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A Study on Developing a Web Application for Construction Services

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Abstract

Almost every industry in the world has used the Internet to widen its business opportunities. This has even moved into the construction industry as well, but it's unusual that they are slow to adopt new technological advances for their processes. According to the observation, which was made on the Internet, it could be found that purchasing land, finding the service providers, selecting house plans, and purchasing hardware items are accomplished in a traditional way or users can access websites that provide only a single service. Five experts with experience in the construction industry were interviewed to identify the requirements and benefits that should be supported by a website for home construction. This study is based on the development and evaluation process of the proposed web application which provides guidance, consultation, and other services for users.

Keywords: Building construction, customer satisfaction, Internet, web application

Introduction

The construction industry has become one of the most challenging and demanding industries in Sri Lanka and still has many opportunities for productivity improvement. Meantime, Information technology also has brought revolutionary changes to almost every sector [1]. According to [2], it has been identified that making use of Information Technology in the construction industry is still at an unsatisfactory level. This was revealed as a potential obstacle to the development of the construction industry. Further, as stated in [3], it has been revealed that the perceived benefits of IT adoption in the construction industry are not being used.

Meanwhile, the COVID-19 virus has negatively impacted on exports, tourism, foreign employment, and industrial sectors in Sri Lanka [4]. As a result of the risks created by the pandemic, the construction industry experiences additional risks such as termination of staff employment as well as payment to employees without work [5].

Apart from the effect of the pandemic, according to the findings of the study [6], they have discovered that the main challenge for the employment of local professionals and workers is the competition of multinational organizations since the opportunities of the local market are acquired by foreign workers. It recommends the creation of a proper mechanism to address competition by providing more opportunities to local professionals and workers in the construction industry.

According to the information gathered, it has been determined that the construction industry should be improved further in terms of information technology. More than that, a solution should be found for the unemployment in the construction industry.

Problem Statement

Before starting the construction, there are some approvals and permissions that should be obtained from the relevant authorities. Approval of building plans is a long process as it involves the government and comes under municipal by-laws. Some approvals and applications that should be filled out prior to the beginning of construction are listed below [7].

- Development approval for construction in urban areas
- Preliminary planning clearance
- Subdivision application
- Building application
- Certificate of conformity

Most of the time, the construction process terminates due to the lack of knowledge in the approval process. The major reason is that most people are not aware of the regulations of the approval process and how and when the approval process should be obtained.

There are particular professionals for each and every task in home construction. Another problem is finding the most suitable service provider at the right time for a construction project. Most of the time, people have grown accustomed to selecting service providers by contacting friends, family, and neighbors and asking for recommendations. Actually, it is not the most effective and appropriate solution. Furthermore, according to [5] and [6], degree holders in the construction industry experience unemployment for many reasons.

Nowadays, purchasing materials for construction becomes hard when considering material quality and pricing. Apart from that, almost everyone has a hectic lifestyle. Because of that, they do not have enough time to go to the shops and purchase the necessary materials. Further, they lack the necessary knowledge to calculate the amount of raw materials required for construction. As a result, they waste their time as well as money.

Additionally, purchasing land through brokers, selecting the service providers through personal identifications, and purchasing hardware items from hardware shops by physically visiting those places

are also some activities that are still done in the traditional way.

Hence, a huge research gap could be found in the perspective of home construction and client perspective. There are trending technologies to support large construction companies. But if someone hopes to carry out their own construction without the support of a construction firm, at that point, they have to follow the process in a traditional way. So, the need for blending Information Technology with the construction sector is clearly reflected in this problem.

Selection of Development Technologies

As part of this research work, a web application was proposed to solve every problem that was discussed above. The proposed system will provide guidance, consultation, and services for people who are dreaming of building their own homes. The popularity of web applications has increased significantly over the previous decade, and the number of users of web applications is rapidly increasing on a daily basis [8]. Every day, new libraries, frameworks, and constructors are released, allowing to automate as much of the process of developing such web applications as possible [9-11]. Among those technologies, the necessary ones should be selected to develop the proposed web application.

Frameworks handle the implementation of certain functionalities for developers in the background. They may study and utilize these frameworks to design and deploy web applications without having a thorough grasp of the programming language [9]. However, it eliminates the opportunity to grasp the programming languages better. Because of that, HTML, CSS, JavaScript, and PHP are selected for development since they are the main programming languages of the web application.

Aims and Objectives

The main aim of this study is to develop a productive and integrated web application for the construction industry, which guides and provides consultation and services for the users and service providers.
For the users,

- Provide all the rules and regulations about house construction.
- Provide professionals for construction.
- Calculate the raw materials for the construction.
- Maintain online hardware store.
- Provide land details that are available to purchase.
- Provide house plans.

For the service providers,

- To advertise the job advertisements.
- To get the contracts through the web application.
- To advertise lands for land-owners.
- To advertise house plans for draughts men.

The objectives of the research are as follows:

- To identify the difficulties in constructing a house according to the employer's point of view.
- To identify the barriers to promoting construction-related professionals in Sri Lanka.
- To evaluate the Sri Lankan status of "construction websites".

Analysis

Background research was conducted to discover the research and the studies that have been done based on the use of ICT technologies in the construction industry. According to [10], the low level of ICT usage has been identified as having a negative impact on the productivity of the construction sector in Sri Lanka. According to the background study, it was identified that there is only a limited number of research studies have been carried out combining the IT industry and the construction industry in Sri Lanka.

The paper [3] highlights a mobile application that was implemented in order to support communication between the laborers who work at the construction site and the management who work at their offices. Furthermore, the research [11] has been carried out to discuss the suitability of applying cloud computing in the construction industry in Sri Lanka. The challenges and strategies in adopting augmented reality for construction project monitoring also have been studied in [12]. Since the research work is also based on home construction and web development, several web applications related to home construction were also identified. Those products were referred to in order to come across the relevant core concepts that are needed to continue with the project.

Various websites on the Internet are specially designed for guiding and consulting users to accomplish their needs in the construction industry. Some of them are for purchasing land, house plans, and hardware items, and some of them are for providing contact details of the service providers. However, currently, users cannot get all the functionalities related to home construction from a single website. In this paper, about ten existing websites are discussed according to the functions that they provide for the user.

Land Selling

There are many land-selling websites on the Internet. Table 1 summarizes the differences and similarities among some of the popular websites.

Table 1. Differences and similarities between land-selling websites

Functions Provided by the Website	Prime Lands [13]	Araliya Lands [14]	Wathupiti. lk [15]
Filtration facilities	Users can filter according to location, price.	Users can filter according to location.	Users can filter according to location, price, and category.
Other services	Sell houses,	It does not provide other	Rent and sell buildings.

	Give details about prime apartments.	services.	
Contact details	Provide the contact details of the agents.	Provide the contact details of the owner.	Provide the contact details of the owner.
Information	Provide facility details, road maps, block plans.	Provide facility details, road maps, block plan, payment details.	Provide facility details, road maps, block plans.

Providing House Plans

There are a limited number of websites that provide house plans on the Internet. Table 2 summarizes the differences and similarities among such websites.

Table 2. Differences and similarities among websites that provide house plans

Functions Provided by the Website	**House Plans** [16]	**Eplans** [17]	**Dream Home Source [18]**
Filtration facilities	Users can filter according to the category, region, and number of bedrooms, bathrooms, stories, garages, and categories.	Users can filter according to the category, designers, area, width, depth, number of bedrooms, bathrooms, stories, and garages.	Users can filter according to the category, interior and exterior designs, region, designers, area, width, and depth, and number of bedrooms, bathrooms, stories, and garages.
Other services	Blog	Blog	Blog
Online purchasing capability	Provide the contact details of the agents.	Provide the contact details of the owner.	Provide the contact details of the owner.
Information	Provide plan description, floor plans, specifications, and features, inclusions in the plan set, and price details.	Provide plan description, floor plans, specifications, features, inclusions in the plan set, and price details.	Provide plan description, floor plans, specifications, and features, inclusions in the plan set, and price details.

Hardware Items Purchasing

There are some websites for purchasing hardware items on the Internet. Table 3 summarizes the differences and similarities among those websites.

Table 3. Differences and similarities among online hardware websites

Functions Provided by the Website	BNS Hardware [19]	M. M. Noorbhoy & Co [20]	Asiri Hardware [21]
Filtration capability	Users can filter items according to category and brand.	Users can filter items according to category and brand.	Users can filter items according to the category.
Online chat service	Does not have	Has	Has
Maintaining a catalog	Does not provide catalogs of various brands.	Provide catalogs of various brands.	Does not provide catalogs of various brands
Maintaining virtual tours	Does not provide virtual tours for their shops.	Provides virtual tours for their shops.	Does not provide virtual tours for their shops.
User-friendliness	The website is very user-friendly and neat.	Medium	Less
Item collection	Contains a rich collection of items and categorization is simple and easy to understand.	Contains a medium collection of items and has a limited number of categories.	Contains a medium collection of items.

Consultancy Service

There are a limited number of websites that provide consultations about construction. Among them, the best website is the Houzz website [22]. It is an advanced website that provides basically the following services.

- Providing construction ideas for users by displaying images.
- Providing contact details of professionals with their experience.
- Showing ratings of the professionals.
- Maintaining an advising blog to communicate.

Methodology

A comprehensive literature review was carried out to identify similar websites on the Internet. According to the data that was gathered, there are many web applications in the market, but they have focused to deliver a single service for the users i.e., selling lands, providing house plans, and online hardware store. If the user needs combined services, they have to access many web applications. Thus, there is no website or system that provides all the construction services through a single system. Hence this research proposes a web application was proposed and designed to solve every problem that was discussed above. The functional and non-functional requirements addressed from the research/work are listed in Table 4.

Table 4. Functional and non-functional requirements

Functional Requirements	Non-functional Requirements
Users should be able to view land details.	The web application is accessible 24/7 hours.
Users should be able to filter land details.	The web application should be mobile responsive.
Users should be able to view professional details.	A requested page should load within 2 seconds.
Users should be able to filter professional details.	Each request should be processed within 10 seconds.
Users should be able to add the hardware items to the cart.	The web application is compatible with the selected web browsers.
Users should be able to do the checkout process.	Multiple users can access the web application simultaneously.
Users should be able to filter hardware items.	
Users should be able to get all the instructions that are necessary for construction.	

Architecture Diagram

The main architecture of the proposed web application is based upon the well-known design pattern known as the client-server architecture. The design of the proposed web application is relatively simple. A database is the main storage repository for all data. The data is managed by the business logic layer of the application. A web page presents human-readable data to the user. When the user requests data, particular data in the database will be fetched and displayed on the web page**.** Simultaneously, some operations performed by the end-user may result in data being written to the database. Figure 1 illustrates the architecture diagram of the developed web application.

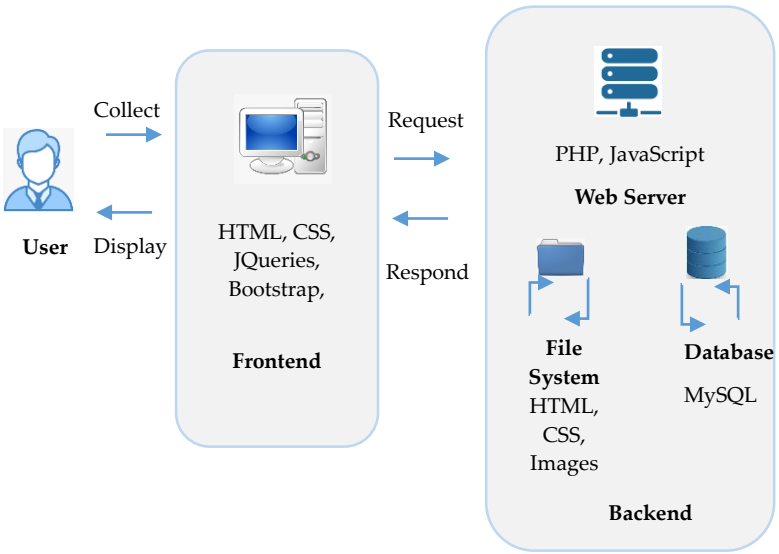

Figure 1. Architecture diagram *[23]*

User Interface Design

The goal of effective user interface is to make the user's experience easy and intuitive, requiring minimum effort on the user's part to receive maximum desired outcome [24]. Hence, implementation of the user interface is very important and more considerable in the development of the websites. Color theory, F-pattern layout, and Visual Hierarchy are some web design concepts that were used as a combination for the development of the user interfaces of the web application. User interfaces that run as web pages in the web browser are developed using HTML, CSS, jQuery, PHP, and Bootstrap. Visual Studio Code is the code editor which was used for coding purposes. Figure 2 depicts the user interface of the home page of the developed web application.

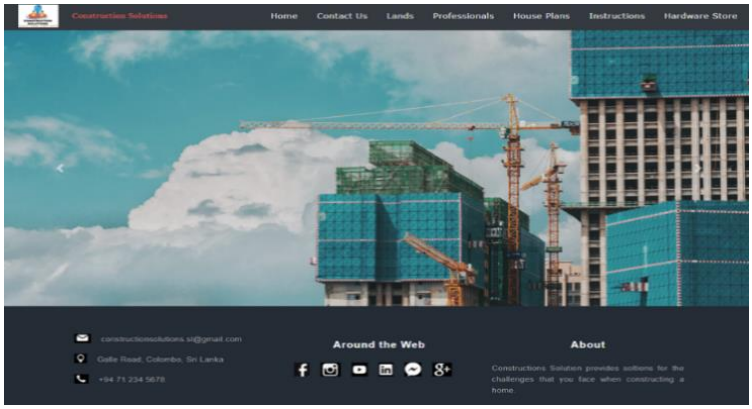

Figure 2. User interface of the home page of the web application

Database Implementation

Database implementation involves the construction of a database according to the specification of a logical schema. For development of the database, phpMyAdmin is used as the database server. According to the database design, tables were created and populated. Structured Query Language (SQL) is used for manipulating the stored data in the database.

Results and Discussion

As expected, the web application was developed successfully by fulfilling all the aims and objectives. The developed web application integrates the functionalities identified in the web applications examined in the study's literature review. The novelty of the web application is that it provides a collection of services for users who are expecting services in home construction. Further, the web application provides a calculator to calculate the raw materials and it is a new feature that is provided only by the developed web application. Rather than using many web applications to accomplish the objectives, users can acquire all the services from a single web application, which is easier and more effective.

When we consider the business outcome of the web application, financial benefits can be acquired by hosting it on the Internet. If someone is willing to purchase and maintain the web application, he or she

can acquire direct financial benefits through it. If someone needs to sell their land through the web application, he/she should pay to advertise the land details on the web application. An online hardware store is maintained. Therefore, it will give a direct income to the person who maintains the web application. The next advantage is that professionals can use the web application as an advertising platform to publish their advertisements on the web application. They should pay to advertise their details on the web application. Through that, the development of the web application also gives a solution to unemployment. The web application was fully tested using unit testing, integration testing, system testing, and user acceptance testing and found to be error-free and it is highly portable.

An evaluation process was carried out for the verification and validation of the developed web application. In the verification process, it was checked and verified for any discrepancies and errors by comparing the system with the functional and non-functional requirements. This was achieved by the submission of the web application and the database for criticism and evaluation by several technical people.

Informal validation by domain experts was used to test the web application. The validation focuses mainly on the performance issues, which are specific to the design and development of the web application. Acceptance validation consists of checking whether the developed web application has reached a reasonable level of quality at the end of the development stage. For the validation of the web application, the survey was conducted by giving users access to the application and providing user guidance and training.

Evaluation Results

For both the verification and validation processes, two separate questionnaires were used, which consisted of open-ended and closed-ended questions, and those questions were based on some categories and shows in table 5. The closed-ended questions were based on the Likert scale. We did not collect any personal information and the responses were used only from a technical perspective. With the help of the SPSS package, descriptive statistical techniques were utilized to analyze the data.

Table 5. Categories and questions

Type of evaluation	Category	Questions
Verification	Information in the Product	The text is readable.
		The information is understandable.
		The language is suitable for the readers.
		The images clearly communicate information.
		Link to other relevant sites.
	User interaction	The interface design is pleasing and artistic.
		The interface is user-friendly/convenient to use.
		Error messages are understandable and helpful to recover.
		The link between pages (navigation) is easy to understand.
		Visual clarity.

	Technical aspects	The application works for different web browsers (Chrome, Edge, Firefox).
	Technical aspects contd.	Page redirects are working properly. Sitemap.
	Support services	Documentation is in satisfactory level.
Validation	Usability	Is the app simple to use? Easy to look at the web pages. Can read and understand the content. Can self-learn.
	Performance	Load the pages within 2 sec. The application does not have an error that will interfere with the operation.
	Satisfaction	Results what you expected? The web application implements all the functions. The web application works according to the specifications.
	Effectiveness	The results are always correct. The web application is suitable to use. The functions that have been implemented are timely.
	Appropriateness	Would you consider using the application in the future? Would you recommend the application to others?

Some bugs and errors were identified by technical people in the verification process, and they were fixed. Comments and suggestions were received from both the validation and verification processes. Relevant suggestions were implemented to maximize the usability of the web application.

In table 6 and table 7, N represents the number of responses received for each evaluation. All the responses were analyzed according to their category and were calculated out of 100. Minimum represents the minimum summarized value of the responses while maximum represents the maximum summarized value of the responses. Table 6 illustrates the descriptive statistics of the responses in the verification process. According to the statistics, it shows that the mean value is more than 75% of all the categories. Thus, we can conclude that the web application has developed successfully and effectively

Table 6. *Descriptive statistics of the verification process*

Category	N	Minimum	Maximum	Mean
Information in the product	34	68.00	84.00	75.0588
User interaction	34	72.00	92.00	84.9412
Technical aspects	34	55.00	90.00	78.5294
Support services	34	70.00	90.00	80.0000
Valid N (listwise)	34			

Table 7 illustrates the descriptive statistics of the responses in the validation process. According to the statistics, it shows that the mean value is more than 80% of all the categories and effectiveness has the highest mean out of all the categories. It highlights that domain experts in the construction industry have seen it as an effective product for the industry.

Table 7. Descriptive statistics of the validation process

Category	N	Minimum	Maximum	Mean
Usability	30	75.00	100.00	84.3333
Performance	30	66.67	93.33	80.4444
Satisfaction	30	73.33	93.33	84.8889
Effectiveness	30	80.00	100.00	92.8889
Appropriateness	30	73.33	100.00	91.5556
Valid N (listwise)	30			

Conclusion

The study was carried out by investigating existing web applications on the Internet that were developed for construction purposes and developing a web application that provides guidance, consultation, and other services for clients and professionals in the construction industry. For the development of the web application, a combination of web design concepts was used. An evaluation process was carried out with the participation of experts from both the construction industry and the ICT industry to verify and validate the functionality of the web application. When the developed web application is compared with the existing web applications, it provides most of the features and facilities that are provided by those existing web applications and new features as well. Table 8 summarizes the comparison of the features of the existing websites and the proposed web application.

Table 8. Comparison of the features of the existing websites and the proposed web application

Feature	Status
Providing filtration facilities	Existing feature, developed in the web application
Providing information about lands, professionals, and house plans	Existing feature, developed in the web application
Online purchasing capability	Existing feature, developed in the web application
Providing a Blog	Existing feature, did not develop in the web application
Online chat service	Existing feature, did not develop in the web application
Maintaining virtual tours	Existing feature, did not develop in the web application
Providing contact details of professionals and landowners	Existing feature, developed in the web application
Calculate the raw materials for the construction	New feature
Provide all the rules and regulations about house construction and the related documents	New feature

In the developed web application, all the functions mentioned in Table 8 have been implemented and the users can access those services by using a single web application instead of accessing several applications. Once the web application is hosted on the Internet from a business perspective, it will provide a great service for clients who are interested and have needs in the scope of home construction. It facilitates from the very beginning of the construction process. Before starting the construction process, the client can read the instruction page and awareness can be gained regarding the approvals and applications process that should be completed prior to the beginning of construction. Furthermore, they can find suitable land from the huge collection. The next advantage is the online hardware store. Since the application provides the calculator to calculate the raw material, it is much more efficient to order the exact necessary amount of hardware items.

Further, if they need to hire a professional for construction work, it is much easier and more efficient since the web application provides a collection and they can select them according to their need, location, and experience level. Hence, the development of the web application gives a direct solution for unemployment also. So, it provides a great opportunity for degree holders who are expecting job vacancies in the construction industry.

Future Work

With rapid advances in this competitive environment, it is difficult to predict how the business will improve and expand in the coming years. There are a few facilities and enhancements that can be added to the web application. A dashboard should be developed to maintain the database. For now, data insertion for the database should be done by a technical person. If a dashboard is created, even a non-technical person can handle the database. A blog can be developed as an additional feature for the web application. Through that, system implementers can directly get user responses and feedback about the services of the web application.

The COVID-19 pandemic has brought profound changes to all sectors of society, including the construction sector. The one saving grace for construction firms, contractors, and employees could be the use of information technology. The development and changes that can be applied to the web application to minimize the effects can be implemented further.

Conflicts of Interest

The authors declare no conflict of interest.

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