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The Exploratory Analysis on Knowledge Creation Effective Factors in Software Requirement Development

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ABSTRACT

The knowledge creation effective factors were found in both necessary elements for stimulus of knowledge creation and the key influencing factors of software project success. The research was carried with the specific successful practices of Microsoft Corporation and William Johnson's analysis of R & D project knowledge creation. The knowledge creation effective factors in requirement development project are clarified through deeply interviewing the software enterprises in Guangdong province as well as other corporate information departments. The effective factors are divided with R & D project knowledge creation model in the view of organizational, team, personal and technical four levels through literature research and interview in enterprises, and the empirical study was done with questionnaire and exploratory analysis.

Keywords: *Software Requirement, Knowledge Creation, Project, Organization, Empirical Study*

1. Introduction

The smooth development of software requirements needs an efficient organization to support [1], this paper discusses the knowledge creation factors in software requirements development process in the meta-level of the software process with the instance of Microsoft corporation [2-4]. Software requirement development as a knowledge creation process, Nonaka etc. have attributed the knowledge effect factors to four reasons: intention, autonomy, creative chaos, requisite variety. On this basis, Krogh etc. re-emphasized the importance of friendly relationship to build efficient "Ba" [5]. J. P. Wan etc. analyzed from knowledge management view, some of them proposed a number of effective factors: experience in the domain, knowledge gaps, user participation, administrative support, personal capability, comprehensive training, methodology and related technology and so on [6,7].

This paper is organized as follows: first knowledge creation effective factors are illustrated and the effective factors in the requirement development process are concluded. With deeply interviewing the software enterprises in Guangdong province as well as other corporate information departments, the knowledge creation effective factors in requirement development project are clarified, finally the empirical study is done with questionnaire survey and exploratory analysis.

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2. Knowledge Creation Effective Factors

Nonaka attributed knowledge creation effective factors to intention, self-management, creative chaos, redundancy and requisite variety [8], and re-emphasizes the friendly environment in the organization [5].

2.1 Intention

Nonaka indicated that the organization intention is the most important criterion in judging the authenticity of intent. If there is no organization intention, the organization will not be able to judge the value of perceived information and creative knowledge, at the same time, the organization intention must be affected by the organizational value. William Johnson considers that it should give one intention for each project at last, and it is obviously that if there is no intention, the next research will not continue [9]. Software requirements development process

is a knowledge creation process in nature [7]. For example, the first is to establish a shared vision to enhance the team's sense of identity, belonging in the Microsoft corporation's successful rules [3].

2.2 Self-Management

It is that the members or the teams take actions voluntarily to improve the organization creativity. Autonomy team refers to taking the team as operation mainstay voluntarily. For example, William Johnson discovers that personal autonomy is very important for knowledge creation with interviews [9]. It allows large teams to work like small teams by dividing work into pieces, proceeding in parallel but synchronizing continuously, stabilizing in increments, and continuously finding and fixing problems in Microsoft Corporation [10].

2.3 Creative Chaos

Nonaka etc. illustrate that turbulence and creative chaos accelerate the interaction between the organization and environment. Members will start to question the validity of the basic attitudes. It will be opportunity to amend the fundamental thinking and insight. It is obviously that turbulence and creative chaos contribute to organizational knowledge creation [5]. William Johnson discovered that only in a few projects, turbulence and creative chaos possess function which promotes knowledge creation, just same as Nonaka's description with R & D's research projects. In most projects, it is often closely linked with the problem's occurrence. There is no data illustrated that the creative chaos and knowledge creation have a strong correlation [9].

2.4 Redundancy

Redundancy usually refers to the repetition and share for group members and the unnecessary information. It is a kind of redundancy to adopt different technologies to solve the same problem during requirement development process. For example, it is an effective knowledge creation process to build a number of schemes and choose the optimal with review.

2.5 Requisite Variety

William Johnson concluded that all projects regard the requisite variety as a positive factor in the project knowledge creation on the R & D project study [9]. Microsoft Corporation emphasized the small teams, which should be diversification and even in a role. There are usually many different working ways and its members should have different job skills or experience levels in a project team [5].

2.6 Friendly Relationship

Krogh etc. considered that the friendly relationship can remove the distrust, fear and dissatisfaction in the knowledge creation process, and allow team members to explore new markets, new customers, new products and new manufacturing technologies in the unknown territory with enough reassurance [5].

3. The Effective Factors in the Requirement Development Process

The goal of software development is to exploit the high quality software which meets the customers' real requirements timely within the budget. The success of the project depends on good requirement management [11]. This paper discusses the effect factors of requirement development process in perspective of knowledge creation.

3.1 Domain Experiences

Cohen and Levinthal argued that if the organization had more relevant knowledge or experiences, and its absorptive capacity is better, it is a function of its past experiences accumulation [12]. Y. H. Ke etc. analyzed the importance of domain experience for system development, and discovered that the system development experience and deeply understanding of domain knowledge have a positive effect on knowledge transfer [13]. Pete Sawyer and Gerald Kotonya considered that one of the key resources in software requirement acquisition is the domain knowledge. Requirements engineers need to acquire effective knowledge on application domain. It can help them to know the tacit knowledge what stakeholders can not clearly illustrate and learn about the necessary balance between the conflict requirements [14]. For example, Microsoft's team model advocates on the basis of deeply understanding the client's business requirements and familiarly mastering related technologies to develop the project and decision-making. Therefore, the project team members should have the professional and deeply technology and business skills in themselves domains [15].

3.2 Knowledge Gap

It refers that the developer is lacking of business operation knowledge, knowledge of technology, and understanding of user business and software technology [16]. S. Alshawi etc. argued that it is important to have the business and technical knowledge for any enterprise [17].

3.3 User Participation

It is particularly important in information systems' development [18-20]. In Standish Group study, the most reason of project "disagree" factor was the lack of user participation, accounting for 13% in all failure projects. All successful projects illustrated that the most important factor was user participation, accounting for 16% of all projects [21,22]. Standish Group enumerated the top ten critical elements of software projects success with surveying 8380 software projects, the lack of user involve-

ment is listed in the top ten reasons of software project failure [23,24].

3.4 Administrative Support

For example, the Microsoft product development process explicitly specifies that when the projects passing the review and approval by higher managers, and the company will make sure the development progress is going smoothly, and appropriate human and resources for development will deploy through human resource department and finance department [3,4].

3.5 Personal Capability

System analyst is a typical compound talent, and his knowledge structure not only strides the social sciences and natural sciences, but also is the perfect combination of theory and practice. For example, Microsoft asked the staff who participates the software development project have good professionalism and excellent job skills. Staff qualities include: personal quality, passion for product, concerning customer feedback, having cooperation spirit and so on [25].

3.6 Comprehensive Training

For example, Microsoft pays much attention to the developer's re-improved process, including learning and training and so on. The training ways are various, such as professional skills training, many kinds of seminars, training of product plan and development and so on. It also pursues to learn from the past and current research projects and products in system way [4].

3.7 Methodology

Today, many software organizations implement the best industry practices as the software development methodology, such as the SW-CMM (Capability Maturity Model For Software) has been promoted the Software Engineering Institute (SEI) of Carnegie Mellon University in United States since 1987 and so on [15,24].

3.8 Related Technology

Eriksson and Dickson argued that people share the existing knowledge and the new knowledge are created in same time, and the IT infrastructure is one of the factors impacting knowledge creation and share, including supporting information circulation, integrating tools for group problem-solving, such as Intranet, Extranet, video conferencing etc. [26].

4. Interview in Enterprises

We interview some experienced requirement developers, project managers, technical directors and other staffs of the software enterprises in Guangzhou P. R. China for the effect factors of software requirement development. The results are summary as follows.

4.1 Positive Factors

Requirement developer generally plays by the veteran in a team with abundant project experience. These skills include: 1) domain knowledge; 2) communication skill; 3) analysis & arranging capability, comprehensive capability; 4) mastering a certain tool, specially the requirement analysis tools.

It has great importance on the methods and techniques of requirement development process in the software enterprise. First, it carries out the project generally according to the project management standards. Second, it uses prescriptive specification to develop requirement, e.g. the standard template, the standard development tool and so on. Finally, it will use variously interview methods, recording methods and tools in the requirement development process.

4.2 Uncertain Factors

Enterprises always hold uncertain attitude about autonomy. They considered that in the project management, whether the team processes autonomy is related to the project property. Employee must complete their work following the requirement specification and the standard format and submit the required report. However, they can complete independently in really operation.

4.3 Negative Factors

Software companies generally oppose chaotic environment, in particularly they do not like working in a tense environment. The creative chaos environment is not established, and tense working environment usually causes staffs turnoff.

5. The Classification on the Effective Factors of Knowledge Creation in Software Requirement Development

The knowledge creative factors in software requirement development are classified into three areas through the literature research and enterprise interviews (**Table 1**). 10 of which factors are positive, 3 are unable to determine clearly, there are two negative factors.

6. Questionnaire Design and Collection

The quantitative sample survey is taken to test the hypotheses of knowledge creation effective factors in software requirement development.

The questionnaire includes the following six areas: basic information, organizational characteristic, personal characteristic, technical characteristic, knowledge creation and requirement development characteristic relationship.

The first area is about the basic information, including industry type, system user, system type, the number of

system development team, the number of system requirement development team and testee related role in order to have a more clear understanding of the sample. The second area is about organizational characteristic scale, including 4 variables and 14 items. The third area is about the team characteristic scales, including 6 variables and 16 items. The fourth area is about the personal characteristic scale, including 3 variables and 8 items. The fifth area is about the technical characteristic scales, including 2 variables and 7 items (**Table 2**). The sixth area is about the knowledge creation and requirement development relationship characteristic scale, including 4 items.

Table 1. Classification on the effective factors

Relativity	Level	Effect factor	Remark
Positive	Organization	Management support Friendly environment	Literature research and enterprise interviews on the effective factors' classification is basically same.
	Team	Project intention Requisite variety User participation Comprehensive training	
	Personal	Domain experience Personal capability	
	Technology	Methodology Related technology	
Uncertain	Organization Team Personal	Redundancy Self-management Self-management	
Negative	Organization Team	Creative chaos Knowledge gap	

Table 2. Questionnaire detailed corresponding table

Level	Variable factors	Item	References
Organization	Management support	Area one O1～O3	Nonaka (2000), Johnson (2000), Standish Group (1994), Zhang Xianghui (2005), Chen Honggang (2003), James Emery (2002)
	Friendly environment	Area two O4～O10	Nonaka (2000), Johnson (2000), Krogh (1994), Zhang Xianghui (2005), Chen Honggang (2003)
	Creative chaos	Area two O11、O14	Nonaka (1995, 2000), Johnson (2000)
	Redundancy	Area two O12、O13	Nonaka (1995, 2000), Johnson (2000)
Team	Project intention	Area three T1～T2	Nonaka (1995, 2000), Johnson (2000), Zhang Xianghui (2005), Cheng Honggang (2003)
	Self-management	Area three T3～T5	Nonaka (1995, 2000), Johnson (2000), Zhang Xianghui (2005), Chen Honggang (2003)
	Requisite variety	Area three T6～T7	Nonaka (1995, 2000), Johnson (2000), Zhang Xianghui (2005)
	User participation	Area three T8～T10	Standish Group (1994, 1995, 1999), Johnson (2000), Zhang Xianghui (2005), Guinan (1998), Henri Barki (1994), Hirschheim (1994)
	Comprehensive training	Area three T11～T13	Humphrey (2002), Constantine (1995), Chen Honggng (2003)
	Knowledge gap	Area three T14～T16	Alshawi (2003), Linda (2000), Ian McBriara (2003), Gilbert (1996)
Personal	Self-management	Area four I1～I2	Nonaka (1995, 2000), Johnson (2000), Chen Honggng (2003)
	Domain experience	Area four I3～I6	Cohen, Levinthal (1990), Ke Yihua (2005), Chen Honggang (2003)
	Personal capability	Area four I7～I8	Johnson (2000), Zhang Xianghui (2005), Chen Honggang (2003), Tian Junguo (2003)
Technology	Methodology	Area five Te1～Te2	Johnson (2000), Zhang Xianghui (2005), Chen Honggang (2003)
	Related technology	Area five Te3～Te7	Johnson (2000), Zhang Xianghui (2005), Chen Honggang (2003), Ellen Gottesdiener (1999), Eriksson, Dickson (2000, 2003)
4	15	45	

7. The Exploratory Analysis of Requirement Development Effective Factors

7.1 Reclaiming Questionnaire

Questionnaire has surveyed during December 2006 to January 2007 in Guangdong region, including Guangzhou Ferryman Management Consulting Co., Ltd., Guangdong Visionsky Information Technology Co., Ltd., Guangzhou KeenFox Engineering Co., Ltd., Computer and Technologies Solution (Shenzhen) Co., Ltd., nearly 20 enterprises, issued totally 50 e-mails, and totally recovered 26s, all are valid.

7.2 Characteristic of Sample

The highest proportion is the software industry, the number is 17, accounting for 65.4%; the rest of the industry includes financial industry, service industry and other industries accounted for 11.5%, 11.5% and 11.8% correspondingly.

The products which belong to interviewee's team are generally provided to the external clients to use (sample number 10, accounting for 38.5%), internal requirement (sample number 8, accounting for 30.8%) and the combination of the two (sample number 8, accounting for 30.8 %). The products which belong to the interviewee's team, mainly MIS (sample number 17, accounting for 26.6%) and DSS (sample number 13, accounting for 20.3%), others such as ERP, EC, KM, special products, common products as well as other, accounting for 9.4%, 9.4%, 6.3%, 10.9%, 1.6% and 15.6% correspondingly.

The 51 persons and above (sample number 16) is dominated, in the software development team where the interviewee is accounting for 38.5%; 1 to 10, 11 to 20, 21 to 50 are accounted for 26.9%, 23.1 % and 11.5% correspondingly. The 4 to 5 persons is dominated in the requirement development team, accounting for 42.3%, while, 11 persons and above, 6 to 10, and less than 3, are accounting for 26.9%, 19.2% and 11.5% correspondingly. The main interviewees are team project management, the sample number is 12, accounting for 36.2%; developer, requirement person, designer, tester and others are accounting for 26.9%, 7.7%, 3.8% and 7.7% correspondingly. Software industry is dominated in the interviewee's enterprises, the main products is MIS and DSS. Interviewee's software development team usually are large, the number of requirement team is 4 to 5 persons. Mainly interviewees are project managers in order to make the data more persuasive.

7.3 Analysis on Reliability and Validity

The Cronbach's α value is used to determine internal consistency because this paper is exploratory research and items are limited. The reliability of every variable is more than 0.350 after deleting items I3 and Te7, and reliability can be basically acceptable (**Table 3**).

7.4 Statistical Analysis

7.4.1 Descriptive Statistics

The descriptive statistics is illustrated in the **Table 4** according to the variables in **Table 2**. The summary is in the following.

1) The average score of knowledge transformation & requirement development is 4.4712 and indicates that there is close relationship between knowledge transformation and requirement development, it is same as with literature research and enterprise interview.

2) Personal capability, comprehensive training, friendly environment, project intent, customer participation, domain experience and requisite variety and etc., score more than 4 and have a higher acceptance.

3) Redundancy, creative chaos, team self-management, individual self-management, methodology and technology, score lower than 3.5, are basically same as the expected results.

7.4.2 One-Sample T Test

It judges one-sample T test which the test value is 3.5, confidence interval is 95%. If the significant coefficient is less than 0.05, and the upper and lower bounds are greater than 0, indicating its value to more than 3.5 large (have passed the examination); if a significant factor greater than 0.05, or the upper and lower bounds are less than 0, then its value is smaller than 3.5. It is illustrated in **Table 5** that the items are passed the test except redundancy, creative chaos, the team self-management, individual self-management, methodology and technology.

Redundancy, creative chaos, team self-management, individual self-management, methodology and technology do not pass the test where the test value is 3.5. The reverse scoring one-sample T test results is illustrated in the **Table 6** where the test value is 3. Only the individual autonomy is significant, it specified that the individual autonomy plays a negative effect on knowledge creation of requirement development. The other variables do not pass the test, they are unclear type. In addition, the knowledge transfer and requirement development still passing the test where test value 4, it illustrates in **Table 7** that the relationship between the requirement development and knowledge transfer is recognized highly.

8. Conclusions

It is illustrated in **Table 8** that the management support, friendly environment, intention, requisite variety, customer participation, comprehensive training, knowledge gap, domain experience and personal capability and so on through the literature research, interview in enterprise and questionnaire survey, The nine variables have the positive effect on the knowledge creation of requirement development, where the knowledge gap is measured by reducing

Table 3. Reliability of variables

Variably	Item number	Cronbach's α value	Remove item	Reference value
Management Support	3	0.710		
Friendly environment	7	0.771		
Redundancy	2	0.447		
Creative chaos	2	0.683		
Intention	2	0.410		
Team self-management	3	0.532		
Requisite variety	2	0.555		
User participation	3	0.502		
Comprehensive training	3	0.824		0.350
Knowledge gap	3	0.379		
Personal self-management	2	0.703		
Domain experience	2	0.552	I3	
Personal capability	3	0.409		
Methodology	2	0.627		
Technology	4	0.469	Te7	
Knowledge transfer& requirements development	4	0.914		

Table 4. Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Management support	26	3.0000	5.0000	3.961538	.5360508
Friendly environment	26	3.4286	4.8571	4.131868	.3426739
Redundancy	26	2.0000	4.0000	3.096154	.6636148
Creative chaos	26	1.0000	5.0000	2.865385	.9225800
Intention	26	3.0000	5.0000	4.115385	.4540417
Team self-management	26	2.0000	4.3333	3.480769	.5931590
Requisite variety	26	3.5000	5.0000	4.019231	.3868015
User participation	26	3.6667	5.0000	4.423077	.4274752
Comprehensive training	26	3.3333	5.0000	4.192308	.5178852
Knowledge gap	26	3.0000	4.6667	3.987179	.4664835
Personal Self-management	26	1.0000	4.0000	2.500000	.7745967
Experience in the field	26	2.5000	5.0000	4.038462	.5463163
Personal capability	26	3.5000	5.0000	4.211538	.4043038
Methodology	26	2.5000	4.0000	3.403846	.4902903
Related technology	26	1.7500	4.0000	3.375000	.4962358
Knowledge transfer & requirements development	26	3.7500	5.0000	4.471154	.4707809
Valid N（listwise）	26				

Table 5. Variable one-sample T test

	Test Value = 3.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Management support	4.390	25	.000	.4615385	.245023	.678054
Friendly environment	9.402	25	.000	.6318681	.493459	.770277
Redundancy	-3.103	25	.005	-.4038462	-.671886	-.135806
Creative chaos	-3.507	25	.002	-.6346154	-1.007254	-.261977
Intention	6.911	25	.000	.6153846	.431993	.798776
Team self-management	-.165	25	.870	-.0192308	-.258813	.220351
Requisite variety	6.845	25	.000	.5192308	.362998	.675463
User participation	11.011	25	.000	.9230769	.750416	1.095738
Comprehensive training	6.816	25	.000	.6923077	.483129	.901486
Knowledge gap	5.325	25	.000	.4871795	.298763	.675596
Personal self-management	-6.583	25	.000	-1.0000000	-1.312866	-.687134
Domain experience	5.026	25	.000	.5384615	.317800	.759123
Personal capability	8.974	25	.000	.7115385	.548237	.874840
Methodology	-1.000	25	.327	-.0961538	-.294186	.101879
Related technology	-1.284	25	.211	-.1250000	-.325434	.075434

Table 6. Not pass the variable reverse scoring one-sample T test where the test value is 3.5

	Test Value = 3.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Redundancy (reverse)	–.739	25	.467	–.0961538	–.364194	.171886
Creative chaos (reverse)	.744	25	.464	.1346154	–.238023	.507254
Team Self-management (reverse)	–4.133	25	.000	–.4807692	–.720351	–.241187
Personal Self-management (reverse)	3.291	25	.003	.5000000	.187134	.812866
Methodology (reverse)	–4.200	25	.000	–.4038462	–.601879	–.205814
Related technology (reverse)	–3.853	25	.001	–.3750000	–.575434	–.174566

Table 7. Knowledge transfer and requirement development one-sample T test

	Test Value = 3.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Knowledge transfer and requirement development	5.103	25	.000	.4711538	.281001	.661306

Table 8. The summarized relationship between variables

Correlation	Level	Effect factor	Remark
Positive (+)	Organization	Management support	The same as with literature research and enterprise interview
		Friendly environment	The same as with literature research and enterprise interview
	Team	Intention	The same as with literature research and enterprise interview
		Requisite variety	The same as with literature research and enterprise interview
		User participation	The same as with literature research and enterprise interview
		Comprehensive training	The same as with literature research and enterprise interview
	Personal	Knowledge gap	The same as with literature research and enterprise interview
		Domain experience	The same as with literature research and enterprise interview
		Personal capability	The same as with literature research and enterprise interview
Uncertain (U)	Organization	Redundancy	The same as with literature research and enterprise interview
		Creative chaos	Chaos is a demon for the software business (Larry • Constantine), but the creative chaos has certain positive effect for enterprise management.
	Team	Self-management	The same as with literature search and enterprise interview
	Technology	Methodology	Small-scale projects require little, but large-scale projects need.
		Related technology	Small-scale projects require little, but large-scale projects need.
Negative (−)	Personal	Self-management	Requirement development projects generally obey the project management method, have clear work plan and method.

knowledge gap and it is positive. Considering the literature research and interview in the enterprise, individual independency is determined negative because it illustrates significance in reverse scoring. The others, including redundancy, creative chaos, team self-management, methodology and technology, are unclear. It concludes that the technology and the methodology are support factors of project development and would be very useful for large scale projects. On the contrary, redundancy, creative chaos and team self-management should be avoided as far as possible in the project, because it is inconsistence with the goals of requirement development.

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