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# Identifying Success Factors for Developing Web Applications: A Research Report

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## 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,<br>[18] Seng 2002,<br>[8] Greene 2002,<br>[24] Yang 2003,<br>[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,<br>[17] Peng 2002,<br>[16] Pant 2001,<br>[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                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Documentation Tools</i>                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| [13] Larsen 1999,<br>[15] Losavio 2004,<br>[21] Tai 2004,<br>[11] Isakowitz 1995,<br>[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. |
| <i>Special Issues</i>                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| [20] Stein 1998,<br>[7] Foo 1999,<br>[3] Chan 2001,<br>[10] Hoffman 2005,<br>[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.                                                                                                                                        |
| <i>Web Services</i>                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| [9] Hof 2005,<br>[1] Anderson 2005,<br>[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?**

| <i>Company Type</i>              | <i>%</i> |
|----------------------------------|----------|
| 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?**

| <i>Code</i> | <i>Evaluation Factor</i>                                         | <i>Very Important %</i> |
|-------------|------------------------------------------------------------------|-------------------------|
| 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?**

| <i>Code</i> | <i>Evaluation Factor</i>                                                                 | <i>Very Important %</i> |
|-------------|------------------------------------------------------------------------------------------|-------------------------|
| 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?**

| <i>Code</i> | <i>Evaluation Factor</i>                                               | <i>Very Important %</i> |
|-------------|------------------------------------------------------------------------|-------------------------|
| 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?**

| <i>Code</i> | <i>Methodology</i>                      | <i>Very Important %</i> |
|-------------|-----------------------------------------|-------------------------|
| 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?**

| <i>Code</i> | <i>Development Phase</i>                                                                  | <i>Very Important %</i> |
|-------------|-------------------------------------------------------------------------------------------|-------------------------|
| 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?**

| <i>Code</i> | <i>Development Tools/Techniques</i>                    | <i>Very Important %</i> |
|-------------|--------------------------------------------------------|-------------------------|
| 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?**

| <i>Code</i> | <i>Adoption Factor</i>                    | <i>Very Important %</i> |
|-------------|-------------------------------------------|-------------------------|
| 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?**

| <i>Code</i> | <i>Failure Factor</i>                          | <i>Very Important %</i> |
|-------------|------------------------------------------------|-------------------------|
| 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**

| <i>Factor</i> | <i>Initial Eigenvalues</i> |                      |                     | <i>Rotation Sums of Squared Loadings</i> |                      |                     |
|---------------|----------------------------|----------------------|---------------------|------------------------------------------|----------------------|---------------------|
|               | <i>Total</i>               | <i>% of Variance</i> | <i>Cumulative %</i> | <i>Total</i>                             | <i>% of Variance</i> | <i>Cumulative %</i> |
| 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**

|     | <i>Factor</i> |             |
|-----|---------------|-------------|
|     | <i>1</i>      | <i>2</i>    |
| EU3 | <b>.860</b>   | .248        |
| EU2 | <b>.781</b>   | .345        |
| EU1 | <b>.653</b>   | .313        |
| EU4 | .319          | .294        |
| EU5 | .314          | <b>.949</b> |

**Table 10.3 Factor Descriptions for End Users' Feedback**

| <i>Factor</i> | <i>Variables</i> | <i>Description</i>                                             |
|---------------|------------------|----------------------------------------------------------------|
| 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**

| <i>Factor</i> | <i>Initial Eigenvalues</i> |                      |                     | <i>Rotation Sums of Squared Loadings</i> |                      |                     |
|---------------|----------------------------|----------------------|---------------------|------------------------------------------|----------------------|---------------------|
|               | <i>Total</i>               | <i>% of Variance</i> | <i>Cumulative %</i> | <i>Total</i>                             | <i>% of Variance</i> | <i>Cumulative %</i> |
| 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**

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

**Table 11.3 Factor Descriptions for Team Members' Feedback**

| <i>Factor</i> | <i>Variables</i>   | <i>Description</i>                                                              |
|---------------|--------------------|---------------------------------------------------------------------------------|
| 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**

| <i>Factor</i> | <i>Initial Eigenvalues</i> |               |              | <i>Rotation Sums of Squared Loadings</i> |               |              |
|---------------|----------------------------|---------------|--------------|------------------------------------------|---------------|--------------|
|               | 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**

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

**Table 12.3 Factor Descriptions for Overall Criteria**

| <i>Factor</i> | <i>Variables</i> | <i>Description</i>                        |
|---------------|------------------|-------------------------------------------|
| 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**

| <i>Factor</i> | <i>Initial Eigenvalues</i> |               |              | <i>Rotation Sums of Squared Loadings</i> |               |              |
|---------------|----------------------------|---------------|--------------|------------------------------------------|---------------|--------------|
|               | 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**

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

**Table 13.3 Factor Descriptions for Development Methodologies**

| <i>Factor</i> | <i>Variables</i> | <i>Description</i>                                           |
|---------------|------------------|--------------------------------------------------------------|
| 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**

| <i>Factor</i> | <i>Initial Eigenvalues</i> |                      |                     | <i>Rotation Sums of Squared Loadings</i> |                      |                     |
|---------------|----------------------------|----------------------|---------------------|------------------------------------------|----------------------|---------------------|
|               | <i>Total</i>               | <i>% of Variance</i> | <i>Cumulative %</i> | <i>Total</i>                             | <i>% of Variance</i> | <i>Cumulative %</i> |
| 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**

|      | <i>Factor</i> |             |             |             |             |             |             |             |
|------|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      | <i>1</i>      | <i>2</i>    | <i>3</i>    | <i>4</i>    | <i>5</i>    | <i>6</i>    | <i>7</i>    | <i>8</i>    |
| SP9  | <b>.836</b>   | .207        | .015        | .172        | .057        | .128        | .054        | -.005       |
| SP8  | <b>.726</b>   | .168        | .134        | .050        | .093        | .069        | .059        | .191        |
| SP10 | <b>.689</b>   | .087        | .147        | .079        | .442        | .026        | .017        | .065        |
| SP18 | .143          | <b>.632</b> | .137        | .129        | .058        | .099        | .033        | .058        |
| SP16 | .058          | <b>.600</b> | -.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        | <b>.712</b> | .268        | .088        | .059        | .049        | .054        |
| SP3  | .075          | .054        | <b>.567</b> | .025        | .189        | .056        | -.005       | .119        |
| SP4  | .174          | .043        | .364        | .348        | .015        | .097        | .248        | .063        |
| SP14 | .041          | .207        | .143        | <b>.726</b> | .184        | .082        | .081        | .074        |
| SP5  | .233          | .330        | .125        | <b>.537</b> | .013        | .079        | .140        | .075        |
| SP11 | .283          | .158        | .202        | .127        | <b>.712</b> | .221        | .104        | .064        |
| SP12 | .176          | .189        | .288        | .145        | <b>.500</b> | .331        | .052        | .265        |
| SP13 | .155          | .235        | .102        | .147        | .295        | <b>.886</b> | .081        | .095        |
| SP15 | .066          | .279        | .122        | .210        | .114        | .061        | <b>.915</b> | .065        |
| SP7  | .186          | .138        | .232        | .138        | .148        | .103        | .076        | <b>.913</b> |

**Table 14.3 Factor Descriptions for Development Process**

| <i>Factor</i> | <i>Variables</i> | <i>Description</i>                                                                      |
|---------------|------------------|-----------------------------------------------------------------------------------------|
| 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  | <b>.845</b> | .212        | .131        | .126        | .100        | .124        |
| ST5  | <b>.716</b> | .214        | .253        | .252        | .112        | .150        |
| ST6  | <b>.611</b> | .201        | .185        | .167        | .394        | .150        |
| ST3  | <b>.543</b> | .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        | <b>.830</b> | .189        | .153        | .176        | .137        |
| ST12 | .247        | <b>.671</b> | .145        | .142        | .182        | .089        |
| ST14 | .252        | <b>.588</b> | .195        | .193        | .143        | .323        |
| ST16 | .242        | .476        | .217        | .140        | .006        | .084        |
| ST19 | .083        | .165        | <b>.726</b> | .111        | .060        | .033        |
| ST18 | .106        | -.026       | <b>.645</b> | .033        | .011        | .043        |
| ST21 | .380        | .309        | <b>.529</b> | .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        | <b>.841</b> | .121        | .077        |
| ST11 | .325        | .434        | .184        | .461        | .208        | .212        |
| ST7  | .367        | .320        | .253        | .197        | <b>.804</b> | .118        |
| ST13 | .187        | .297        | .177        | .119        | .090        | <b>.907</b> |

**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**

| <i>Factor</i> | <i>Initial Eigenvalues</i> |                      |                     | <i>Rotation Sums of Squared Loadings</i> |                      |                     |
|---------------|----------------------------|----------------------|---------------------|------------------------------------------|----------------------|---------------------|
|               | <i>Total</i>               | <i>% of Variance</i> | <i>Cumulative %</i> | <i>Total</i>                             | <i>% of Variance</i> | <i>Cumulative %</i> |
| 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**

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

**Table 16.3 Factor Descriptions for Adoption Factors**

| <i>Factor</i> | <i>Variables</i> | <i>Description</i>                                  |
|---------------|------------------|-----------------------------------------------------|
| 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**

| <i>Factor</i> | <i>Initial Eigenvalues</i> |                      |                     | <i>Rotation Sums of Squared Loadings</i> |                      |                     |
|---------------|----------------------------|----------------------|---------------------|------------------------------------------|----------------------|---------------------|
|               | <i>Total</i>               | <i>% of Variance</i> | <i>Cumulative %</i> | <i>Total</i>                             | <i>% of Variance</i> | <i>Cumulative %</i> |
| 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**

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

**Table 17.3 Factor Descriptions for Failure Factors**

| <i>Factor</i> | <i>Variables</i> | <i>Description</i>                                                                            |
|---------------|------------------|-----------------------------------------------------------------------------------------------|
| 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.