek (2006), and Alkhaldi et al (2012) found that *training* also has an impact on how the user perceives the technology implementation. Thomas and O'Hanlon (2011) point out that installing the software is only a small part of the technology implementation. The argument is that inadequate training of users can create apathy, weaken acceptance and lead to failure, especially if the training focuses on the technology itself in a manner that does not equally emphasise, for example, how the technology engenders sound business principles and practice, or how it facilitates and supports a person's method of performing tasks. For brevity, we have summarised the range of issues surrounding user acceptance and perception of technology implementations as illustrated in Table 1.

Table 1 – Summary of issues around user acceptance and perception of technology implementations

<table>
<tr><th>Technology acceptance</th><th colspan="2">User perception</th></tr>
<tr><td>Apathetic attitudes during the pre-implementation phase</td><td colspan="2">May be pre-defined in terms of 'quality of experience' or 'impairment of experience'</td></tr>
<tr><td rowspan="3">Intransigent perceptions during implementation</td><td>Ontologies</td><td>Constructs</td></tr>
<tr><td>relative advantage
compatibility
complexity
trialability
observability</td><td rowspan="2">perceived ease of use
perceived usefulness
systems characteristics
training</td></tr>
<tr><td>Post-implementation reluctance to accept and utilise the associated technologies</td><td>systems
quality
programmability</td></tr>
</table>

Assuming that user acceptance of technology can be measured in terms of the perception constructs illustrated in Figure 2 (the top half of the figure is adapted from Alkhaldi et al (2012)), we then applied the four user perception constructs, otherwise referred to as "perceptors", i.e.;

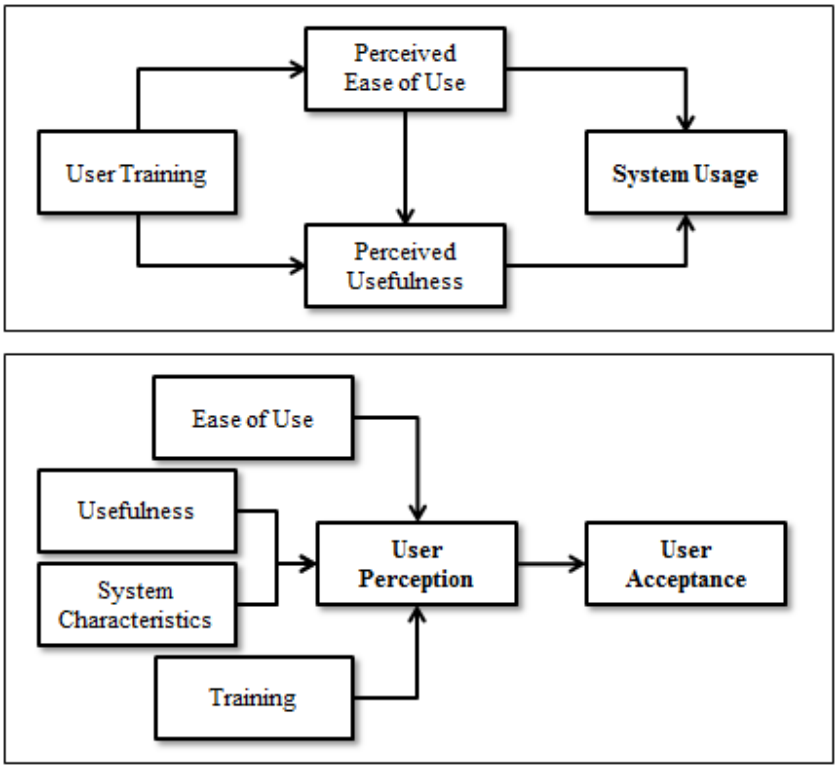


Figure 2 – Constructs for measuring user perception of CMMS implementations

i. *ease of use*,
ii. *usefulness*
iii. *system characteristics*, and
iv. *training*

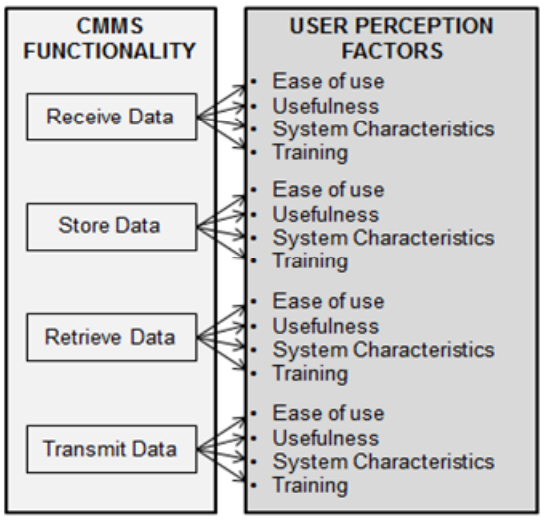
in order to measure user re-collection of, and reflection on what happened during actual CMMS implementations, so as to gauge the level of acceptance of the technology. The word 'technology' here refers to the functionalities of the particular CMMS deployed, including software and physical artefacts that constitute the CMMS.

III. Survey

The study reported in this article was designed to examine post-implementation perceptions and acceptance of CMMS by users. The rationale for the study arises from the assertion by Thomas and O'Hanlon (2011) that the number of CMMS implementations depicts an exponential trend, in terms of applications to facilitate maintenance activities such as:

i. job requests, planning, and scheduling,
ii. work order data and maintenance effort management,
iii. condition monitoring and reliability analyses,
iv. spare parts management,
v. document access and control,
vi. budgeting and cost control, as well as
vii. reporting on maintenance performance.

The study was conducted from the point of view of a vendor of computerised maintenance management information systems. Even though we have applied statistical methods to analyse our data, however, the research was not designed to test any hypothesis per se, rather, the objective was to gain some insight into how users perceive or accept the CMMS post-implementation. Thus, in order to measure user perceptions and hence provide an indication of the level of technology acceptance, we devised a questionnaire to assess each of the basic functionalities of a typical CMMS as depicted in Figure 3. The majority of the questions were close-ended statements using the *Likert* five-point scale, where a value of 1 means that the respondent strongly agrees with a positive statement, and a value of 5 means that the respondent strongly disagrees with the positive statement. The user perception questions were derived using the matrix also shown in Figure 3.



	Ease of Use	Usefulness	System Characteristics					Training
			A	B	C	D	E	
Receive Data	1	2, 3	4	5	1	6	3	7
Store Data	8	9	10		9		11	12
Retrieve Data	13, 14, 22	15	16	17	13	18	19,21	20
Transmit Data	23, 24	25	26		24	28	27	

Figure 3 – Mapping of survey questions

For example, question/statement 1 was focused on whether the system was easy to use (i.e. easy to generate a query) when applied to receive data, while questions 2 and 3 were about how useful the system enabled the user to receive data (i.e., prompt receipt of correct data requested in the query). Question/statement 5 was specifically worded as follows. 'The way that data is captured fits in with the current business processes and requirements of the organisation'. Question/statement 12 was specifically worded as 'I was trained to edit stored information in the database'; statement number 20 was - 'using the system improves the productivity because I can search for data much quicker compared to a manual system'; statement number 23 was - 'I can create my own reports in the CMMS to display the information I want to see'; and statement number 27 was - 'It is easier for me to find the information from other systems in the CMMS than in the other systems themselves'.

Two general perception statements were included in the questionnaire (Questions 29 and 30). These statements were: "I feel positive using the system" and "The CMMS is a useful system and assists me in carrying out my daily activities". This was done to determine the effect of each of the constructs on user perception. There were questions regarding demographics of the respondents, including organisational sector, employment level and years' of experience using a CMMS. Before administering the survey, 15 persons were requested to complete the questionnaire so as to establish reliability and consistency *apriori*. The *Cronbach*'s test results in Table 2 shows $\alpha > 0.7$, while Table 3 shows the same test with one question removed. Except for questions 14 and 23, the α values were generally above 0.7, meaning that this is acceptable for a questionnaire of this nature (cf: George and Mallery (2003)).

Table 2 – Cronbach's α values

	Ease of use	Usefulness	System characteristics	Training	Perception	Total
k	7	5	13	3	2	30
Σvar	4.91	3.92	9.18	4.43	1.29	23.7
var	13.1	10.6	40.9	10.7	2.12	211
α	**0.73**	**0.79**	**0.84**	**0.88**	**0.78**	**0.92**

Table 3 - Cronbach's α values with one question removed

	Ease of use							Usefulness					Training		
Q#	1	8	13	14	22	23	24	2	3	9	15	25	7	12	20
k	6	6	6	6	6	6	6	4	4	4	4	4	2	2	2
Σvar	4.26	3.81	4.52	4.24	4.28	3.95	4.37	2.39	3.36	3.7	3.27	2.96	2.71	3.16	2.98
var	10.7	9.58	10.9	8.86	10.8	9.32	10.5	5.45	7.66	8.43	7.33	7	4.52	6	4.64
α	**0.72**	**0.72**	**0.7**	**0.63**	**0.72**	**0.69**	**0.7**	**0.75**	**0.75**	**0.75**	**0.74**	**0.77**	**0.8**	**0.95**	**0.72**

	System Characteristics												
Q#	4	5	6	10	11	16	17	18	19	21	26	27	28
k	12	12	12	12	12	12	12	12	12	12	12	12	12
Σvar	9.07	8.94	7.87	9.12	8.99	8.54	8.49	7.73	8.83	8.32	8	8.13	8.16
var	39.5	36.8	35.7	39	36.9	33.5	32.4	31.8	35.1	37	34.2	34.1	33
α	**0.84**	**0.83**	**0.85**	**0.84**	**0.83**	**0.81**	**0.8**	**0.83**	**0.82**	**0.85**	**0.84**	**0.83**	**0.82**

The validated questionnaire was then sent via email to 165 respondents randomly chosen to reflect users of CMMSs in education, manufacturing, food processing, and information technology organisations. It is important to note that the respondents were clients from only one CMMS implementation vendor. One hundred and four completed responses were received but, two were rejected because the respective executive respondents admitted that they never used the CMMS, so data from 102 survey returns was analysed and forms the basis of discussion that follows.

IV. Analysis and Discussion

Sixty-five respondents were male, and 37 were female, while 52 respondents were from food processing and information technology organisations. It was disappointing to obtain only 25 respondents from the utilities (e.g., electricity and water) where equipment maintenance is a dominant activity, and such organisations usually deploy CMMS extensively. It is interesting that the more than 15 respondents were

middle managers from food processing organisations but, the number of respondents that chose "other" as an employment level option was also a surprise. More than 50% of the respondents had used CMMSs for more than 5 years while less than 10% (i.e., 9 respondents) had only one year user experience of CMMS. The remaining 30% of respondents claimed to have user experiences of between one and five years. When 30% is added to the 50% with more than five years user experience as reflected in Figure 4, we were encouraged that 80% of the people who responded to our survey were at least knowledgeable about the subject matter, such that their aggregate perception is a worthwhile indication of the acceptance of CMMS technology implementations.

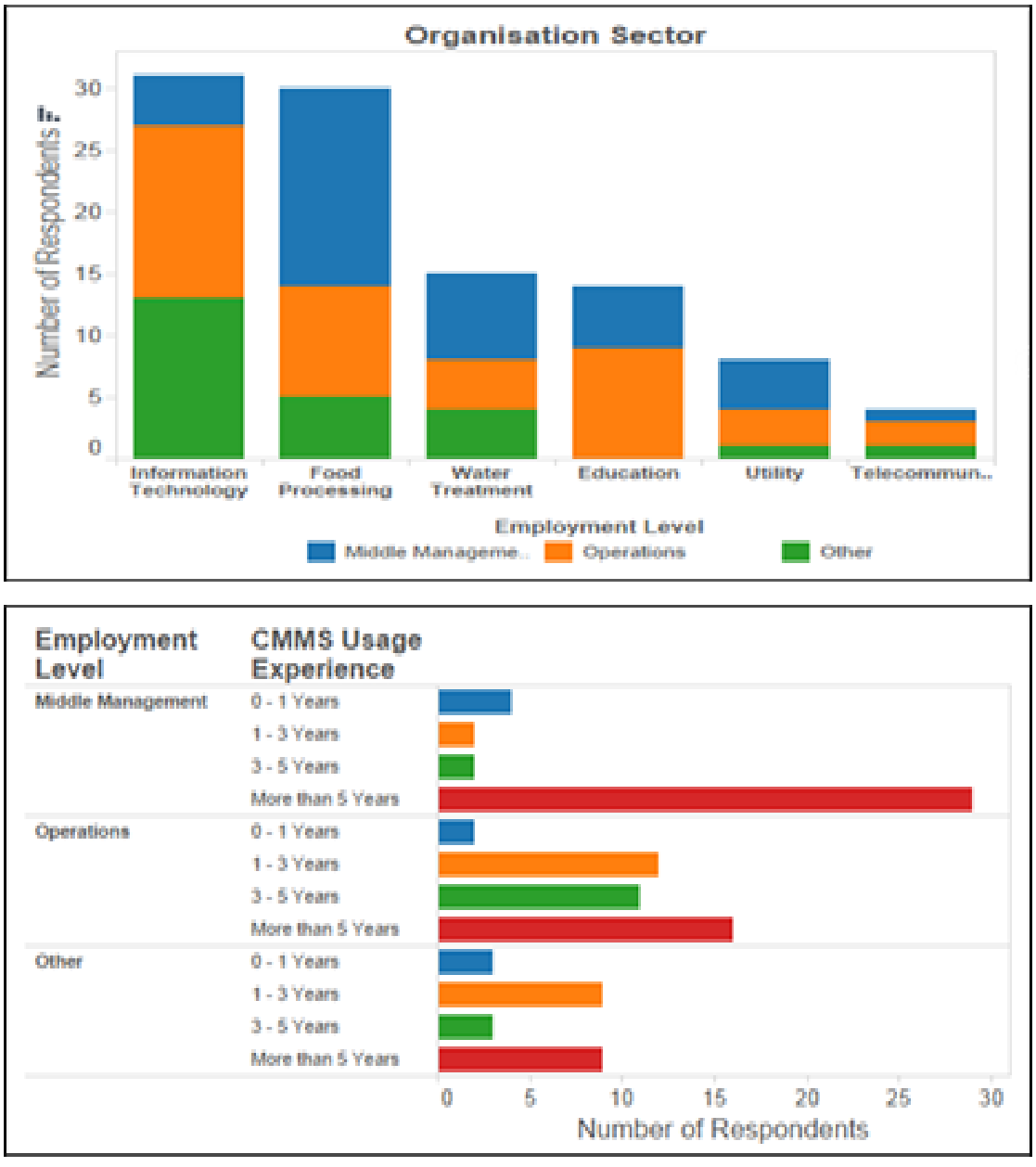


Figure 4 – Summary of respondent profile

The respondents' feedback is summarised in the descriptive statistics shown in Table 4.

Table 4 – Descriptive statistics for user perception constructs

	ease of use	*usefulness*	*system characteristics*	*training*
Mean	1.94	1.64	1.80	2.03
Standard Error	0.07	0.05	0.05	0.09
Median	2	2	2	2
Mode	2	1	1	2
Standard Deviation	0.68	0.50	0.50	0.94
Sample Variance	0.47	0.25	0.25	0.89
Kurtosis	-0.09	1.54	-0.76	0.41
Skewness	0.42	1.11	0.30	0.98
Range	3	2	2	4
Minimum	1	1	1	1
Maximum	4	3	3	5
Sum	198	168	184	207
Count	102	102	102	102
Upper Bound (95%)	2.07	1.74	1.90	2.22
Lower Bound (95%)	1.81	1.55	1.70	1.85

Using the scale (1 = strongly agree, 5 = strongly disagree), the mean calculated for *ease of use* was 1.94, and for the perceived *usefulness* of a CMMS was 1.64. It can be surmised from these results that most of the respondents agree, to strongly agree that the CMMS is useful and easy to use. The feedback regarding *system characteristics* was also positive with a mean of 1.80. The feedback from the respondents' show that the mean and standard deviation were highest for the *training* construct than for the other three user perception constructs. The mean ranking for *training* was 2.03 with a standard deviation of 0.89. The perception on *training* concurs with the view (see Sternad and Bobek (2006); Thomas and O'Hanlon (2011); and Alkhaldi et al (2012)), i.e., that *training* strongly influences user perception of the CMMS.

The lower and upper 95% confidence limits of 1.55 and 2.22 respectively indicate that the respondent perceptions of the CMMS implementations were positive. The skewness of all four "perceptors" is positive and greater than 0.3, meaning that the statistics tends to the positive side of a normal distribution. The positive kurtosis of the perceived *ease of use* and *system characteristics* indicate a steeper than normal distribution. The *usefulness* and *training* statistics were flat when compared to that of a normal distribution. Figure 5 shows the histograms of the data regarding the four "perceptors". It is interesting to note that none of the 102 respondents disagreed with any of the statements on *system characteristic* 'perceptor'. From the graphs in Figure 5, the *usefulness* preceptor is most positive, meaning that the respondents perceived the CMMS as useful.

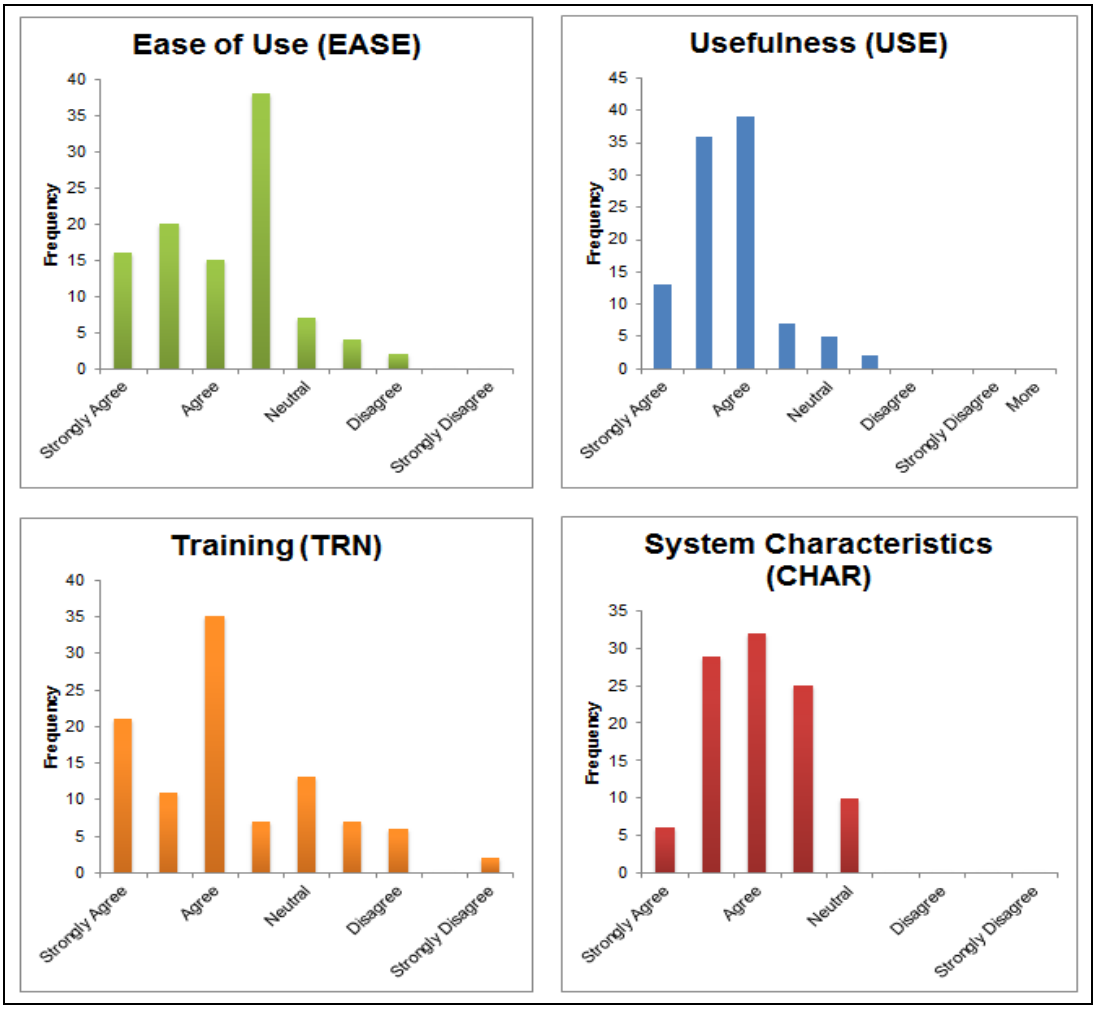


Figure 5 – Histograms of respondent feedback

The *t*-test values in Table 5 do not reveal significant differences in the perception between the two levels of employees in the CMMS user organisations that responded to our survey. As it is typical in hypotheses testing, a *t*-test indicates that there is a significant variance if the null hypothesis is true but, our data showed *t*-values greater than 5% (0.05), thus signalling agreement on all four user perception constructs. It is surprising that operational personnel (who mostly utilise CMMS) do not differ with management cadre in their respective reflections of how well the system functions. The histograms in Figure 6 provide indication of the utilization of the CMMSs post-implementation.

Table 5 – A comparison of *t*-test values for the user perception constructs

	ease of use		*usefulness*		*system characteristics*		*training*	
	MAN	***OPS***	***MAN***	***OPS***	***MAN***	***OPS***	***MAN***	***OPS***
Mean	1.93	2.07	1.63	1.77	1.84	1.86	1.97	2.13
Stddev	0.68	0.75	0.39	0.60	0.50	0.53	1.06	0.91
Count	37	41	37	41	37	41	37	41
T-test	**0.39**		**0.22**		**0.86**		**0.49**	

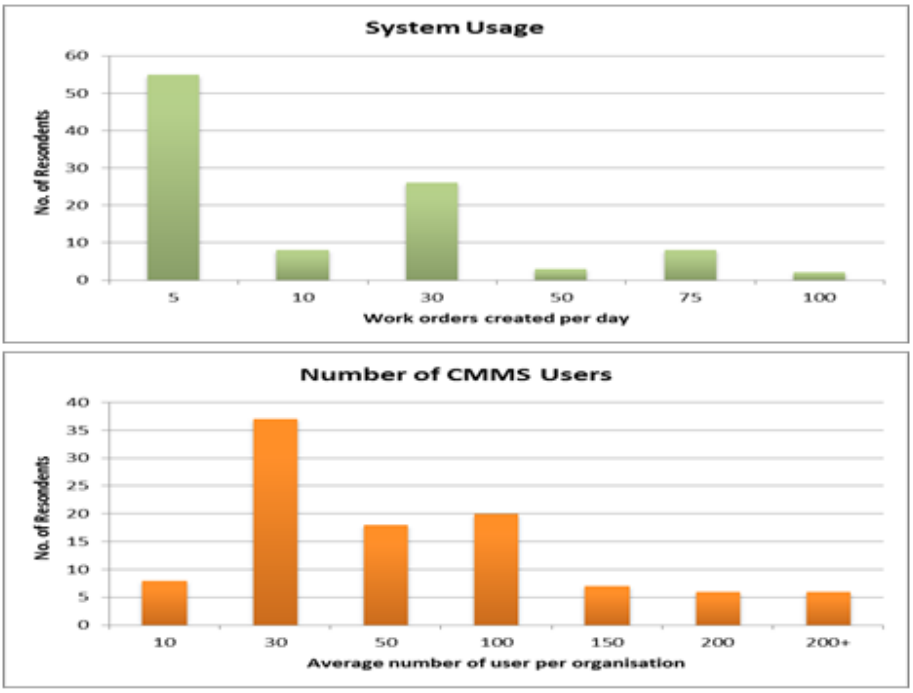


Figure 6 – CMMS usage post-implementations

The usage graph indicates that most of the respondents create on average between 0 – 5 work orders or job requests per day. Almost 10% of the users create more that 75 work orders per day, and the mean number of work orders that are created per day is 12.1. The second histogram in Figure 6 shows a mean of 52.7 and standard deviation of 55.5, suggesting that the client companies have relatively small groups of users, even though some groups may comprise over 200 users.

This was not a longitudinal study but, it was important to examine whether users felt that the purported benefits of the CMMS were being achieved. For this, we created a multiple regression model based on the respondent feedback data. The aim was to predict whether our data would support a positive perception of the benefits CMMS. The tables in Figure 7 and the scatter plots in Figure 8 show the strong correlation coefficients between the "perceptors", and the associated strong regression statistics. The strength of the correlations supports the assumption that the psychological ontologies are not mutually exclusive. This is not surprising since a typical user of CMMS may not necessarily discern with a high degree of discrimination, the difference between *ease of use* and *usefulness*, even though the *Likert* scale had a resolution of 20%.

Correlation coefficients				
	EASE	USE	CHAR	TRN
USE	0.673			
CHAR	0.764	0.787		
TRN	0.702	0.603	0.825	
UP	0.813	0.765	0.831	0.762

Regression Statistics	
Multiple R	0.892
R Square	0.796
Adjusted R Square	0.788
Standard Error	0.316
Observations	102

Figure 7 – Correlation between “perceptors”

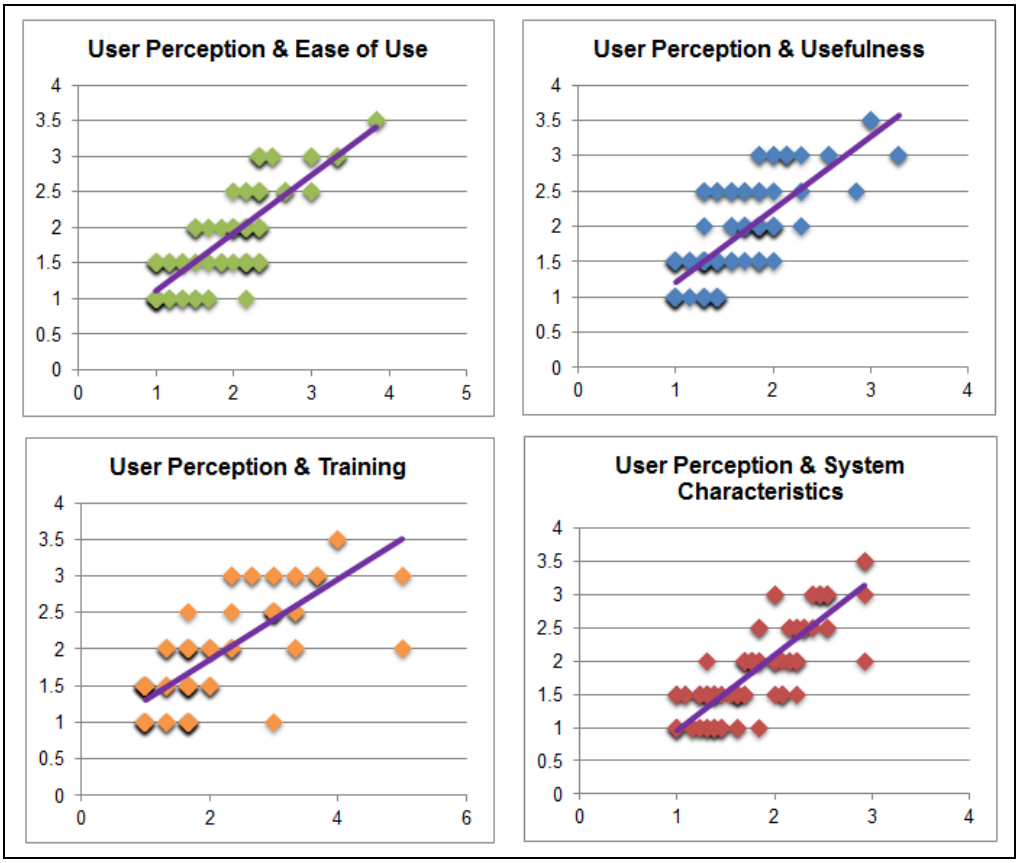


Figure 8 – Scatter plots of correlation between "perceptors"

The correlation statistics shows variability close to 80%, and standard error of 0.316, indicating that the user perceptions may be reasonably described by the four "perceptors" used in this study. The tables in Figure 9 are summaries of the analysis of variance (ANOVA) and the regression model. The *p*-level in the ANOVA table suggests that there is a very low probability that the "perceptors" are random. This is confirmed in the *p*-values in the regression model, indicating that the four "perceptors" are significant representations of user perception of the CMMS.

Analysis of variance (ANOVA)					
	df	SS	MS	F	p-Level
Regression	4	37.788	9.447	94.707	1.25E-32
Residual	97	9.676	0.100		
Total	101	47.463			

Regression estimates						
	Coefficients	Std. Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.157	0.126	-1.246	0.216	-0.408	0.093
EASE	0.351	0.074	4.736	0.01	0.204	0.498
USE	0.338	0.104	3.246	0.002	0.131	0.544
CHAR	0.277	0.149	1.861	0.046	-0.018	0.572
TRN	0.143	0.061	2.358	0.02	0.023	0.263

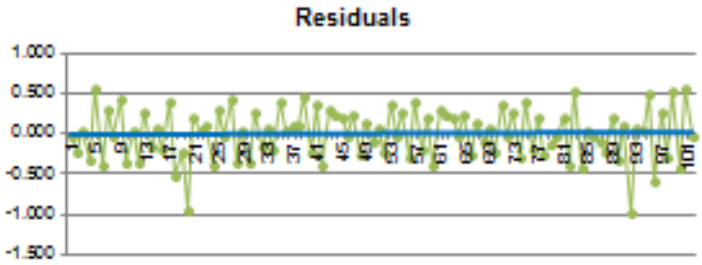


Figure 9 – Analysis of variance and regression coefficients of "perceptors"

The regression estimates shows a normal distribution (i.e., white noise), and leads to the following expression for the perception prediction:

$$USER\ PERCEPTION = -0.157 + 0.351(EASE) + 0.338(USE) + 0.277(CHAR) + 0.143(TRN) \quad (1)$$

This equation may be used to predict user perception based on the data extrapolated from the respondent feedback. It is important to note that negative coefficient of the intercept is not a problem. It means that if all the variables have a value of 0, the user perception value will be -0.157. This is however an extrapolation as none of the variables could be 0 as the scale is between 1 and 5.

V. Conclusion

Without recourse to pre-implementation issues, our study reiterates the view that user perception influences the acceptance of technology. This is based on the premise that *ease of use*, *usefulness*, *technology* (i.e., *system*) *characteristics*, and *training* are ontological constructs that may be applied to describe user perception. We have provided some empirical data that upholds the conventional wisdom that *training* has a very strong influence on how a user not only perceives but also, accepts a technology system and its utilisation post-implementation. Most vendors are excited by the functionalities embedded in their ICT systems, and tend to 'market or hard sell' the functionalities to the users, often neglecting to deal with the latent psychological issues of user perception and acceptance.

It is important to remark that the study was conducted from the viewpoint of a CMMS vendor, and this limitation is complicated by lack of information or knowledge about the pre-implementation level of readiness of the user clients that participated in the survey. Although we had planned to follow up the questionnaire-based survey with semi-structured interviews of some of the respondents – our attempts to set up appointments within time limits proved to be a chore. Nevertheless, a ramification of our study is that *training* must not only focus on the functionality of the system but also, on the content. Furthermore, process of *training* must appeal to the psychological pre-disposition of the eventual users of the system. The emphasis of *training* on the human psychological aspects may reduce apathy and engender positive impressions that the technology is invaluable to the user.

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