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Research Article

STRUCTURAL EQUATION MODELING OF SOFTWARE DEVELOPMENT: IRAN EXPERIENCE

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ABSTRACT
Present research intends to study challenges of computer software development in Iran. Taking time and costs more than initial estimation and quality less than initial expectations are regarded as challenges. Studying resources, some of the most challenging factors in software development phases which mentioned in scientific texts have been extracted and 201 questionnaires out of 234 questionnaires have been returned by managers of companies' project team i.e. nearly 86%. Research variables had acceptable Cronbach's alpha, oscillating in range of 741% to 823%. At first in order to analyze gathered data, demographical characteristics of the sample people in descriptive level have been studied including members of project team, projects duration, average experience of project team and the methodology. Confirmatory factor analysis was used in analytical statistics of this research in order to examine significance between observer variable and latent variable and also fitting the measurement models and finally, structural equation modeling has been used by LISREL to study causal relations of variables and conceptual model test of research. Findings show that the most important challenges of computer software development which have influence upon challenges concerning maintenance phase are related to documentation and programming quality and also personnel resources phases.

Keywords: *SEM, Computer Software, Challenge, Iran*

INTRODUTION
Principally, several factors should be considered in software development which their absence or failure can affect on computer software development: **Documentation**: Documentation is set of information, notes and diagrams that describe function, application and keeping a software (or hardware) (Collin, 2004). Examining activities qualitatively and quantitively both verifies reason of a certain strategy and presents detailed data of software due to save and record approaches in all phases including planning, programming, setup and installation and maintenance.
Employers always try to decrease their need to contractors after software system installation in organization or affiliated units and they try to be independent enough to keep and support received software and this subject is possible merely by presenting accurate and suitable documentations including documentations related to system requirements, planning, construction such as documentations related to source code, and also implementation, testing and system maintenance by contractor. On the other hand, it seems that contractors try to decrease employer's independency on the subject due to keep themselves and their job.
Thus, perhaps job insecurity is one reason of lack of documentations.
System Requirement: Principally, software are developed for a certain purpose and to meet specified needs and for special target goals, therefore, focusing the software internal quality that is called functional requirements includes cases such as examining the structure and its complexity. Meanwhile, through architecture or planning phase, it is possible to evaluate system behavior i.e. nonfunctional requirements such as security, confidentiality, usability, sustainability and functionality (Emadi, 2009). So the software external quality may be improved. Requirements engineering provides suitable bed to comprehend stakeholders' requests and also makes arrangement for requirements analysis.

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Programming: The activity of writing programs for computers. Programming languages are grouped into different levels: the high-level languages are easy to understand and use, but offer slow execution time since each instruction is made up of a number of machine code instructions; low-level languages such as assembler are more complex to read and program in but offer faster execution time (Collin, 2004). The fourth generation programming language including Report generators and Quarry and Graphic languages are widely used in recent years.

Maintenance: Maintenance is the tasks carried out in order to keep a system running, e.g. repairing faults and replacing components (Collin, 2004). The ease with which a software system or component can be modified to correct faults, improve performance or other attributes, or adapt to a changed environment (Pigoski, 1994). Lack of adoption with new conditions by the software makes it less usable and it will be out of date or retired after a while. One example is disk operating system (DOS) that is out of date at present time.

More challenges in relation to software maintenance, makes less possibility of software survival. These results are consequences of challenges that have been made in previous phases of software development and have been transferred to maintenance phase. On the other hand, challenges concerning maintenance phase have feedbacks on other phases of software development and finally leads to decrease or remove affiliated challenges.

Software life cycle means considering the very subject. Thus, it seems that maintenance is one of the most important phases in software life cycle. Some researchers believe that there is a great importance for software maintenance phase in a way that they have divided software life cycle to two main phases of software development (deployment) and software maintenance. About 66% of whole the costs of software life cycle is allocated to maintenance phase (Yip and Lam, 1994; quoted in Chen and Huang, 2009). The other factors which are related to software development are:

Personnel Resources: People are the most important resource on a project. Human resources management focuses on creating and developing the project team as well as understanding and responding appropriately to the behavioral side of project team (Marchewuka, 2012).

Considering the fact that attention to personnel is one important principle in project management, due to companies' reliance on manpower's skill and specialty and necessity to encourage and motivate them organizationally in business environment, they try to keep their personnel by various techniques and methods but many personnel leave the organization when faced with better offers by other competitors and are employed in competitive companies.

This is one of the main concerns of mangers in governmental and private companies. Applying protection plan of manpower by Informatics Higher Council or any other authorities related to ICT may decrease worries and keep manpower in their companies.

Process Management: Principally, process is called a set of correlated activities that turn certain input data into certain output data (Informatics Higher Council, 2004). Process management means there should be procedures in order to be sure from quantitative and qualitative trend in direction of project goals and to predict and examine software development challenges in all project phases and to overcome them and bring precautionary and pursuing actions, affected by unified and consistent managerial activities. Software development process means a part which is related to all phases of software development and its goal is to manage process and phases or software life cycle in order to supervise and evaluate better and finally, to decrease challenges and promote qualities.

Methodology consists of consecutive, successive methods and guidelines that are tools to formulate and regulate these processes with respect to evolutionary phases in software development. Hence, software developers use various methodologies such as Software Process Improvement (SPI), Agile (XP, Scrum, Kanban, etc.), and Rational Unified Process (RUP), in software manufacturing phases. Although, each mythology uses special techniques and standards in software development; however they follow same principles and phases which observing them is avoidable. These principles begin with analysis, feasibility study and it leads to software manufacturing operation and finally maintenance and care after study on technical problems, planning, manufacturing & implementation, program test.

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MATERIALS AND METHODS

Present research which belongs to applied type is an analytical-survey research. It means that computer software development challenges have been studied by analytical-survey method. The questionnaire is also used by five-level Likert scale as a tool to gather information. Items of this questionnaire have been extracted as a result of studying texts and resources related to this branch, particularly, a prepared questionnaire by Chen and Huang which had been published in 2009 in Journal of Systems and Software no.82. It should be noted that this journal belongs to Institute for Scientific Information (ISI) with Impact Factor of 1.28.

Thus, items of initial questionnaire have been produced and compiled in 6 dimensions and 30 items based on the most challenging factors reported by software developers during 1981 to 2007 and official valid resources have published these challenges in scientific texts. It was formulated as final questionnaire considering opinions and final confirmation by associate professor, assistant professor and software experts, and pilot survey in a society consist of 30 members of working people in valid ICT companies, then the questionnaire was distributed in research society by targeted method.

In other words, Library & Information Science and software engineer masters' opinions have been used in order to obtain questionnaire validity and the questionnaire has been confirmed by experts of this field. So it can be considered as a researcher-made questionnaire. Also Cronbach's Alpha Coefficient was used for questionnaire reliability. According to alpha coefficient column in table-1; it is observed that research variables have acceptable alpha value.

Table 1: Cronbach's Alpha Coefficients for Research Variables

Variables	Cronbach's Alpha
Challenges as for documentation quality	0.861
Challenges as for system requirement	0.811
Challenges as for programming quality	0.755
Challenges as for maintenance	0.823
Challenges as for personnel resources	0.741
Challenges as for process management	0.799

This research statistical society includes all tailor made computer software developers who have a valid technical confirmation certificate issued by Informatics Higher Council. Names of these companies have been extracted from website of Informatics Higher Council. First they were separated from other companies and 600 computer software developers were specified. According to Krejcie & Morgan Table of sample size of questionnaire; sample volume consists of 234 companies with ranks 1 to 7 for which questionnaires were sent. 201 questionnaires were filled and returned by project managers of software development team, therefore, about 86% of questioners have been returned. It should be noted that, computer games developers which work under Computer Games National Institute, are not included in this research society. At first in order to analyze gathered data, demographical characteristics of the sample people in descriptive level have been studied including members of project team, projects duration, average experience of project team and the methodology. Confirmatory factor analysis was used in analytical statistics of this research in order to examine significance between observer variable and latent variable and also fitting the measurement models and finally, structural equation modeling or SEM has been used by LISREL method to study causal relations of variables and conceptual model test of research.

RESULTS AND DISCUSSION

Results

Research Objectives and Questions

The object of this research is to determine factors related to challenges of computer software development phases which influence upon challenging concerning maintenance phase. So the main questions of present research are:

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1- What are demographical specifications of computer software development projects' team members?
2- Which software development challenges phases including documentation qualities (DOC), system requirements (SYS), programming quality (PGM), personnel resources (PER) and process management (PM) has the most significant influence on maintenance phase?

Distribution of Responders Regarding Number of Members of Project Team

Table 2 of frequency distribution shows status of number of project team member. Among all sample groups, 14 project team among groups have 1-2 members (about 7%), 70 project team have 3-4 members (about 35%), 56 project team have 6-10 members (about 28%), 35 project team have 11-20 members (about 17%) and 26 project team have more than 20 members (about 13%).

Table 2: Distribution of responders regarding number of project members

Number of Members of Project	Frequency	Frequency Percentage
1-2	14	70
3-5	70	34.8
6-10	56	27.9
11-20	35	17.4
More than 20	26	12.9
Total	201	100

As it is observed in table 2, the highest frequency belongs to project team with 3-5 members with 34.8%.

Distribution of Responders Regarding Duration of Projects Completion

Table 3: Distribution of responders regarding duration of projects completion

Duration of Project Completion	Frequency	Frequency Percentage
Less than 6 months	40	19.9
6-12 months	73	36.3
13-24 months	51	25.4
More than 24 months	37	18.4
Total	201	100

Table 3 of frequency distribution shows status of duration of projects completion. Among all sample groups, 40 team have completed the project less than 6 months (about 20%), 73 team have completed the project between 6 to 12 months (about 36%), 51 team have completed the project between 13 to 24 months (about 25%) and 37 team have completed the project more than 24 months (about 18%). As it is observed in table-3, the highest frequency belongs to groups which have completed the projects between 6 to 12 months with 36.3%

Distribution of Responders Regarding Average Experience of Project Team Members

Table 4: Distribution of responders regarding average experience of project team members

Average Experience of Team Members	Frequency	Frequency Percentage
Less than 1 year	1	0.5
1-3	47	23.4
4-6	109	54.2
7-9	34	16.9
More than 9	10	5
Total	201	100

Table 4 of frequency distribution shows status of average experience of project teams' members. Among sample groups, 1 team members are experienced less than 1 year (about 0.5%), 47 team members are experienced between 1-3 years (about 23%), 109 team members are experienced between 4-6 years

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(about 54%) 10 team between 7-9 years (about 17%) and 10 team members are experienced more than 9 years (about 5%). As it is observed in table 4, the highest frequency belongs to team in which members are experienced 4-6 years with 54.2%

Distribution of Responders Regarding used Methodology in Software Development

Table 5 of frequency distribution shows status of used methodology of project in software development. 4 projects used SPI methodology (about 2%) 45 projects used agile methodology (about 22%) 66 projects used RUP (about 33%) and 63 projects used other methodologies (about 31%).

Table 5: Distribution of responders regarding used methodology in software development

Used Methodology	Frequency	Frequency Percentage
No methodology	23	11.4
SPI (Software Processing Improvement) models	4	2
Agile	45	22.4
RUP	66	32.8
Other	63	31.3
Total	201	100

Table 6: Factor loading and significance coefficient of challenges related to computer software development

Indices	Challenges	factor loading	significance coefficient
1.The project has been documented unreliably or obscurely		0.73	11.48
2.There has been no documentation or they have been incomplete		0.79	12.63
3.Tracking previous documentation in project is hard concerning design specification & users' requirements		0.71	10.93
4-Changes have not been documented completely		0.71	10.98
5-Documentation are not consistent and comprehensive		0.80	12.89
6-System requirements have been recognized mistakenly		0.84	14.02
7- System requirements have been recognized incomplete or obscure		0.78	12.59
8- System requirements have been recognized unreal or conflict		0.77	12.44
9-Paying no attention to software quality requirements		0.59	8.80
10- System requirements are changed constantly		0.46	6.51
11-It is not conforming to programming standards		0.67	9.97
12-Comments are incomplete in relation to source code		0.52	7.31
13-Various modules are not allocated in program in a way that they be independent to each other concerning functionality and operationally		0.76	11.62
14-The program is very complicated and restructuring is not possible		0.55	7.81
15- Inappropriate use of programming technique decreased ability of source code comprehension		0.58	8.33

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Table 6: Factor loading and significance coefficient of challenges related to computer software development (cont)

Indices	Challenges	factor loading	significance coefficient
16-Submitted software systems are not comprehendible and analyzable easily	related to MA	0.60	8.78
17- Submitted software systems are not changeable and optimizable easily		0.74	11.45
18- Submitted software systems are not sustainable and resistible against unexpected effects arisen from changes		0.63	9.22
19- Submitted software systems are not testable easily		0.63	10.13
20-Overally, submitted software systems are not maintainable easily		0.84	13.45
21-Frequent replacements happen in project team		0.44	6.12
22-Members of project team are not experienced or skilled sufficiently	related to PER	0.64	9.38
23- Members of project team have not passed appropriate educations		0.64	9.36
24- Members of project team are not able to manage human resources & time		0.69	10.30
25- Members of project team are not obligated toward the project		0.60	8.65
26-There isn't managerial support and policies in software development process	related to PM	0.55	7.87
27-Project planning and control are not effective		0.79	12.53
28-There is no proper estimation of project execution schedule & cost		0.66	9.87
29-It is not effective to control changes in configuration management software		0.73	11.31
30- Quality control verifications are not effective to be sure from qualitative level		0.66	9.88

Also no methodology has been used by 23 projects. As it is observed in table 5, the highest frequency in used methodology in software development belongs to RUP methodology with 32.8%.

2- Which software development challenges phases including documentation qualities (DOC), system requirements (SYS), programming quality (PGM), personnel resources (PER) and process management (PM) has the most significant influence?

Confirmatory Factor Analysis of Research Variables

Results of confirmatory factor analysis have been obtained by LISREL software for each variable of research separately. It should be noted that, factorial load should be more than 0.3 to decrease variables and considering them as a latent variable (Momeni and FaalGhayum, 2007). The researcher knows that which question is related to which dimension in factorial analysis. It means that there are conceptual model for each concept or variable of research in confirmatory factor analysis. The main question to study each model is whether these models of measurement are appropriate or not? On the other hand, whether the research data is consistent with conceptual model or not? Generally, there are two types of indices to examine fitting of models.

1-Indices for good status

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2-Indices for bad status

There are indices for good model such as AGFI, NFI…., more value of these indices show better status. The recommended value is 0/9 for such indices. Also, there are indices for bad status such as x^2/dfand RMSEA, so that their lower value shows models with better fitting. The permitted limit is 3 for x^2/df and it is 0.08 for RMSEA. Indices of good status and bad status (x^2/df, RMSEA, AGFI, AGF, NFI and CFI) should be examined relative to each other in order to answer fitting of model.

Measurement Model of Research Variables

Table 6 shows summary results of factor loading and significance coefficient of challenges related to computer software development. As it can be observed all coefficients are significance and factor loadings are greater than 0.3. An indication of all questions of questionnaire has validity.

Results of estimation (or fitting of the model) show indices are appropriate relatively. According to output of LISREL, value of x^2 calculated is 636.02 that is less than 3 with regards to degree of freedom (390). Value of RMSEA is 0.056. The permitted limit of RMSEA is 0.08. Indices of GFI, AGFI and NFI are respectively 0.92, 0.96 and 0.95 and it means that there is a relative high fitting.

Exam of Main Hypotheses of Research by Structural Equation Modeling or SEM

In order to study influences of research independent variables (documentation, system requirements, programming quality, personnel resources and process management), and based on research introduction and background that has been presented earlier, hypothesized models has been designed.

Null hypothesis and one hypothesis to confirm or reject research hypotheses are obtained as follows:

H_0: There is no significant relation between two variables.

H_1: There is a significant relation between two variables

Table 7: Examination of confirmation or reject of hypotheses

Hypothesis	Description	Level of Influence (Standard Estimation)	Significance	Confirmation or Reject
H1	DOC has a positive effect on MA	0.28	3.53	Confirmation
H2	SYS has a positive effect on MA	-0.04	-0,44	Reject
H3	PGM has a positive effect on MA	0.21	2.32	Confirmation
H4	PER has a positive effect on MA	0.19	1.99	Confirmation
H5	PM has a positive effect on MA	0.16	1.67	Reject

If significant value of exam (T coefficients) is more than 1.96 in regression testing, then hypothesis of null is rejected and hypothesis of one is confirmed and vice-versa. Table 7 shows briefly confirmation or reject of relations among variables of research.

Therefore SEM has been selected for this research as a statistical method due to independent and dependent variables, various latent variables and also suggested multi-variables model.

There are various methods to perform SEM. One of the available methods is covariance-based SEM and it is used for normal variables and volume of mentioned samples. Hence, LISREL method has been used in this research to solve the model. Performing SEM with covariance-based method requires certain software of which, LISREL software is used more than other software. So, it has been used in present research to form SEM. As it is cited in previous parts, structural model in position of standard estimate and significance coefficients will be discussed to examine mentioned hypotheses. Figure 1 and figure 2 shows rate of influence by output latent variables (documentation, system requirements, programming quality, personnel resources and process management,) on input latent variables (maintenance).

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As evident from the values of the standardized regression weights in figure 1, challenges of documentation quality is the most influential factor affecting challenges of maintenance, with the next most important factor being challenges of programming quality, followed by personal resources.
Path analysis may explain which path is more important (or more significant) and that it may explains predetermined causal hypotheses are justified, as it can be observed according to path analysis the challenges of documentation have the most affect on problem factors of maintenance phase. So to reduce the challenges related to maintenance phase, the challenges related to documentation should be reduced firstly. The challenges of programming quality have also more affect on challenges related to maintenance phase. For to reduce or remove it, challenges of programming quality should be decreased. The problem factors of personnel resources with less degree also should be considered in order to reduce challenges concerning maintenance.

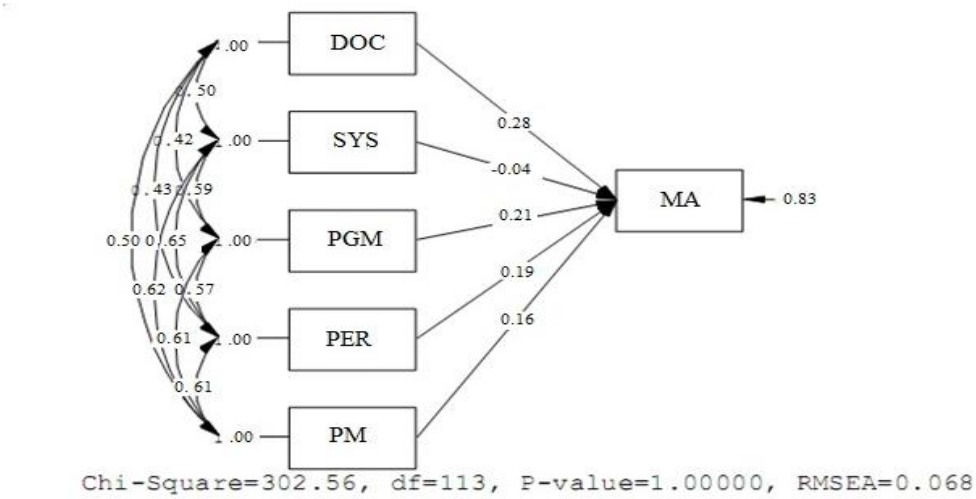

Figure 1: Path diagram in position of standard estimation

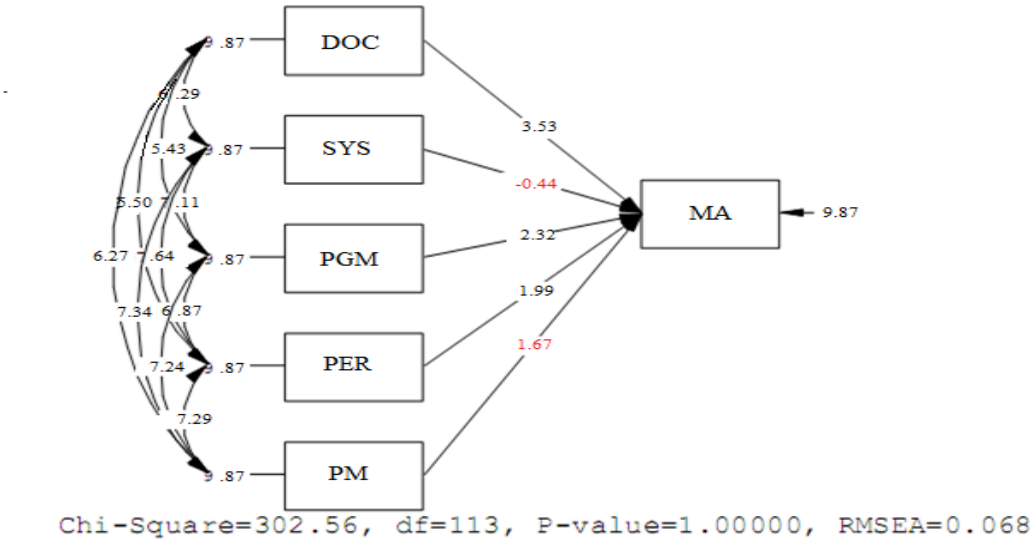

Figure 2: Path diagram in position of significance coefficients

Testing the research hypotheses by SEM; output of software shows the fitted structural model is appropriate for testing the hypotheses. Ratio of x^2 to df is less than 3. Also, value of RMSEA=0.068 shows the structural model is appropriate. In other words, the observed data conforms to data of research

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conceptual model significantly. Values of GFI, AGFI and NFI are respectively 0.91, 0.93 and 0.95 that shows the fitting of model is relative appropriate. Table 8 shows summary of indices of model fitting.

Table 8: Indices of fitting of research general model

Index	Standard value	Obtained value
X^2 / df	Less than 3	2.67
RMSEA	Less than 0.1	0.068
AGFI	More than 8	0.91
GFI	More than 9	0.93
NFI	More than 9	0.95

Discussion

Principally, several factors should be considered in software development. This research has been examined two groups of them. One is related to some phases (System Requirements, Programming Quality and Maintenance) of software development and the other is related to factors (documentation, personnel resources and process management) that their absence or failure can affect on computer software development.

As regard to demographical specifications; the highest frequency of number of members of project teams belongs to teams with 3 to 5 members (35%), also, computer software projects have been completed often in period of 6-12 months (36.3%). More than half the software developer teams have experiences 4 to 6 years (54%) and they often have used RUP methodology (32.8%) in software development.

According to findings to overcome challenges of maintenance phase in computer software development in Iran and presenting appropriate solutions, lack of documentation is the most important challenges for computer software developers. Also based on results part of challenges of maintenance phase is related to challenges of programming quality. Lack of modularity to divide the program into functionality and operationally independent components, lack of conforming to standard programming, adequacy of source code command are among the most important ones. On the basis of research results to reduce or remove challenges of maintenance phase attention to personnel is also one important principle in project management, due to companies' reliance on manpower's skill and specialty and necessity to encourage and motivate them organizationally in business environment.

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