Software Process Model for Dynamic Website Development towards Quality Product

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Abstract—**Most sectors today, such as industries, banking, travel, education, and government, are moving towards the web as an improvement and enhancement to their businesses and services. Dynamic websites, which are considered as one type of web applications, should follow systematic and sound software development methodology to achieve quality and standard of the product. However, previous studies have revealed that many websites which are available on the Internet do not fulfil the quality requirements to be considered as a successful quality website. This study investigates the current issues in dynamic website development including the methodology, quality attribute, and the process for dynamic website development in order to achieve quality website. This work also determines factors that motivate developers to follow sound methodology in developing the dynamic websites and the barriers of not following one. Lastly, this paper presents the development of the software process model for dynamic website development that aim is to ensure the quality of the website as a good software product. The proposed model is developed based on findings from the empirical study conducted that involves software developers and practitioners as the respondents.**

Index Terms—**Dynamic Website Development; Empirical Study; Software Process Model; Software Product Quality.**

I. INTRODUCTION

The Internet and World Wide Web (WWW) have grown rapidly in such a way that they are now affecting all aspects of our life. They have also taken fast and wide steps in their scopes of implementation [1]. Various sectors such as industries, banking, travel and tour, education and government have moved towards the web development and usage as an improvement to their businesses and services. In today's competitive environment, there is a strong need to employ methods and tools to help achieve speed and accuracy in web application and development in order to keep pace with the rapid growth in global business. The term "Web Engineering" has emerged to describe the tools and methods used for web application development [2]. A comprehensive methodology and process, advanced development tools, and a set of good guidelines are required. It uses scientific principles and systematic approaches to develop, deploy, and maintain high-quality web systems and applications [3, 20].

Nonetheless, the development of dynamic websites, which are considered as web applications too, should follow sound methodology with systematic approaches as other software products development [3, 4]. A website is a collection of related web pages or a connected group of pages on the World Wide Web regarded as a single entity, usually maintained by one person or organization and devoted to a single topic or several closely related topics. A dynamic website contains information that changes, depending on the viewer, the time of the day, the time zone, the viewer's native language, and other factors. Initially, the WWW was emerged to provide an environment for information sharing, such as research reports, user manuals, and databases, amongst geographically dispersed individuals [2]. Since then, organisations worldwide have developed a huge array of commercial and educational web applications for their own purposes either static websites or dynamic websites.

This paper is organized as follows. In section II, the research background and the related works are presented. Section III presents the empirical findings and results. In Section IV will present the formulation of guidelines for dynamic website development and proceed with the development of software process model in section V. Lastly we have a discussion and conclusion in section VI.

II. RESEARCH BACKGROUND

Dynamic website follows the same trend as web application implementation. Thus, many websites are being published on the Internet to gain advantages from all the facilities and privileges that the WWW presents to different groups of people and companies. Large numbers of website have been developed and launched but do not achieve the quality and standard to be considered as a successful website implementation [5].

A dynamic website is also considered as one type of software [3]. From this perspective, web-engineering principles that are driven by software engineering principles should be followed in order to meet quality requirements and standard such as accessibility, usability, compatibility and functionality. Putting in consideration the special characteristics that dynamic websites have such as respond to different parameters, have a "memory," almost always integrate HTML forms, and often have interfaces. Hence, clear specifications for these principles should be identified and followed when developing a dynamic website. To date, many of those who are related to website development consider dynamic websites to be merely a number of well-designed pages that are related to one another, and the whole process does not follow a standard software development methodology but instead, the process is depended on the developer's personal experience and knowledge [4].

Several issues related to dynamic website development are discussed in the following sub-sections.

A. Web Engineering

Web applications have rapidly increased and spread widely despite the short history of web development compared with software and information systems development. A large number of web applications have been published on the internet to provide different services with multilingual functionality. Thus, the complexity of these web applications has increased as well [6].

Web Engineering uses scientific, engineering, and management principles and systematic approaches to develop, deploy, and maintain high-quality web systems and applications successfully. It aims to bring web-based system development under control, minimise risks, and improve the quality, maintainability, and scalability of web applications. However, many developers and clients consider web development as a plain process containing just simple pages developed using simple language or web development software, hooking some pictures and hyper linking documents [7].

Literature study has revealed that most practitioners have several constraints in following proper methodology and processes of web design development [4, 19]. The development process in web application involves more than just visual design and user interface but more complex activities such as planning, architecture design, system and page design, coding, testing, quality assurance, and performance evaluation. The process requires continual maintenance and updates as new functionalities are introduced and as usage of website applications continue to grow [8, 19].

B. Dynamic Website Development Process and Characteristic

Although there are hundreds of resources on website development, it is not easy to find one related specifically to dynamic website development. Most of them are either related to web application development methodology in general without distinguishing between web applications and dynamic websites, or they concentrate on the technologies of creating websites, in addition to the design and graphic aspects.

A simple subset of the Unified Modelling Language (UML) by using stereotypes to support the reuse of both business logic and visual design modules and the communication between dynamic website development team members has been proposed and developed [9]. The development of dynamic websites involves two categories of people: the software developers realising the business logic and the graphic designers who are responsible for the layout. However, short production life cycles require the implementation to be worked in parallel by these two groups. Moreover, the relative simplicity of the application gives rise to the need for a simple design process and modelling approach to support organising tasks among team members.

Dynamic websites should be flexible, user friendly, easy to maintain, and they are more accurately described as applications than simply sites. Aside from the quality characteristics mentioned previously, dynamic websites can be described as follows [10]:

i. Respond to different parameters (the version of the visitor's Web browser or the time of day)
ii. Have a "memory," allowing for user registration and login, as well as similar processes
iii. Always integrate HTML forms in order to allow visitors to perform searches and provide feedback.
iv. Often have interfaces through which administrators can manage the site's maintenance and content.
v. Easier to maintain, upgrade, and reuse than statically made sites.

There are many technologies available for creating dynamic websites and the most common are Java Server Pages (JSP), Active Server Pages, a Microsoft construct (ASP.NET), ColdFusion, PHP, and Ruby on Rails, which is a web development framework for the Ruby programming language [11] and many more. Most dynamic websites rely on databases such as MySQL and are becoming available at low to no additional cost [10].

Recently, the Internet has shown rapid growth in providing different services online, thus leading to a new definition of almost all aspects of services. The explosion of the web has given rise to the need for measurement criteria to evaluate the aspects related to the quality of software in general, such as functionality, reliability, usability, efficiency and maintainability. Awareness of quality issues has affected every industrial sector in recent years, given that an organisation with a website that is difficult to use and interact with acquires a poor image and gains a weaker position. Therefore, it is important for organisations to assess the quality of its services in order to improve them over time and benchmark them against competitors as best practices in any industry [12]. Therefore, focus must be given more to dynamic website development processes because they are a key factor in having a good quality website. However, most of those who involves in dynamic website development process still look at websites as simply pages related to each other and not as software in general. Software products hold certain quality standard to be guaranteed the quality and user satisfaction fulfilled [13].

C. Software Development Process

Most software process models list a similar set of phases and activities. These models are different from each other only in the order and frequency of the phases. The basic phases that are common in most software process models are [14, 15]:

i. Planning
ii. Requirement Analysis
iii. Design
iv. Implementation
v. Testing
vi. Maintenance

The most common and well known software process models are the waterfall model, iterative and incremental development model, prototyping, spiral model, agile method and rational unified process. Each methods and models have its own assumptions about the reality, its own techniques to support working principles and enforce discipline, and its own tools to generate the deliverables for activities.

The waterfall model was developed in 1970 as a traditional software development model. It is considered as the earliest well known model but still usable and valid until today. The processes flow sequentially where the development is executed according to phases. The waterfall model preserves that moving to the next phase should be done only after the previous phases are fully completed and no jumping forth and back or overlap between them.

Agile method is found to response fast to unexpected changes and emergent threats. Agile methods principle is to

present an optimum customer solution by using evolutionary, iterative and incremental delivery to maximize the business value with right-sized and just-in-time processes.

D. Software Quality Attributes

Classification for the techniques of refactoring to pattern based on the measurable effect on software quality attributes was introduced, both internally and externally [18]. The external quality attributes were measured based on the measurement results of internal quality attributes as well as on the correlations between them. Yet, software engineers do not have clear guide to choose the suitable refactoring to pattern techniques that improve certain quality.

ISO9126 represented the well-known software quality model and its associated attributes. Most studies in this area adopt ISO9126 model as their baseline and benchmark. The attributes are: functionality, efficiency, reliability, portability, maintainability and usability. This model was developed based on McCall and Boehm model of software quality [13].

Yahaya and Deraman (2010) proposed a software quality measurement metrics that includes human aspect as well as behavioural aspect in measuring statics set of attributes [13]. The Pragmatic Quality Factors (PQF) took in consideration the quality model from both technical and non-technical perspective. In technical and behavioural attributes of software quality includes efficiency, functionality, portability, reliability, maintainability, usability and integrity. The attributes were verified and validated through empirical study conducted by this research. PQF also embedded the human factor which measures the impact of the software to the users in the operating environment.

ISO/IEC 25010 was developed and it cancels and replaces ISO/IEC 9126-1:2001, which has been technically revised. ISO/IEC 25010 is a part of the SQuaRE series of International Standards. This new software product quality model categorises product quality properties into eight characteristics which are functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability and portability [16].

It clearly demonstrates that relevant and appropriate software quality attributes are more still relied on basic ISO9126 model. Thus, for this study we investigate the importance and significance of quality attributes in web development from developer's perspective. The following section will explain the result.

III. The Empirical Findings and Results

Fifty respondents are surveyed in this study to come up with the guideline and model that are recommended for use when developing dynamic website. The sampling technique used is purposive sampling. The questionnaire includes 12 questions that are categorised into four sections. The first section specifies the background, specialisation and experience of the respondents in the industry. The second section surveys the quality attributes. The third section surveys the methodologies, processes and phases of dynamic website development and the forth section surveys the problems or difficulties the developers face during the development process and what may motivate them to follow sound methodology for this process. The detail discussion regarding this survey can be found in our previous publication [17].

A. Respondents Background

The main targeted respondents to be surveyed are web developers, HTML developers and graphic designers. However, other job titles are also included such as quality assurance, software engineers, IT executives, programmer and project manager.

B. Quality Attributes and the success of Dynamic Websites

Eleven software quality attributes are surveyed to highlight their importance in achieving a successful website from a web developer's perspective. The attributes are rated in Likert scale as very significant (5) and significant (4) with no rating for natural (3), not significant (2), and not significant at all (1). The finding shows the attributes that should be highlighted are usability, accessibility, compatibility, and functionality. Table 1 shows the results.

Table 1
The Significant of Quality Attributes

Quality Attributes	5	4	3	2	1
usability	78%	22%	0%	0%	0%
accessibility	74%	26%	0%	0%	0%
comprehension	30%	44%	22%	4%	0%
maintainability	58%	32%	8%	0%	2%
compatibility	72%	28%	0%	0%	0%
security and integrity	60%	35%	5%	0%	0%
reliability	70%	24%	6%	0%	0%
flexibility	32%	56%	8%	2%	2%
functionality	70%	30%	0%	0%	0%
efficiency	32%	54%	14%	0%	0%
testability	34%	30%	26%	0%	0%

C. Process and the Success of Dynamic Websites

Seven processes are identified as the important processes in software development. These processes are surveyed and it is believed that following them would lead to successful website development from web developers' perspective. The processes are rated in Likert scales as very significant (5) and significant (4), natural (3), not significant (2), and not significant at all (1). Refer to Table 2. The processes that should be considered are planning, design, development and implementation, and evaluation and testing.

These processes are highlighted because the respondents of this survey answered between very significant and significant only with no neutral and below in the scale.

Table 2
The Significant of Software Process

Process	5	4	3	2	1
Planning	72%	28%	0%	0%	0%
Requirements Analysis	60%	26%	10%	2%	2%
Design	74%	26%	0%	0%	0%
Development/ implementation	80%	20%	0%	0%	0%
Evaluation & Testing	64%	36%	0%	0%	0%
Website Promotion	14%	20%	60%	4%	2%
Update & Maintenance (Innovation)	30%	54%	14%	2%	0%

D. Motivation Factors for Adopting Software Development Methodology

The survey includes four motivation factors, namely policy, basic SW methodologies, useful tools, and customised method. The respondents can choose more than one factor. Approximately half of the respondents think that providing

useful development tools will motivate web developer to follow a sound methodology. The second motivation is a strict organisational policy. Third, free space must be given for the developers to customise the method that want to use. Last is following basic SW methods. Figure 1 illustrates a comparison of the percentages of the factors.
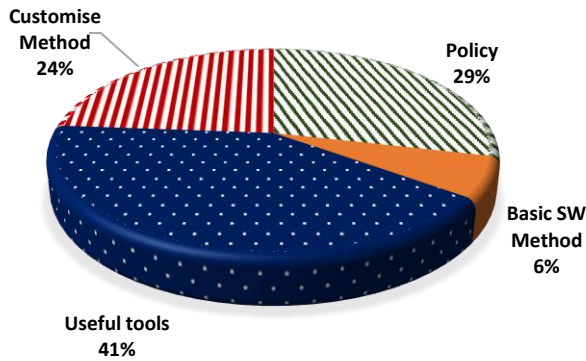

Figure 1: Motivation Factors

From the four motivation factors surveyed, useful tools dominated at 41%. This highlights the significant importance of the tools that should be provided to developers. One of the most important tools is Content Management System or CMS.

E. Use of Content Management System (CMS)

This question is included in the questionnaire because of vital role of CMS is currently plays in the dynamic website domain. This is obvious from the result, with 78% who answered that they do use CMS when developing dynamic website. Meanwhile, 22% answered that they do not use a CMS, citing the reasons for using or not using as shown in Table 3.

Table 3
Reasons for Use or Not Use of CMS

Use CMS	Do Not Use CMS
Free or low cost with many support Faster development for any kind of sites with good feature Easy to use and maintain with good tools and plugins and reuse codes Fully tested compared to self-build Less experience needed to work with Assist in making secure website	• Using framework programming (like Cakephp, Laravel, RubyOnRails) and Interface Design Framework (such as Bootstrap). • More secure and fast development tools.

IV. FORMULATION OF GUIDELINES FOR DYNAMIC WEBSITE DEVELOPMENT

From the findings and result of the empirical study as discussed in Section III, six guidelines are suggested to be followed by practitioners for dynamic website development to achieve quality under a sound methodology. These six guidelines are divided into three main categories which are quality attributes, methodology, process and phases, and tool and motivation.

A. Quality Attributes

One of the objectives of the development process should be achieving the main quality attributes that are identified from the findings of the survey.

The four main quality attributes highlighted from the findings of the survey are usability, accessibility, compatibility, and functionality.

B. Methodology, Process, and Phases

The methodology should contain the processes that obtained a higher rating in the survey. These processes are planning, design, development and implementation, and evaluate and testing, which should be redefined with respect to the RAD methodology definition [17].

The emphasis should be on two processes. First, requirement gathering process, which includes the team. Second, the design process, which includes navigation design, data storage and access design, presentation, page layout design, component design, and page communication design.

Given that the main problem that developers specify is the complexity of traditional methodologies, processes should be kept clear and simple, with a sound sequence, to overcome the complexity and the long time that traditional methods may take or the unclear separation between phases that agile methods may fall into.

C. Tool and Motivation

The development process should be supported by a strict organisational policy, and useful tools should be provided to the developers and permit them to give their opinion about the appropriate way to work for different projects, thus, the processes being followed are enhanced continuously.

Adopting CMS as a framework to consume time and cost, reduce the need for a high-level programing specialist, and enable the user to edit the website or update it easily without the need for high-level developing knowledge.

V. DEVELOPMENT OF THE SOFTWARE PROCESS MODEL FOR DYNAMIC WEBSITE DEVELOPMENT

The proposed model is developed based on the guidelines which was discussed in previous section. The proposed model is shown in Figure 2.
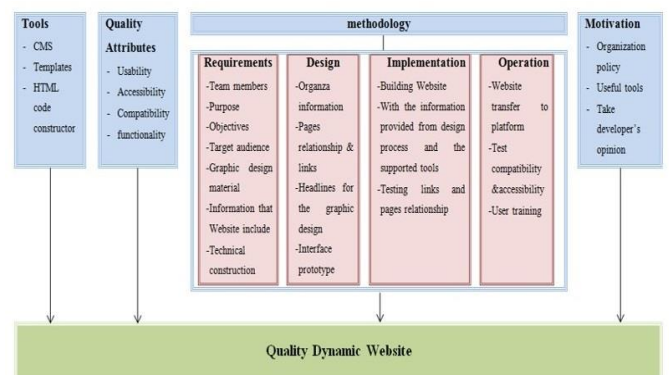

Figure 2: Software Process Model for Dynamic Website Development towards Quality Product

A. Components of the Model

There are four inputs for the model that are derived from the guidelines: the quality attributes, methodology and its processes, tool and motivation. The model contains four quality attributes: usability, functionality, compatibility and accessibility. The tools mainly based on CMS provide a variety of devices and adds-in that are very useful, in addition

templates and the HTML code constructor. For the motivation, a strict organisational policy in terms of following the model during the development process, provision of the useful tool mentioned previously, and consideration of developers' opinions about suitable enhancements or improvements that should be made to the methods used.

Promotion and innovation are the last two processes suggested by the survey. However, we did not include them in the model because the main objectives of the model are to overcome complexity, reduce cost and times, and motivate developers to follow it. Thus, promotion, which means bring visitors to the website, could refer to the users' responsibility to attract an audience to browse their websites. On the other hand, innovation for the website mainly refers to updating it. This process is the user's responsibility, especially in term of appropriate training and the use of CMS with an administrator interface that make the updating process very informal.

Finally, for the methodology, four processes are highlighted as important. These processes are requirement engineering, design, implementation, and operation and maintenance. The methodology and processes included in this model are the following:

1) Requirement Planning

This determines the team members who will define the purpose, objectives, target audience, and materials needed for the graphic design, information domain that the website will include, and technical construction of the website using validation tools. Gathering and comparing information about the website and its operation would improve the overall website quality. When talking about dynamic website development, two team with sound knowledge of graphic design and development tools are ideal to help in the latest phases concerning database and platforms. This will reduce the team and communication problems highlighted by the survey. The user involved in this process could have a clear definition and information about the objectives and components of the website.

2) Design

This refers to organising the information within pages, deciding the page relationships and links, and placing the headlines for graphic design. Finally, an interface prototype is developed to give the general look that the user could understand and modify. Given that this prototype is the main interaction between developers and users that will continue through the next process, it is important to create a consistent look and feel for the interface to give the user a clear image of the website's design and look. This would help enhance usability and functionality because the user reflects the opinion and limits the technical information that most of the audience have.

3) Implementation

In this process, the actual website is built using CMS as a framework. Automated tools help with the construction of the needed HTML code. Templates are used to provide a consistent look and feel, and creating and testing databases are employed. The code construction will not be the main phase in this process because the CMS provides most of the components needed to build a coherent dynamic website with reliable features without the need for notable programming experience. The user continues to interact and suggest improvements. The active use of the helpful tools consumes time, cost, and reduces complexity. Testing links and page relationships and components would be an on-going phase during this process.

4) Operation and Maintenance

The website is transferred to the platform that it relies on. It is tested in various browsers, and any problem of incompatibility is solved. User training includes how to update the information on the website. Testing during this process ensures the accessibility and compatibility of the website. The websites are put on operation and they need to be maintain from time to time to ensure the relevancy of the website.

B. Model Validation using Expert Review

A validation form is designed and applied for two experts to examine the validity and efficiency of the model in motivating developers to implement and practice it in the dynamic website development process. The two experts have experience in dynamic website development, as they both developed more than 40 Iraqi official dynamic websites by creating and developing a CMS; all the websites they developed are relying on it as a framework.

The form surveyed the main inputs of the model through five questions. The two experts answered "yes" to the first four questions in the form, while their answers to the fifth question are as follows:
  i. *It is really very good to start with any software.*
  ii. *I think the model is perfect for any programmer.*
The five questions in the form are as follows:
  i. Do you think the tools mentioned in the model are useful and would improve the development process and motivate a developer to use it?
  ii. Do you think this model would achieve the quality attributes?
  iii. Do you think the methodology, including its processes and phases, is suitable for the dynamic website development process in terms of quality and workflow?
  iv. Do you think the motivation factor would motivate web developers to follow this model when developing dynamic websites?
  v. Do you have any suggestion to improve the model in terms of all its components (tools, quality attributes, methodology, and motivation)?

The two expert's answers are positive towards the model components, and their opinions reflect that the model is suitable for any developer to follow especially for dynamic website development.

VI. DISCUSSION AND CONCLUSION

A survey was performed in this study to accomplish the objectives. This survey included 12 questions that were categorised into four sections, namely demographic information, quality attributes, methodologies processes and phases, and problems and motivations. One more question was employed to survey the use of CMS.

The analysis of the findings showed that 58% of the fifty survey respondents with significant experience in building websites were directly involved in the dynamic website development process, which made the results more reliable.

Usability, accessibility, compatibility, and functionality are

the important quality attributes that the respondents highlighted. Yet, 40% of them believed that only 40% to 60% of dynamic websites published on the Internet meet these quality requirements.

Planning, design, development and implementation as well as evaluating and testing are the main processes for dynamic website development that the respondents considered as important. However, 50% of the respondents did not follow sound methodology when building dynamic websites despite the fact that 78% of them believe in the importance of following sound methods.

Among the difficulties that prevented them from using a sound methodology was the complexity, rated 100%, of these methodologies. Yet, Rapid Application Prototyping (RAD) got the highest percentage among those who used sound methodologies in their work.

Design and planning got the highest ratings among the phases surveyed with 43% of the respondents indicating that they had no problems in these phases. Meanwhile, the rest highlighted team and communication as the major difficulties encountered.

Among other factors, useful tools are the most likely motivational factor that would encourage developers to follow sound methodologies. For instance, 78% of the respondents stated that content management system (CMS) is one of the important tools that they use in their work. Further and detail discussion of this survey and the findings can be referred to Yahaya, Deraman & Ibrahim [17].

Accordingly, based on the analysis and findings, guidelines were established and a model was proposed that took into consideration the characteristics of dynamic website development process with respect to software engineering principles. Moreover, an evaluation form was designed to examine the validity and suitability of the model, which was applied by two experts to get their opinions on the components of the model. Largely, their answers were positive towards the model components and their opinions showed that the model could generally be adopted by developers.

This study contributes the initial or preliminary model of software process for dynamic website development. Further research is recommended to enhance the model specifically in term of:

    i. analysis and investigation on a wider scope of the quality attributes,
    ii. enhance the motivation factors and deficiencies identified in this study,
    iii. wider scope of respondents in the survey.

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