Fall 9-30-2008

Indentifying Success Factors for Developing Web Applications: A Research Report

Monica Lam

Identifying Success Factors for Developing Web Applications: A Research Report

Monica Lam, California State University, Sacramento, USA, lamsm@csus.edu

Abstract

A survey for success factors of Web application development reveals that development methodologies, tools, and techniques are not considered as important by developers for the success of Web application development. Rapid application prototyping, ERD (entity relationship diagram), program flowchart, and application framework are more highly regarded than the object-oriented tools such as use case diagram, class diagram, object diagram, and sequence diagram. Developers focus more on maintainability and scalability than end users and management for evaluating the success of Web application development. Ambiguous user requirements, scope creeping, and lack of success metrics are evaluated as the most important issues for the failure of Web application development. Research results also indicate that developers need more help in communication, management, and control than the technology aspects of the development process. The overall findings point to flexible, simple, proven, participative, and management-oriented methodologies, tools, and techniques to address ambiguous and changing user requirements in the next generation development approaches for Web applications.

Keywords: Web Application Development, Documentation Tool

1. Introduction: Research Questions and Significance

This research project defines a Web application as a software system that relies on the Web as its interaction medium with the end users to create, exchange, and modify data for transaction requirements. The survey was designed to identify the methodologies, techniques, and tools which are frequently used by practitioners to develop Web applications. The goal is to determine whether methodologies, techniques, and tools affect the success of Web application development. Given practitioners' feedback and comments, the investigator will attempt to modify existing methodologies, techniques, and tools or develop new ones that can overcome existing development problems, in order to facilitate Web application success.

Methodologies for application development are defined as the step-by-step procedures to carry out the development activities consisting of different phases in a system development life cycle. A methodology has its own assumptions about the reality that affect how it divides a development cycle into different tasks, has its own techniques to support working principles and enforce discipline, and has its own tools to generate the deliverables for activities. In other words, there are a collection of corresponding techniques and tools for a certain development methodology.

As Web application development is different from traditional information system development in terms of user participation, user environment, communication control, testing requirements, and functionality design, existing methodologies for information system development may not well suit Web applications. Web application development has well passed its introduction phase in a technology adoption life cycle. A survey of the literature reveals that although many methodologies for Web application development have been suggested, they have not been consolidated into a few proven, effective, and valid approaches for Web developers. Web developers still more or less rely on their own experience and preferences to select the methods and tools to accomplish their missions. It is in this proliferation phase of the Web technology adoption cycle that we need to determine what works and what does not and why.

2. Literature Review

The literature for development life cycle, documentation tools, special issues such as security and accessibility, and Web services as imported components in a Web application are summarized in Tables A and B.

Table A. Research Results for the Direction of Development Life Cycle

Studies	Research Results
[22] Taylor 2001	The research has case studies for 20 UK organizations regarding technical, analytical, and business skills and knowledge required for Web developers. None of the IT practitioners interviewed within the 20 organizations mentioned academic literature or standard bodies as a source of knowledge.
[19] Standing 2002, [18] Seng 2002, [8] Greene 2002, [24] Yang 2003, [2] Artz 1996	The proposed different phases in Web application development life cycle are based on traditional system development life cycle with some unique phases such as component strategy, navigation schema, domain modeling, and page schema. The suggested techniques for different phases are also borrowed from traditional system development.
[14] Katerattanakul 2002, [17] Peng 2002, [16] Pant 2001, [23] Wang 2001	This group of research suggests some important design factors for Web application development. Some factors are specific to certain industries such as manufacturing and to certain site functions such as electronic advertisement, product delivery, or payment collection.

Table B. Research Results for the Directions of Documentation Tools, Special Issues, and Web Services

Studies	Research Results
Documentation Tools	
[13] Larsen 1999, [15] Losavio 2004, [21] Tai 2004, [11] Isakowitz 1995, [4] [5] Conallen 1999, 2003	This research direction focuses on adapting UML (Unified Modeling Language) as a documentation tool to Web application development. As UML was not originally designed to satisfy the modeling needs for Web applications, the adaptation process relies on the stereotyped class in UML to represent the unique elements in Web applications. While UML seems to emerge as a popular documentation tool for Web applications, there are still ongoing works to enhance UML for Web purposes.
Special Issues	
[20] Stein 1998, [7] Foo 1999, [3] Chan 2001, [10] Hoffman 2005, [12] Johnson 2004	This research direction discusses different special issues for Web application development such as accessibility needs for handicapped users, security, and operational concerns for transactional Web applications. It was stressed that those special concerns must be designed into the applications at early stages of the development life cycle.
Web Services	
[9] Hof 2005, [1] Anderson 2005, [6] Currie 2004	XML (Extensible Markup Language) Web services are considered as one of the important technical challenges and business opportunities for Web applications in the future. The issues include computing platforms, payment structure, copyrights, integration, confidentiality, and customization.

3. Research Methodology

The preliminary questionnaire was submitted to ten Web developers for pretest. Feedback from pretest was used to revise the questionnaire in terms of meaning clarification, format, ordering of questions, and addition of questions. The questionnaire was administered by an Internet survey company in a period of 4 weeks. There were one initial invitation email and one follow-up reminder email to potential participants. The survey sample of potential participants include Chief Computing Architect, CIO, VP for eBiz/Internet, VP for IT, VP for Network, VP for Quality Assurance, VP for Software Development, Director for eBiz/Internet, Director for IT, Director for Network, Director for Software Development, Manager for Quality Assurance, and Chief Technology Officer. The initial collection of responses was filtered using a reliability test based on multiple pairs of variables in the survey. The reliability test generated a total of 254 valid responses for the analysis phase. The remaining of this research report consists of descriptive statistics of variables, factor analysis results, interpretation of research results, and conclusion.

4. Descriptive Statistics of Variables

This section reports the descriptive statistics of some significant variables in the survey.

Table 1. What is your company type?

Company Type	*%*
Multi-national company	25
Public limited company	7
Small/medium enterprise	53
Federal or state government type	3
Others	12

Table 2. How important are the following end users' feedback for evaluating the success of Web application development in your organization?

Code	*Evaluation Factor*	*Very Important %*
EU1	End users' feedback about functionality	64.9
EU2	End users' feedback about navigation	44.9
EU3	End users' feedback about usability/user friendliness	57.1
EU4	End users' feedback about security	24.9
EU5	End users' feedback about visual/audio/aesthetic characteristics	26.1

Table 3. How important are the following development team members' feedback for evaluating the success of Web application development in your organization?

Code	*Evaluation Factor*	*Very Important %*
TM1	development team members' feedback about functionality	26.9
TM2	development team members' feedback about navigation	17.1
TM3	development team members' feedback about easiness to interact with	16.7
TM4	development team members' feedback about security features	55.1
TM5	development team members' feedback about visual/audio/aesthetic characteristics	12.2
TM6	development team members' feedback about suitability of development methodology	31.8
TM7	development team members' feedback about suitability of development tools and techniques	37.6
TM8	development team members' feedback about how well the system performs required tasks	35.9
TM9	development team members' feedback about system maintainability	44.1
TM10	development team members' feedback about system scalability	41.2

Table 4. How important are the following overall criteria for evaluating the success of Web application development in your organization?

Code	*Evaluation Factor*	*Very Important %*
CC1	Whether the application passes the cost/benefit threshold?	28.6
CC2	Whether the application is within the approved budget?	21.6
CC3	Whether the application can be delivered within the approved timeline?	26.1
CC4	Whether the application satisfies the business needs as expected?	66.9
CC5	Whether the application delivers the overall quality as expected?	41.2
CC6	Whether the application is maintainable?	28.6
CC7	Whether the application is scalable?	28.2
CC8	Whether different deliverables are on time?	17.1

Table 5. How do you attribute the following methodologies to the success of Web application development if they are used in your organization?

Code	*Methodology*	*Very Important %*
SM1	Rational Unified Process	3
SM2	Extreme Programming	7
SM3	Rapid Application Prototyping	14
SM4	WebML (Web Modeling Language)	2
SM5	Waterfall System Development Life Cycle	4
SM6	Compuware's UNIFACE	0

Table 6. How do you attribute the following development phases to the success of Web application development if they are used in your organization?

Code	*Development Phase*	*Very Important %*
SP1	Creative Brief/Concept Creation	27.3
SP2	Functional/Technical/Operational Feasibility Studies	15.5
SP3	Cost/Benefit Analysis	9.4
SP4	Generation of Project Plan: Mission, Objectives, Targeted Users, Scope, Budget, Web Teams	24.9
SP5	Functionality Requirements	40
SP6	Data Storage and Access Design	17.1
SP7	Operations and Business Process Design	26.1
SP8	Navigation Design	18
SP9	Presentation/Page Layout Design	19.2
SP10	Page communication/relationship	11.4
SP11	Web service design	14.3
SP12	Component design	13.9
SP13	Infrastructure configuration	16.3
SP14	Technical specifications	29
SP15	Kickoff meeting to review functional and technical specifications	27.8
SP16	Application coding	29.4
SP17	Code review	18.4
SP18	Testing	47.3
SP19	Launch	31

Table 7. How do you attribute the following tools/techniques to the success of Web application development if they are used in your organization?

Code	*Development Tools/Techniques*	*Very Important %*
ST1	Entity Relationship Diagrams (ERD)	13.5
ST2	Story Boarding	13.1
ST3	Use Case Diagrams	9.4
ST4	Class Diagrams	6.1
ST5	Object Diagrams	5.7
ST6	Sequence Diagrams	4.9
ST7	Collaboration Diagrams	2.9
ST8	Statechart Diagrams	2.4
ST9	Activity Diagrams	5.3
ST10	Component Diagrams	5.3
ST11	Deployment Diagrams	5.3
ST12	Web Application Extension to Unified Modeling Language	3.7
ST13	Program Flowcharts	9.8
ST14	Decision Tables	5.3
ST15	Hierarchy-Input-Process-Output Charts (HIPO)	4.1
ST16	Pseudocode	5.3
ST17	Workflow Analysis	17.6
ST18	Review/Staging Web Site for Communication Purposes	20
ST19	Periodic and standardized Progress Reports	12.7
ST20	Project Management Software	12.2
ST21	Diagram Generation Software	5.3
ST22	Code Generation/Review/Testing Software	12.2
ST23	Application Framework	22.4

Table 8. How do you rate the importance of the following factors that drive the choices of methodologies, tools, and techniques for Web application development in your organization?

Code	*Adoption Factor*	*Very Important %*
AF1	Improve overall quality of applications	37.1
AF2	Improve maintenance	29.4
AF3	Improve management of development process	17.1
AF4	Improve team member communication	20.8
AF5	Improve communication with end users	23.7
AF6	Reduce cost	22
AF7	Reduce development time	32.2

Table 9. How do you rate the importance of the following reasons for failure of Web application development in your organization?

Code	*Failure Factor*	*Very Important %*
FF1	Ambiguous user requirements from beginning	58
FF2	Ambiguous or lack of metrics for success	21.2
FF3	Scope creeping	42
FF4	Unacceptable/unsatisfactory quality	17.6
FF5	Lack of clear communication among team members	20.4
FF6	Lack of clear communication with end users	32.2
FF7	Lack of proper management control	22.4
FF8	Lack of clear roles and responsibilities	17.6
FF9	Lack of top management support	21.2
FF10	Inappropriate/incorrect methodologies	8.6
FF11	Inappropriate/incorrect tools/techniques	9.4
FF12	Political reasons	14.7
FF13	Insufficient manpower	27.8
FF14	Insufficient expertise	22.4
FF15	Insufficient time	30.2
FF16	Poor planning	21.6
FF17	Unresolved conflicts among team members	4.9
FF18	Unresolved conflicts with end users	8.2

5. Factor Analysis

Factor analysis is a statistics technique to reduce the number of variables for a concept by grouping them into different factors based on their distribution, variance, and contribution to the concept. This section shows explained variance for factors, factor matrix, and factor description from factor analysis for selected variables in the study. We adopted the factor analysis results from the extraction method of Maximum Likelihood and the factor rotation method of Varimax with Kaiser Normalization in SPSS. The rotation factor loadings generated more descriptive factors than the pre-rotation solutions. The cutoff threshold for selecting variables into a factor is a loading of not less than 0.5 in this study.

5.1 End Users' Feedback for Success Evaluation (EU1-EU5)

Table 10.1 Explained Variance for End Users' Feedback

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	3.034	60.687	60.687	1.976	39.511	39.511
2	.800	16.004	76.691	1.266	25.322	64.833

Table 10.2 Factor Matrix for End Users' Feedback

	Factor	
	1	*2*
EU3	**.860**	.248
EU2	**.781**	.345
EU1	**.653**	.313
EU4	.319	.294
EU5	.314	**.949**

Table 10.3 Factor Descriptions for End Users' Feedback

Factor	*Variables*	*Description*
euF1	EU1, EU2, EU3	The what and how of Web applications as evaluated by end users

5.2 Development Team Members' Feedback for Success Evaluation (TM1-TM10)

Table 11.1 Explained Variance for Team Members' Feedback

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	4.522	45.224	45.224	2.655	26.555	26.555
2	1.881	18.807	64.031	2.032	20.317	46.872
3	.896	8.961	72.992	1.643	16.429	63.301
4	.687	6.870	79.861	.395	3.945	67.246
5	.608	6.079	85.940	.278	2.781	70.026

Table 11.2 Factor Matrix for Team Members' Feedback

	Factor				
	1	*2*	*3*	*4*	*5*
TM3	**.917**	.176	.078	.065	-.035
TM2	**.849**	.154	.099	.055	.156
TM5	**.714**	.118	.137	.174	-.091
TM1	**.620**	.069	.157	.098	.405
TM9	.138	**.873**	.189	.070	.063
TM10	.075	**.733**	.260	.251	-.172
TM8	.247	**.575**	.274	.079	.180
TM6	.157	.250	**.954**	.042	-.015
TM7	.145	.381	**.688**	.169	.109
TM4	.260	.346	.149	.493	.045

Table 11.3 Factor Descriptions for Team Members' Feedback

Factor	*Variables*	*Description*
tmF1	TM1, TM2, TM3, TM5	The what and how of Web applications as evaluated by team members
tmF2	TM8, TM9, TM10	The future of Web applications as evaluated by team members
tmF3	TM6, TM7	The development methodology, tools, and techniques as evaluated by team members

5.3 Organization's Overall Criteria for Success Evaluation (CC1-CC8)

Table 12.1 Explained Variance for Overall Criteria

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.684	46.044	46.044	1.732	21.652	21.652
2	1.488	18.596	64.641	1.341	16.766	38.419
3	.902	11.273	75.913	1.335	16.690	55.109
4	.640	8.006	83.920	1.126	14.072	69.181

Table 12.2 Factor Matrix for Overall Criteria

	Factor			
	1	*2*	*3*	*4*
CC6	**.943**	.060	.189	.246
CC7	**.676**	.127	.100	.303
CC8	.168	**.856**	.166	.057
CC3	.008	**.652**	.265	.190
CC2	.150	.303	**.838**	.075
CC1	.127	.150	**.637**	.228
CC5	.467	.110	.145	**.683**
CC4	.317	.193	.251	**.640**

Table 12.3 Factor Descriptions for Overall Criteria

Factor	*Variables*	*Description*
ccF1	CC6, CC7	The future of Web applications
ccF2	CC3, CC8	Development time of Web applications
ccF3	CC1, CC2	Cost/benefit analysis of web applications
ccF4	CC4, CC5	The what and how of Web applications

5.4 Web Application Development Methodologies (SM1-SM6)

Table 13.1 Explained Variance for Development Methodologies

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.425	40.419	40.419	1.360	22.663	22.663
2	1.138	18.974	59.393	1.215	20.254	42.917
3	.846	14.095	73.488	1.034	17.238	60.155

Table 13.2 Factor Matrix for Development Methodologies

	Factor		
	1	*2*	*3*
SM4	**.798**	.131	.053
SM6	**.579**	.200	.184
SM1	**.524**	.261	.184
SM2	.180	**.979**	-.085
SM3	.174	.361	.089
SM5	.224	.023	**.974**

Table 13.3 Factor Descriptions for Development Methodologies

Factor	*Variables*	*Description*
smF1	SM1, SM4, SM6	The latest, formal, and systematic development methodologies

5.5 Web Application Development Process (SP1-SP19)

Table 14.1 Explained Variance for Development Process

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	6.232	32.802	32.802	2.088	10.988	10.988
2	1.621	8.531	41.333	1.954	10.283	21.272
3	1.527	8.036	49.370	1.600	8.419	29.691
4	1.197	6.300	55.670	1.340	7.052	36.742
5	1.118	5.885	61.555	1.295	6.817	43.560
6	.910	4.789	66.343	1.098	5.780	49.340
7	.771	4.058	70.401	1.082	5.694	55.034
8	.749	3.944	74.345	1.034	5.441	60.475

Table 14.2 Factor Matrix for Development Process

	Factor							
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
SP9	**.836**	.207	.015	.172	.057	.128	.054	-.005
SP8	**.726**	.168	.134	.050	.093	.069	.059	.191
SP10	**.689**	.087	.147	.079	.442	.026	.017	.065
SP18	.143	**.632**	.137	.129	.058	.099	.033	.058
SP16	.058	**.600**	-.134	.179	.135	.062	.110	-.003
SP17	.111	.471	.104	.246	.313	.089	.223	.126
SP19	.140	.438	.384	-.067	.090	.091	.196	.088
SP1	.193	.415	.381	.038	-.053	-.041	.143	.089
SP6	.164	.397	.144	.236	.028	.242	-.001	.066
SP2	.016	.057	**.712**	.268	.088	.059	.049	.054
SP3	.075	.054	**.567**	.025	.189	.056	-.005	.119
SP4	.174	.043	.364	.348	.015	.097	.248	.063
SP14	.041	.207	.143	**.726**	.184	.082	.081	.074
SP5	.233	.330	.125	**.537**	.013	.079	.140	.075
SP11	.283	.158	.202	.127	**.712**	.221	.104	.064
SP12	.176	.189	.288	.145	**.500**	.331	.052	.265
SP13	.155	.235	.102	.147	.295	**.886**	.081	.095
SP15	.066	.279	.122	.210	.114	.061	**.915**	.065
SP7	.186	.138	.232	.138	.148	.103	.076	**.913**

Table 14.3 Factor Descriptions for Development Process

Factor	*Variables*	*Description*
spF1	SP8, SP9, SP10	Navigation design, presentation and page layout design, page communication/relationship
spF2	SP16, SP18	Application coding and testing
spF3	SP2, SP3	All sorts of feasibility analyses
spF4	SP5, SP14	Functionality requirements and technical specifications
spF5	SP11, SP12	Web service design and component design

5.6 Web Application Development Tools and Techniques (ST1-ST23)

Table 15.1 Explained Variance for Development Tools and Techniques

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	9.867	42.900	42.900	3.709	16.126	16.126
2	1.725	7.498	50.399	2.953	12.839	28.965
3	1.422	6.182	56.581	2.818	12.252	41.218
4	.944	4.106	60.687	1.536	6.677	47.894
5	.903	3.928	64.615	1.300	5.652	53.546
6	.819	3.559	68.174	1.252	5.444	58.991

Table 15.2 Factor Matrix for Development Tools and Techniques

	Factor					
	1	*2*	*3*	*4*	*5*	*6*
ST4	**.845**	.212	.131	.126	.100	.124
ST5	**.716**	.214	.253	.252	.112	.150
ST6	**.611**	.201	.185	.167	.394	.150
ST3	**.543**	.189	.294	.098	.126	-.006
ST1	.493	.163	.198	.155	.068	.094
ST8	.477	.343	.213	.222	.401	.034
ST9	.461	.245	.108	.454	.231	.139
ST15	.170	**.830**	.189	.153	.176	.137
ST12	.247	**.671**	.145	.142	.182	.089
ST14	.252	**.588**	.195	.193	.143	.323
ST16	.242	.476	.217	.140	.006	.084
ST19	.083	.165	**.726**	.111	.060	.033
ST18	.106	-.026	**.645**	.033	.011	.043
ST21	.380	.309	**.529**	.132	.141	.139
ST17	.207	.237	.492	.108	.111	.270
ST23	.344	.112	.489	.066	.109	-.024
ST20	.108	.260	.478	.088	.189	.106
ST22	.299	.303	.429	.069	.087	.075
ST2	.296	.210	.301	.079	.026	.158
ST10	.363	.312	.206	**.841**	.121	.077
ST11	.325	.434	.184	.461	.208	.212
ST7	.367	.320	.253	.197	**.804**	.118
ST13	.187	.297	.177	.119	.090	**.907**

Table 15.3 Factor Descriptions for Development Tools and Techniques

Factor	*Variables*	*Description*
stF1	ST3, ST4, ST5, ST6	Use case diagram, class diagrams, object diagrams, sequence diagrams
stF2	ST12, ST14, ST15	Web application extension to Unified Modeling Language, decision tables, hierarchy-input-process-output charts
stF3	ST18, ST19, ST21	Review/staging Web site, periodic and standardized progress, diagram generation software

5.7 Adoption Factors for Development Methodologies, Tools, and Techniques (AF1-AF7)

Table 16.1 Explained Variance for Adoption Factors

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	3.245	46.359	46.359	1.703	24.323	24.323
2	1.194	17.062	63.421	1.476	21.087	45.410
3	.906	12.939	76.359	1.392	19.892	65.302

Table 16.2 Factor Matrix for Adoption Factors

	Factor		
	1	*2*	*3*
AF4	**.969**	.223	.098
AF3	**.533**	.349	.184
AF5	**.506**	.204	.192
AF2	.266	**.888**	.154
AF1	.297	**.634**	.121
AF6	.231	.005	**.972**
AF7	.102	.270	**.573**

Table 16.3 Factor Descriptions for Adoption Factors

Factor	*Variables*	*Description*
afF1	AF3, AF4, AF5	Communication and management of development process
afF2	AF1, AF2	Quality and maintenance of Web application
afF3	AF6, AF7	Cost and development time

5.8 Failure Factors for Web Application Development (FF1-FF18)

Table 17.1 Explained Variance for Failure Factors

Factor	*Initial Eigenvalues*			*Rotation Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	7.413	41.182	41.182	2.285	12.696	12.696
2	1.695	9.417	50.598	2.233	12.408	25.103
3	1.407	7.816	58.415	1.888	10.486	35.590
4	1.055	5.859	64.273	1.772	9.842	45.432
5	1.000	5.555	69.828	1.610	8.946	54.378
6	.803	4.461	74.289	1.565	8.694	63.072

Table 17.2 Factor Matrix for Failure Factors

	Factor					
	1	*2*	*3*	*4*	*5*	*6*
FF8	**.695**	.269	.251	.041	.241	.171
FF7	**.665**	.113	.163	.154	.118	.203
FF9	**.565**	.311	.207	.158	.176	.175
FF4	.444	.224	.248	.217	.160	.384
FF16	.434	.283	.224	.396	.265	.193
FF18	.186	**.859**	.171	.055	.127	.135
FF17	.243	**.749**	.178	.117	.064	.288
FF12	.284	.400	.241	.154	.177	.077
FF11	.281	.208	**.912**	.186	.032	.101
FF10	.350	.340	**.706**	.191	.014	.153
FF15	.173	.036	.125	**.775**	.178	.062
FF13	.047	.072	.072	**.703**	.125	.111
FF14	.214	.368	.311	.468	.213	.078
FF1	.092	.090	.002	.116	**.668**	.034
FF3	.109	.069	-.059	.120	**.601**	.068
FF2	.171	.079	.229	.154	**.592**	.149
FF5	.296	.202	.118	.200	.081	**.900**
FF6	.253	.319	.086	.041	.318	**.528**

Table 17.3 Factor Descriptions for Failure Factors

Factor	*Variables*	*Description*
ffF1	FF7, FF8, FF9	Lack of project management control, lack of role and responsibility, top management support
ffF2	FF17, FF18	Unresolved conflicts with end users and team members
ffF3	FF10, FF11	Inappropriate/incorrect methodologies, development tools, and techniques
ffF4	FF13, FF15	Not enough time and manpower
ffF5	FF1, FF2, FF3	Ambiguous initial user requirements, ambiguous or lack of metrics for success, scope creeping
ffF6	FF5, FF6	Lack of clear communication with team members and end users

6. Interpretation of Research Results

6.1 Important Factors for Evaluating Web Applications

The results of the very important variables in Section 3 and the factor analysis in Section 4 show that the factor of "what and how of Web application" is very significant for end users to evaluate the success of Web applications. The factor of "what and how of Web application" is mainly represented by the variables of functionality, navigation, and usability/user friendliness. On the other hand, from the developers' viewpoint, the most significant factor for success evaluation includes the maintainability and scalability of Web applications. The importance of the factor methodologies/tools/techniques is considered as secondary by developers. From the company's overall viewpoint, the most important factor is represented by Web applications' satisfying business needs and their overall quality. The emphasis differences among different stakeholders are logical and understandable. While end users focus on the functionality and navigation of Web applications, the management perspective is more on business needs and product quality. While satisfying current business needs are important, developers know it better than anyone else that the users will demand upgrades and changes soon enough for them to focus more on the maintainability and scalability of Web applications. Web applications have the characteristic of being constantly in their beta mode. How to wisely and effectively capture the participation and input from users to enhance Web applications will be a challenge to developers. Methodologies/tools/techniques have to be modified to address different stakeholders' concerns and the emerging challenges in the future.

6.2 The Importance of Development Methodologies

None of the development methodologies receives high marks from survey respondents. Rapid application Prototyping is by far the most popular among respondents. Factor analysis shows that rational unified process, WebML, and Compuware's UNIFACE are in the same group regarding how important they are for Web application development. The results in Section 3 indicate that they are not important. It seems that development methodologies which are too new, too complicated, too formal, or too specific are not considered as important. Many comments from respondents mention about hybrid approaches utilizing different methodologies, tools, and techniques work well for their companies.

6.3 The Importance of Development Phases

The factors of "application coding and testing" and "functionality requirements and technical specifications" as development phases are considered as very important, followed by the factors of "operations and business process design" and "kickoff meeting to review functional and technical specifications". While the phase of "launch" cannot be grouped into any factor, about one-third of respondents rank it as very important.

6.4 The Importance of Development Tools and Techniques

For development tools and techniques, the factor of "review/staging Web site, periodic and standardized progress, and diagram generation software" and the factor of "application framework" are very important, followed by "program flowchart", "ERD and story boarding", and "work flow analysis". The use case diagram, class diagram, object diagram, and sequence diagram in UML are loaded into one factor, which is considered as not important by survey respondents. The survey results indicate the preference of management tools and well-established modeling tools over the relatively new diagrammatic tools. Tools that can reduce development time such as diagram generation software and application frameworks are also ranked as important.

6.5 Important Adoption Factors for Methodologies/Tools/Techniques

The adoption factor of "improving quality and maintenance" is very important, followed by the factor of "improving communication and management", and the factor of "reducing cost and development time". The important adoption factor of "improving quality and maintenance" echoes developers' emphasis on maintainability and scalability as an important evaluation factor for Web applications, as discussed in Section 6.1.

6.6 Important Failure Factors for Web Application Development

The survey results for failure factors clearly fall into three categories in terms of importance. The most important failure factor is represented by the variables of ambiguous initial user requirements, scope creeping, and lack of metrics for success. Factors of secondary importance include the factor of "lack of role and responsibility, top management support, and lack of project management control", the factor of "not enough time and manpower", and the factor of "lack of clear communication with end users and team members". The least important category has the factor of "unresolved conflicts with end users and team members" and the factor of "inappropriate/incorrect methodologies/tools/techniques".

7. Conclusion

There are several key findings for the research question in this project based on the variable ranking and factor analysis results from the data set. First, development methodologies, tools, and techniques are not considered as important for the success of Web application development by practitioners. Among the methodologies of rational unified process, extreme programming, rapid application prototyping, WebML, waterfall system development life cycle, and Compuware's UNIFACE, Rapid application prototyping is considered as the most important for Web application success. Regarding tools and techniques, the new diagrammatic tools such as use case diagram, class diagram, object diagram, and sequence diagram, which are being taught as standard diagrams for object-oriented system development in classrooms, are not considered as important by practitioners. Instead, well-established and well-understood tools such as ERD and program flowchart are considered as more important. The result also

suggests that the management, communication, and control aspects of Web application development need more help than its technology aspects.

Second, end users, developers, and management have different focuses for evaluating Web application development. The focuses are functionality and navigation, maintainability and scalability, business needs and application quality respectively for end users, developers, and management. The different focuses bring our attention to the importance of developing flexible methodologies, tools, and techniques that can address different stakeholders' needs and concerns.

Third, for failure factors of Web applications, the most important factor is lack of clear user requirements, scope creeping, and lack of metrics for success. Feedback and comments show strong frustration towards ambiguous and constantly changing user requirements. The next generation of system development aids need to seriously address that issue.

References

[1] Anderson, D., Howell-Barber, H., Hill, J., Javed, N., Lawler, J., & Li, Z. (2005). A study of Web services projects in the financial services industry. *Information Systems Management*, *22(1)*, 66-76

[2] Artz, J. M. (1996). A top-down methodology for building corporate Web applications. *Internet Research*, *6(2/3)*, 64-74.

[3] Chan, M. T., & Kwok, L. F. (2001). Integrating security design into the software development process for e-commerce systems. *Information Management & Computer Security*, *9(2/3)*, 112-122.

[4] Conallen, J. (1999). Modeling Web application architectures with UML. *Communications of the ACM*, *42(10)*, 63-70.

[5] Conallen, J. (2003). *Building Web Applications with UML*. Addison-Wesley.

[6] Currie, W. L., Wang, C., & Weerakkody, V. (2004). Developing Web services using the Microsoft.Net platform: technical and business challenges. *Journal of Enterprise Information Management*, *17(5)*, 335-350.

[7] Foo, S., Leong, P. C., Hui, S. C., Liu, S. (1999). Security considerations in the delivery of Web-based applications: a case study. *Information Management & Computer Security*, *7(1)*, 40-50.

[8] Greene, S. L., Jones, L., Matchen, P., & Thomas, J. C. (2003). Iterative development in the field. *IBM Systems Journal*, *42(2)*, 594-612.

[9] Hof, R. D. (2005). Mix, match, and mutate. *BusinessWeek*, *7/25/2005*, 72-75.

[10] Hoffman, D., Grivel, E., Battle, L. (2005). Designing software architectures to facilitate accessible Web applications. *IBM Systems Journal*, *44(3)*, 467-483.

[11] Isakowitz, T., Stohr, E. A., & Balasubramanian, P. (1995). RMM: a methodology for structured hypermedia design. *Communications of the ACM*, *38(8)*, 34-56.

[12] Johnson, R. D., & Reimer, D. (2004). Issues in the development of transactional Web applications. *IBM Systems Journal*, *43(2)*, 430-440.

[13] Larsen, G. (1999). Designing component-based frameworks using patterns in UML. *Communications of the ACM*, *42(10)*, 38-45.

[14] Katerattanakul, P. (2002). Framework of effective Web site design for business-to-consumer Internet commerce. *INFOR*, *40(1)*, 57-70.

[15] Losavio, F., Chirinos, L., Matteo, A., Levy, N., & Ramdane-Cherif, A. (2004). Designing quality architecture: incorporating ISO standards into the unified process. *Information Systems Management*, *21(1)*, 27-44.

[16] Pant, S., Sim, H. T., & Hsu, C. (2001). A framework for developing Web information systems plans: illustration with Samsung Heavy Industries Co., Ltd. *Information & Management*, *38*, 385-408.

[17] Peng, Q. (2002). A survey and implementation framework for industrial-oriented Web-based applications. *Integrated Manufacturing Systems*, *13(5)*, 319-327.

[18] Seng, J. L., & Wang, I. P. (2002). A database-centric and Web-automatic hypertext application design method. *Journal of Computer Information Systems*, *43(1)*, 91-109.

[19] Standing, C. (2002). Methodologies for developing Web applications. *Information and Software Technology*, *44*, 151-159.

[20] Stein, L. D. (1998). *Web Security: A Step-by-Step Reference Guide*. Addison Wesley.

[21] Tai, H., Mitsui, K., Nerome, T., Abe, M., Ono, K., & Hori, M. (2004). Model-driven development of large-scale Web applications. *IBM Journal of Research and Development*, *48(5/6)*, 797-809.

[22] Taylor, M. F., England, D., & Gresty, D. (2001). Knowledge for Web site development. *Internet Research*, *11(5)*, 451-461.

[23] Wang, S. (2001). Designing information systems for electronic commerce. *Industrial Management + Data Systems*, *101(5/6)*, 304-314.

[24] Yang, H. L., & Tang, J. H. (2003). A three-stage model of requirements elicitation for Web-based information systems. *Industrial Management + Data Systems*, *103(5/6)*, 398-409.