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A SIMPLE INTERACTIVE 3D INTERIOR DESIGN APPLICATION FOR LIVING ROOM - COST MANAGEMENT

By

Chin Winnie

A REPORT
SUBMITTED TO
Universiti Tunku Abdul Rahman
in partial fulfillment of the requirements
for the degree of
BACHELOR OF INFORMATION SYSTEMS (HONS) BUSINESS INFORMATION SYSTEMS
Faculty of Information and Communication Technology
(Kampar Campus)

JANUARY 2017

DECLARATION OF ORIGINALITY

I declare that this report entitled "A SIMPLE INTERACTIVE 3D INTERIOR DESIGN APPLICATION FOR LIVING ROOM - COST MANAGEMENT" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

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Name : CHIN WINNIE

Date : 19 APRIL 2017

ACKNOWLEDGEMENTS

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names not all may be enumerated. Their contribution are sincerely appreciated and grateful acknowledged.

However, I would like to express my deep appreciation and gratitude particularly to Ms. Saw Seow Hui, my supervisor for her patient, guidance, enthusiastic encouragement and constructive feedbacks in this project.

Also to all friends and family for their support either morally, financially and physically, thank you.

ABSTARCT

This project is titled “A SIMPLE INTERACTIVE 3D INTERIOR DESIGN APPLICATION FOR LIVING ROOM - COST MANAGEMENT”, focusing to develop an application that enables cost estimation to be done during the designing phase itself. This is because cost information is necessarily important to support cost-based decision making process, especially for large-scale housing project, where a small change in the costs of a unit plan will then lead to a follow-on effect on hundreds or thousands of uniform unit plans, resulting in the project cost overruns. Therefore, it is being proposed in this system that the total cost to be updated real-time as user add or remove an item into the workspace. Other features include budgetary control, allowing user to set budget at the very beginning of the project as well as generating documents that are readily presentable to clients.

The methodology being proposed in this project is Prototyping Development, categorized under Rapid Application Development (RAD) starting off with planning, while analysis, design and implementation phases are performed concurrently and repeatedly in a cycle to produce a system prototype until the system is completed. The end result of the development of this application is expected to provide a better solution towards cost management for interior design.

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1-1 Background Information

Interior design phases consist of conception, modelling, review, finalization, detailing and costing as illustrated as in Figure 1-1-F1. Whereby, interior designer starts a project by developing design concept in term of theme and style, transforming the design into model, reviewing it with client as well as builder and supplier, adding specific details such dimensions, texture and color code, and lastly estimating the costs.

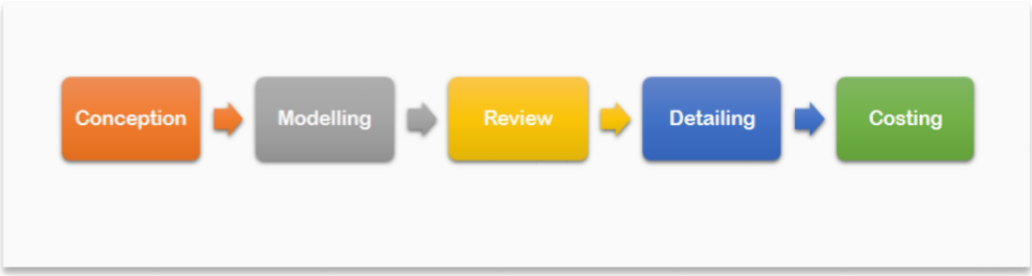


Figure 1-1-F1 Interior Design Phases

For that reason, most of the interior design software, even RoomSketcher, Planning Wiz and Autodesk Homestyler, of the top three Interior Design Software according to GuidingTech, does not involve cost estimation in their application. This is because in the existing interior design model, costing is done at the very final stage after design is finalized.

As results, any changes on the interior design specification demanded by client at this stage will cause an increase in costs and delay in time. Therefore, in this project, an interior design software that enables costing and designing phase to be executed concurrently is being proposed.

1-2 Motivation and Problem Statement

In the existing interior design process model as illustrated in Figure 1-2-F1, homeowner or developer first request ideas from architect or directly from interior designer. The interior design shall be reviewed by homeowner or developer, builder and supplier for design, constructability and availability, however without taking cost into consideration. If and only if the design is reviewed successfully, it will then proceed to cost estimation and followed by a final reviewing by homeowner or developer in which cost is the major concern whether to move on with construction work or not.

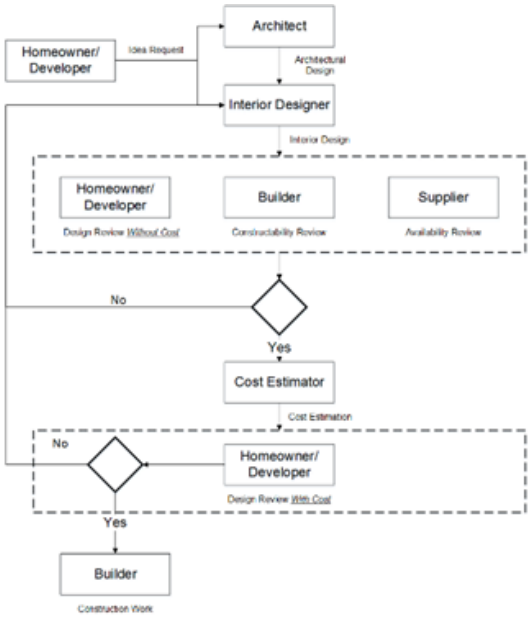


Figure 1-2-F1 Existing Interior Design Procedure (Lee, Lee & Kim 2008)

The major problem of the existing model is that cost is not taken into consideration during early review of the design. As a result, the process is repeated when the design is not accepted by the homeowner/developer during the late review. This often leads to increase in unnecessary costs and time. Besides, it is very important to determine the costs during the design phase itself especially for large-scale housing project. In a large-scale housing project, even a small change in the costs of an interior design item, it will then has a follow-on effect on hundreds or thousands of uniform unit plans, resulting in cost overruns in the overall project.

1-3 Project Objectives

The objective of the project is aimed to devise a real-time cost-management module to be included in the interior design software, allowing interior designer to make cost-based decision in the interior design phase itself suited to their own interior design specifications. Therefore, cost information is to be stored in a database, where interior designer is allowed to check costs accordingly as they add items into the workspace. At the end of the design, the system will automatically generate a list of all items, allowing builder to examine and plan the resources, thus increases the accuracy of cost estimation. Most importantly, the design is ready to be reviewed by the homeowner/developer for approval with costs directly after the design phase is completed.

1-4 Impact, Significance and Contribution

Targeting on the world's urbanization trends where the urban population is expected to rise by 2.5 billion persons, from 3.9 billion to 6.3 billion, while the total world population is projected to grow by somewhat less, 2.3 billion, from 7.3 billion in 2014 to 9.6 billion in 2050 (United Nations 2014). Therefore, large-scale housing project is expected, whereby interior design is involved. In contrast to many 3D Interior Design application, the proposed project acknowledge the significant of cost estimation to be included in the interior design phase itself. This is because cost information is necessarily important to support cost-based decision making process in the interior design phase, especially for large-scale housing project, where a small change in the costs of a unit plan will then lead to a follow-on effect on hundreds or thousands of uniform unit plans, resulting in the project cost overruns. With that reason, it is worth investing, in term of time and effort, developing a solution for the proposed project.

1-5 Project Scope

This project develops a real-time cost management module to be included into the interior design software. This project involves an improved interior design procedure as shown in Figure 1-5-F1. Through the proposed interior design software with real-time cost management module, interior designer can easily add interior design objects into the workspace from the database. While the database store all interior design object provided by the supplier with specific information such as types of materials, color availability, sizes and most importantly the prices. At the end of designing, the list of items required and the total costs are generated automatically.

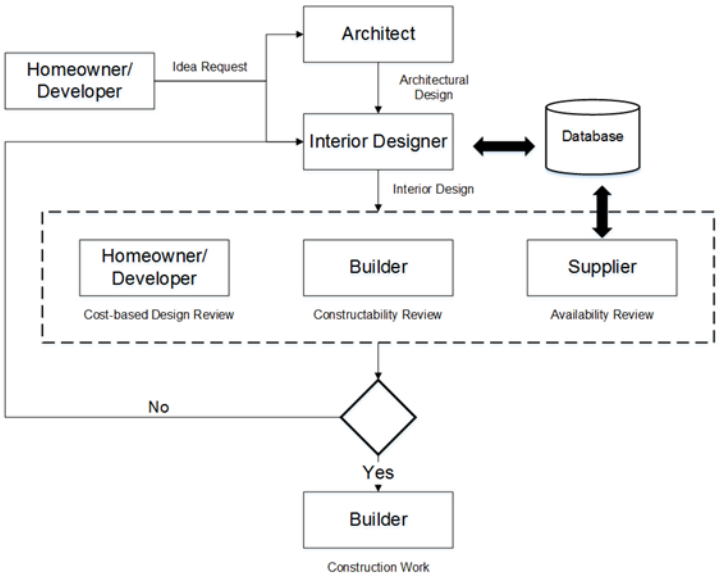


Figure 1-5-F1 Proposed Interior Design Procedure (Lee, Lee & Kim 2008)

To conclude, the overall interior design procedure has been shorten, hence reducing the risks of unnecessary increase in costs and time.

1-6 Structure of the Report

This report consists of a total of six chapters, including introduction, literature review, methodology, system design, implementation and testing and conclusion respectively. The next chapter that is the chapter 2 of literature review, three of the existing similar applications will be discussed on their current solutions toward the proposed problem statements and also in comparison to the proposed application. While, in chapter 3 of methodology will look into the reasons why Prototyping Development is being chosen in this project and how it is derived to suit this project. In the chapter 4 of system design, the proposed application are visualized with system diagrams such as flow chart, use case diagram and ERD diagram. On the following chapter 5 of implementation and testing, software and hardware used, algorithms involved, graphical interface as well as system testing are documented in detailed. Lastly, the chapter 6 of conclusion will summarize the overall project, highlight some of the problems encountered while developing the application and also recommendations to be improved in future.

In this chapter, similar existing 3D Interior Design applications and their solutions towards the problems on cost estimation in interior design project are being reviewed. Also, the strengths and weaknesses of their solutions are being studied, contributing to a better solution in the proposed application.

2-1 IKEA Planning Tools

IKEA Planning Tools are web based applications using browser plug-in being offered by IKEA for free at their website. The aim of this application is to make everyone an interior designer of their own dream home. This is possible because it is easy to use by simply drag and drop any furniture into the workspace and can try them out with different colors, styles, sizes and configurations.

Apart from ease-of-use, another strengths of this application is that it allows user to work with real life products. Also, the costs of the project is updated real-time as user add in or remove any items from the workspace and shown on the top right of the user interface as shown in Figure 2-1-F1. At the end of the project, the planner will automatically calculate the total costs as well as generating a product list, where user can get the listed products from any IKEA stores at the specific price.

However, it will be convenient only if user are getting everything from IKEA store. This is because all furniture are limited only to IKEA products. Besides, even the planner allows user to keep track of the cost, hidden costs are often applied. This is because the advertised price does not take in consideration of delivery, assembly, and installation costs.

In fact, IKEA Planning Tools consist of IKEA Home Planner, Kitchen Quick Quote, Bathroom Planner, PAX Wardrobe Planner, BESTÅ Storage Planner, Office Planner and STUVA Children's Storage Planner, in which all serve different purposes that make it its greatest weaknesses. This is because often more than one planner is required to customize for even just a room, and so will need user to download each separate planner individually.

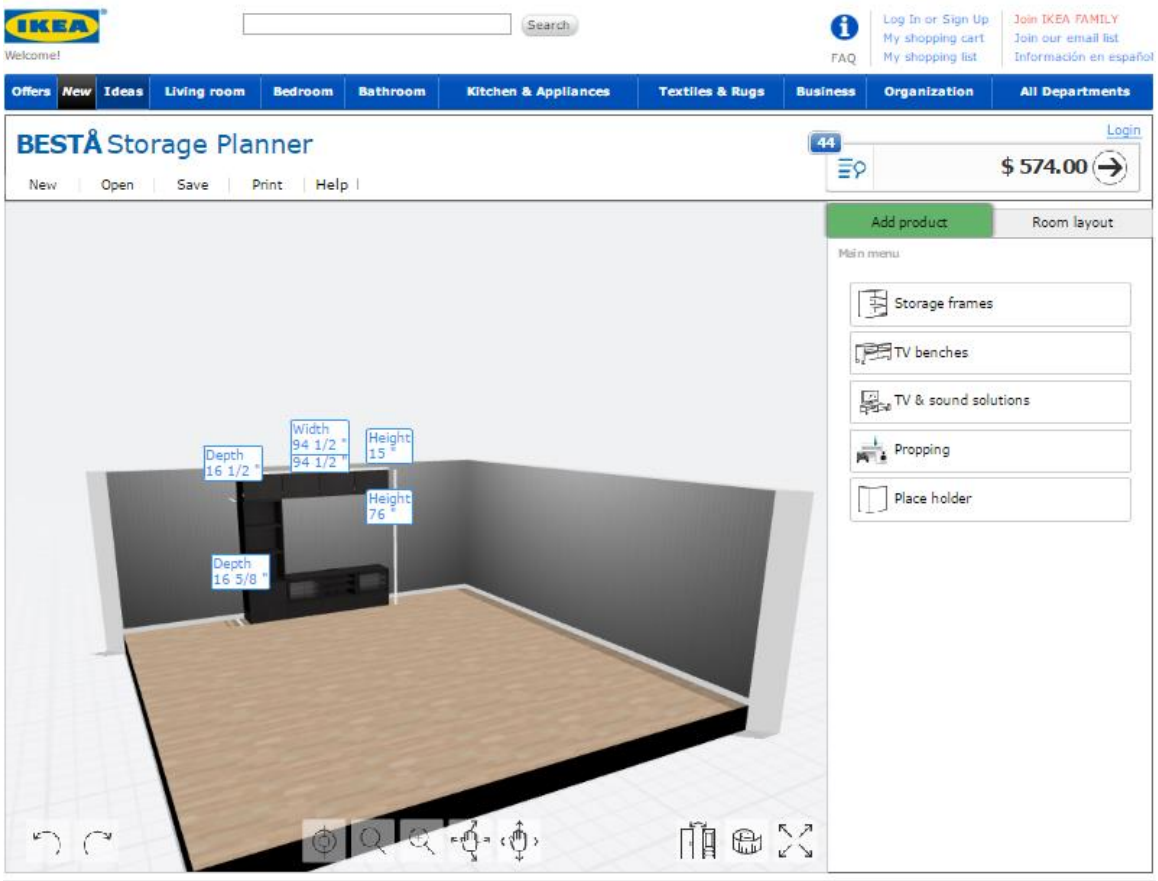


Figure 2-1-F1 Screenshot of BESTÅ Storage Planner Interface (BESTÅ Storage Planner 2015)

2-2 Home Designer Pro

Home Designer Pro is a full-featured software for home design, interior design and outdoor living projects developed by Chief Architect. And so, it is top-rated the best home design software of the year 2016 in a review conducted by Top Ten Reviews. Other than its powerful features such as design tools, 3D tools and landscaping tools, most importantly, it supports cost estimating. In which, it will automatically generate a material list for budgeting and planning at the end of the project, with the options to calculate by all floors, a room or an area as shown in Figure 2-2-F1. For example of calculating by room, the garage or attic can be specified either to be included or excluded in the living area calculation. Besides, it also enables user to export the material list to spreadsheet programs such as Microsoft Excel and even save the screenshot of the material list for different stages of the project to evaluate and compare the differences in cost. Whereas, within the material list, each individual component can be further broken down and assign cost for each of them as in Figure 2-2-F2 (Home Designer Professional 2016).

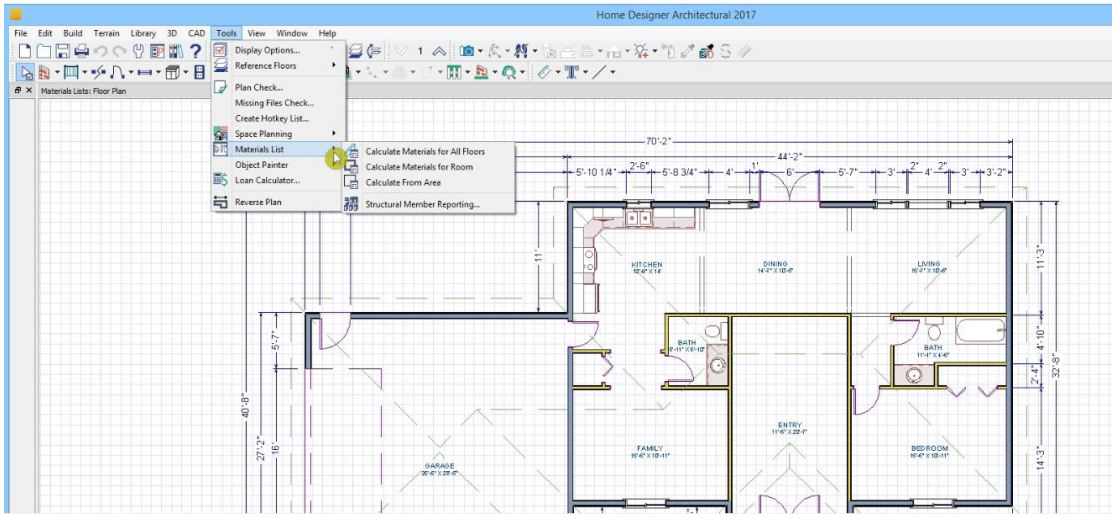
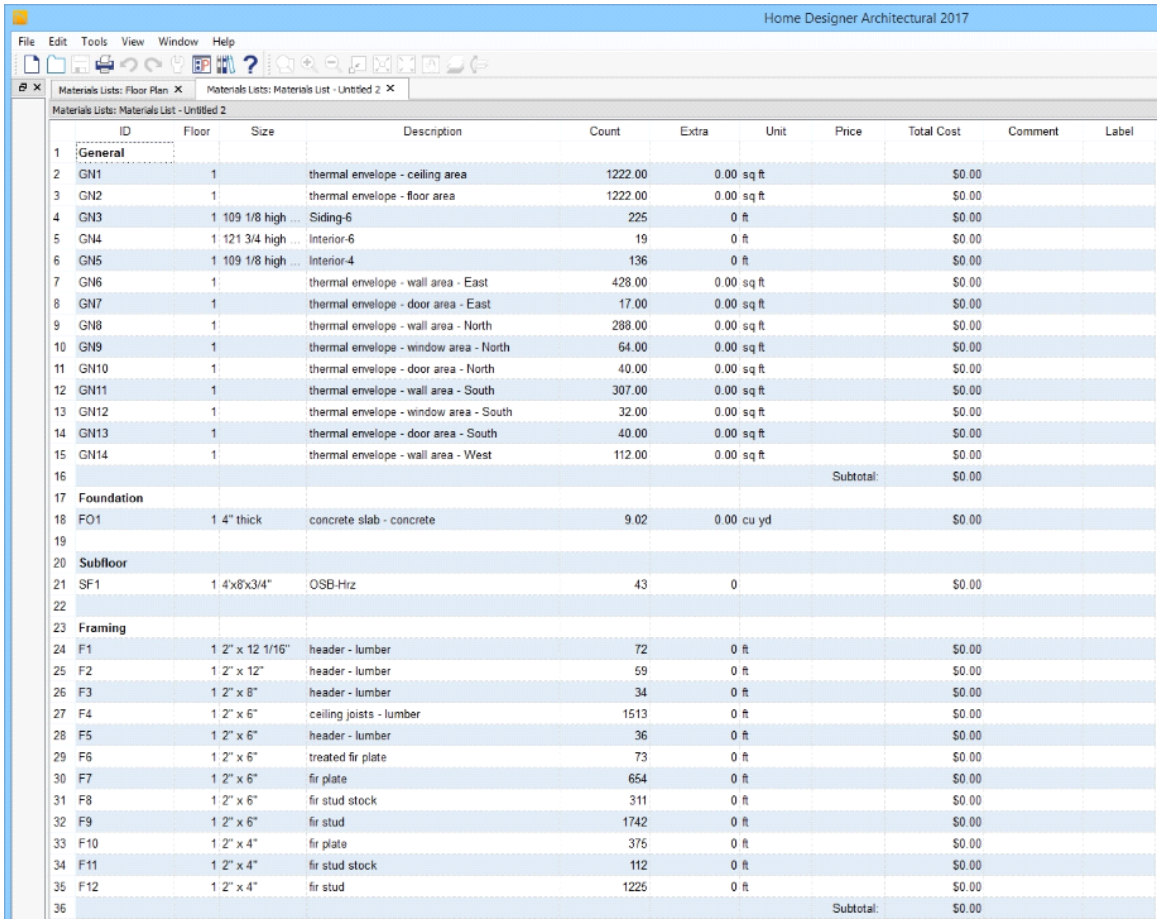


Figure 2-2-F1 Screenshot of Home Design Pro



Home Designer Architectural 2017

File Edit Tools View Window Help

Materials Lists: Floor Plan | Materials Lists: Materials List - Untitled 2

Materials Lists: Materials List - Untitled 2

	ID	Floor	Size	Description	Count	Extra	Unit	Price	Total Cost	Comment	Label
1	**General**										
2	GN1	1		thermal envelope - ceiling area	1222.00	0.00	sq ft		$0.00		
3	GN2	1		thermal envelope - floor area	1222.00	0.00	sq ft		$0.00		
4	GN3	1	109 1/8 high ...	Siding-6	225	0	ft		$0.00		
5	GN4	1	121 3/4 high ...	Interior-6	19	0	ft		$0.00		
6	GN5	1	109 1/8 high ...	Interior-4	136	0	ft		$0.00		
7	GN6	1		thermal envelope - wall area - East	428.00	0.00	sq ft		$0.00		
8	GN7	1		thermal envelope - door area - East	17.00	0.00	sq ft		$0.00		
9	GN8	1		thermal envelope - wall area - North	288.00	0.00	sq ft		$0.00		
10	GN9	1		thermal envelope - window area - North	64.00	0.00	sq ft		$0.00		
11	GN10	1		thermal envelope - door area - North	40.00	0.00	sq ft		$0.00		
12	GN11	1		thermal envelope - wall area - South	307.00	0.00	sq ft		$0.00		
13	GN12	1		thermal envelope - window area - South	32.00	0.00	sq ft		$0.00		
14	GN13	1		thermal envelope - door area - South	40.00	0.00	sq ft		$0.00		
15	GN14	1		thermal envelope - wall area - West	112.00	0.00	sq ft		$0.00		
16								Subtotal:	$0.00		
17	**Foundation**										
18	FO1	1	4" thick	concrete slab - concrete	9.02	0.00	cu yd		$0.00		
19											
20	**Subfloor**										
21	SF1	1	4'x8'x3/4"	OSB-Hrz	43	0			$0.00		
22											
23	**Framing**										
24	F1	1	2" x 12 1/16"	header - lumber	72	0	ft		$0.00		
25	F2	1	2" x 12"	header - lumber	59	0	ft		$0.00		
26	F3	1	2" x 8"	header - lumber	34	0	ft		$0.00		
27	F4	1	2" x 6"	ceiling joists - lumber	1513	0	ft		$0.00		
28	F5	1	2" x 6"	header - lumber	36	0	ft		$0.00		
29	F6	1	2" x 6"	treated fir plate	73	0	ft		$0.00		
30	F7	1	2" x 6"	fir plate	654	0	ft		$0.00		
31	F8	1	2" x 6"	fir stud stock	311	0	ft		$0.00		
32	F9	1	2" x 6"	fir stud	1742	0	ft		$0.00		
33	F10	1	2" x 4"	fir plate	375	0	ft		$0.00		
34	F11	1	2" x 4"	fir stud stock	112	0	ft		$0.00		
35	F12	1	2" x 4"	fir stud	1225	0	ft		$0.00		
36								Subtotal:	$0.00		

Figure 2-2-F2 Material List of Home Design Pro

Home Design Pro is good enough in overall aspects, however, in term of cost estimating, there is a limitation in which the cost is estimated based on the material list generated at the end of the project. Thus, cost is yet not taken into consideration during the designing phase itself.

2-3 Designer Logic

Designer Logic is a project management software that caters specifically for interior design industry. It is a complex software that links the business of design players, including interior designers, suppliers and contractors and design clients, to access differently to different portal. It provides the interior designers a full project management, the suppliers and contractors to list their products or services and lastly the design clients to view their projects to either approve or decline them.

The strength of this software is that the total costs of the project can be estimated more accurately as the cost price of products or services are listed by the suppliers or contractors themselves and then again allowing markup by interior designers. However, the only weaknesses of this software is that it does not allow interior designers to work in a 3D environment for designing (Designer Logic 2017).

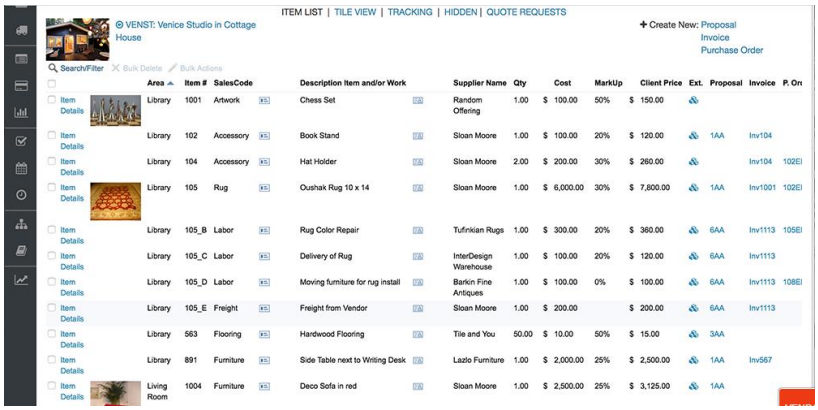


Figure 2-3-F1 Screenshot of Designer Logic

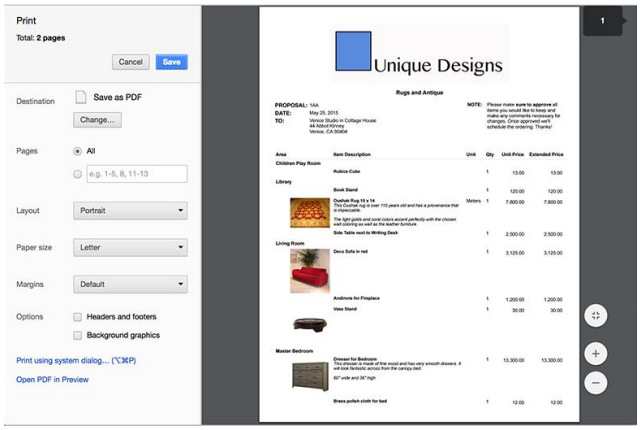


Figure 2-3-F2 Designer Logic Invoice Template

2-4 Comparison between Existing Applications and Proposed Application

In this section, Table 2-4-T1 is formulated after analyzing the benchmarked applications.

Features	**IKEA Planning Tools**	**Home Designer Pro**	**Designer Logic**	**Proposed Application**
Ease of Use	High	Moderate	Moderate	High
Objects Library	Limited to IKEA	Contributed by users	Contributed by suppliers	Contributed by users
Real-Time Cost Management	Yes	No	Yes	Yes
Budget Management	No	No	No	Yes
Material List Generation	Yes	Yes	Yes	Yes
Designer Charges Calculator	No	No	Yes	Yes

Table 2-4-T1 Comparison of System Features

3-1 Methodologies and General Work Procedures

The methodology being proposed in this project is Prototyping Development, categorized under Rapid Application Development (RAD). In brief, prototyping methodology starts off with planning, while analysis, design and implementation phases are performed concurrently and repeatedly in a cycle to produce a system prototype until the system is completed. The overall process is illustrated as in Figure 3-1-F1 (Ku 2015).

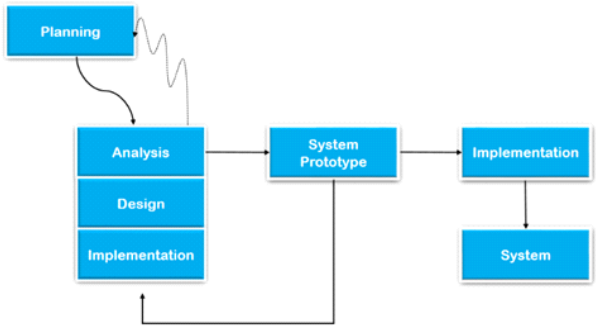


Figure 3-1-F1 Prototype Methodology

The main reasons for selecting Prototyping methodology is due to the project short time schedule as well as to quickly refine user requirements. This is because the methodology is excellent in unclear user requirements and short time schedule. However, in comparison to Waterfall methodology and Phased methodology, it is poor in unfamiliar technology and complex system. Even with that, the methodology is chosen because the project does not involve a complex system. The criteria for selecting a methodology is justified as in Table 3-1-1-T1.

Criteria	**Waterfall**	**Phased**	**Prototyping**
Unclear User Requirements	Poor	Good	Excellent
Unfamiliar Technology	Poor	Good	Poor
Complex Systems	Good	Good	Poor
Short Time Schedule	Poor	Excellent	Excellent

Table 3-1-T1 Comparison between Methodologies

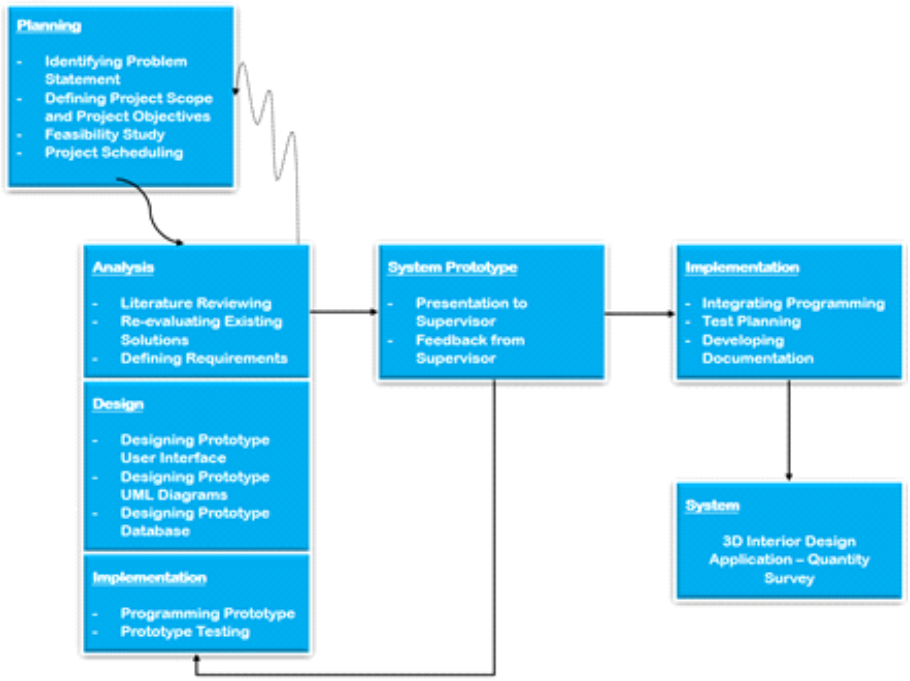


Figure 3-1-F2 Derived Prototyping Methodology

With this, the work procedures of this project is derived from the proposed methodology as in Figure 3-1-1-F2 and each phases is to be discussed. In planning phase, an introduction concerning the project is provided including a brief background information, problem statement, project scope and objectives and contribution of the project. Whereas, the feasibility study is necessary to assess the practicality of the proposed plan, which involve technical feasibility, economic feasibility and organization feasibility. Lastly, a Gantt chart is developed to illustrate the timeline of the project.

To the next phase, system prototype is re-analyse, re-design and re-implemented concurrently in a cycle until refinement occurs. In the analysis phase, literature reviewing is conducted by benchmarking the proposed solution with the existing solutions and analysing the strength and weaknesses of the solutions. Besides, requirements are defined by determining the types of functional and non-functional requirements applicable to the project. The analysis phase is the followed by the design phase, where the user interface, UML diagrams and database of the prototype are designed. Subsequently, the program is coded and run for testing in the implementation phase. The initial prototype is then presented to supervisor of this project, where feedback is gathered. The analysis, design and implementation phases are repeated.

When the system prototype is eventually completed, all programs are integrated into a single program and a test plan is developed and conducted such as integration tests, system tests and acceptance tests. At the end of the phases, system documentation and user documentation are compiled and finalized. With this, the proposed system, namely ‘A Simple Interactive 3D Interior Design Application for Living Room - Cost Management” is achieved.

4-1 System Flowchart Diagram

The system flowchart as in Figure 4-1-F1 illustrates the functionalities include in the proposed system and its description in Table 4-1-T1.

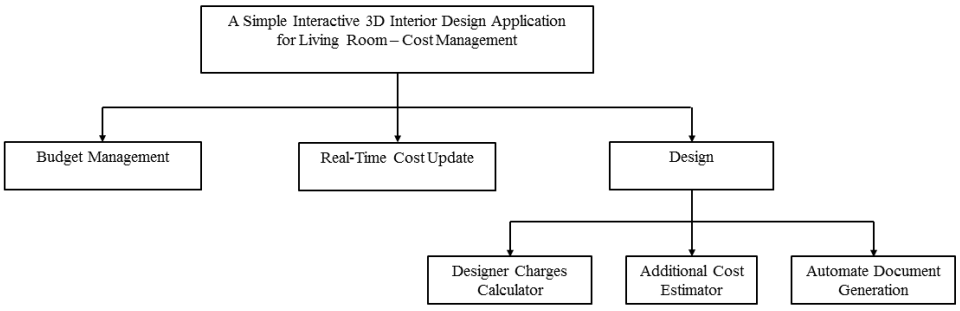


Figure 4-1-F1 System Flowchart Diagram

Functionality	**Explanation**
Budget Management	User may set a budget at the very beginning of designing. Alert will be prompted to user when the total cost exceeded its budget amount. Also, a graphical presentation of pic chart shows the total cost over its budget.
Real-Time Cost Update	As user add or remove an item from the workspace, the total cost will be updated real-time with the cost price information stored in a database.
Designer Charges Calculator	It allows user to select a preferred design charges structure and then calculate the total charges for interior design services, adding to the accuracy of interior design cost estimation.
Additional Cost Estimator	Additional costs such as shipping, assembly or installation and electrical wiring, can be added to each individual item.
Automate Document Generation	At the end of the project, user may generate documents including material list and invoice, either to print or save them.

Table 4-1-T1 Explanations of System Functionality

4-2 Entity-Relationship Diagram

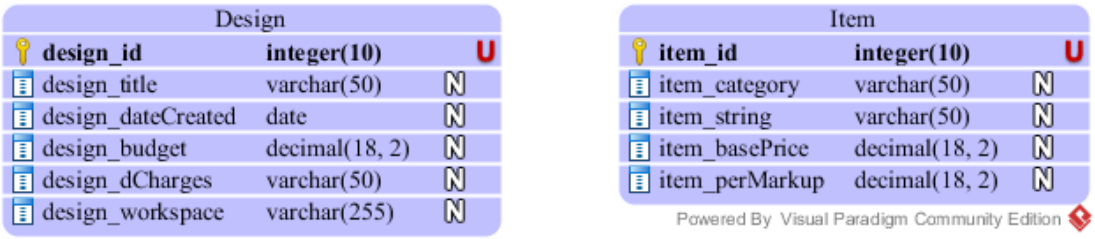


Figure 4-2-F1 Entity-Relationship Diagram

4-3 Use-Case Diagram and Descriptions

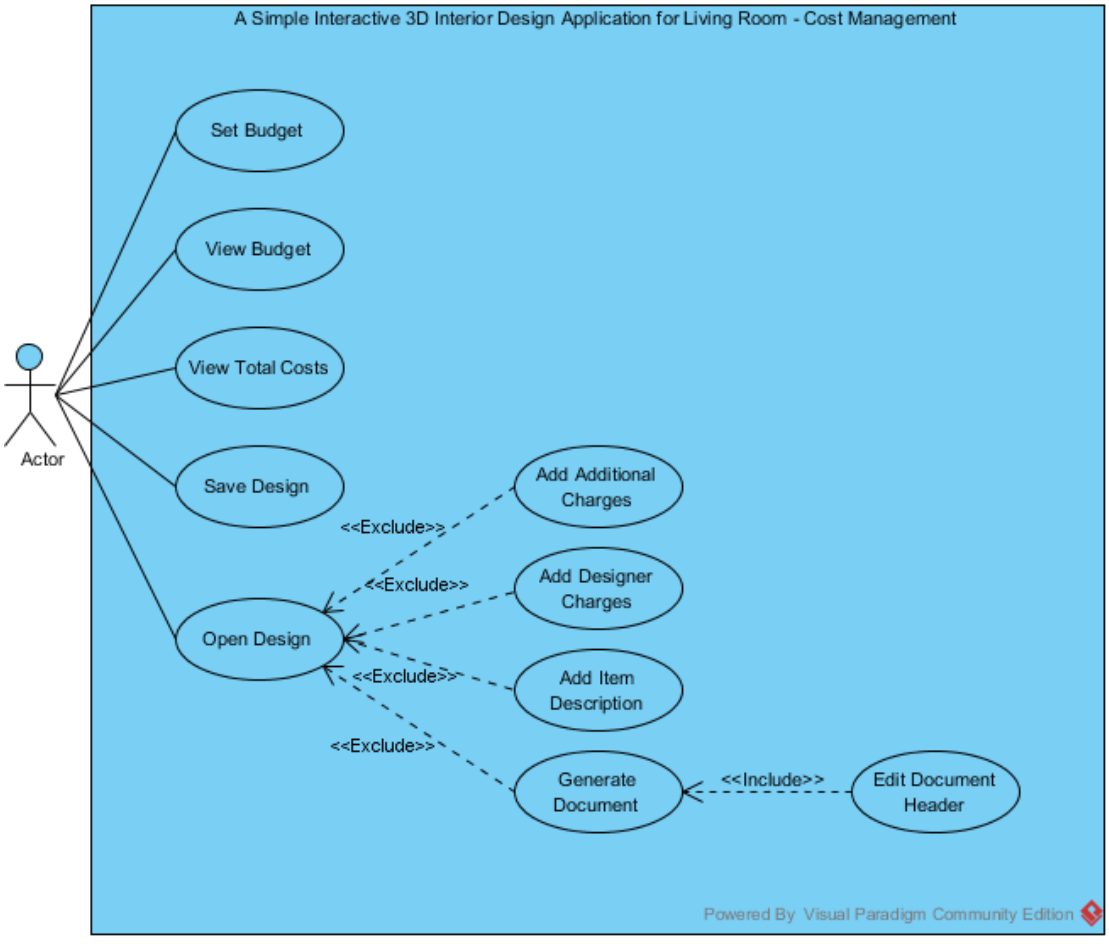


Figure 4-3-F1 Use-Case Diagram

Name	:	Set Budget
Actor	:	User
Description	:	This use case describes on how user can set a budget.
Successful Completion	:	1. User enter an amount for the budget. 2. User click on "Confirm" button to set the budget.
Alternative	:	The default amount for budget is RM 500.
Pre-Condition	:	None
Post-Condition	:	None
Exception Conditions	:	Input string is entered.

Name	:	View Budget
Actor	:	User
Description	:	This use case describes on how user can view the amount of budget set and the graphical presentation of total costs over budget amount.
Successful Completion	:	1. User click on "Go To Budget" button.
Alternative	:	The total costs text will be displayed in red if it exceeded the budget amount.
Pre-Condition	:	None
Post-Condition	:	None
Exception Conditions	:	None

Name	:	View Total Costs
Actor	:	User
Description	:	This use case describes on how user can view the changes in total costs as adding/ removing an item.
Successful Completion	:	1. User add/ remove an item to/from workspace.
Alternative	:	None
Pre-Condition	:	None
Post-Condition	:	None
Exception Conditions	:	None

Name	:	Save Design
Actor	:	User
Description	:	This use case describes on how user can save the details for the design.
Successful Completion	:	1. User enter a title for the design. 2. User click on “Save” button.
Alternative	:	None
Pre-Condition	:	None
Post-Condition	:	None
Exception Conditions	:	Design title already existed.

Name	:	Open Design
Actor	:	User
Description	:	This use case describes on how user can open a specific design.
Successful Completion	:	1. User enter the title of the design to be opened. 2. User click on “Load” button.
Alternative	:	Select design from the preloaded most recent design.
Pre-Condition	:	The design to be opened must be saved.
Post-Condition	:	None
Exception Conditions	:	No design selected.

Name	:	Add Item Description
Actor	:	User
Description	:	This use case describes on how user can add descriptions to each individual item.
Successful Completion	:	1. User checked on either “Custom” or “Default”. 2. User enter the descriptions accordingly.
Alternative	:	No descriptions are entered.
Pre-Condition	:	None
Post-Condition	:	None
Exception Conditions	:	Invalid values entered.

Name	:	Generate Document
Actor	:	User
Description	:	This use case describes on how user can generate documents of the specific design.
Successful Completion	:	1. User checked on either “Invoice” or “Material List”. 2. User click on “Generate Document” button.
Alternative	:	None
Pre-Condition	:	User must select a document header.
Post-Condition	:	None
Exception Conditions	:	No document header selected.

Name	:	Edit Document Header
Actor	:	User
Description	:	This use case describes on how user can select or edit the document header.
Successful Completion	:	1. User click on “Edit Document Header” button. 2. User either select on existing or add a new document header. 3. User click on “Confirm” button.
Alternative	:	None
Pre-Condition	:	None
Post-Condition	:	None
Exception Conditions	:	Invalid values entered.

Name	:	Add Additional Charges
Actor	:	User
Description	:	This use case describes on how user can add additional charges on every individual item.
Successful Completion	:	1. User checked on the additional charges type. 2. User enter the amount of charges for the particular type. 3. User click on "Add" button.
Alternative	:	None
Pre-Condition	:	None
Post-Condition	:	None
Exception Conditions	:	Input string is entered to the amount of charges.

Name	:	Add Designer Charges
Actor	:	User
Description	:	This use case describes on how user add designer charges to accurately estimate the total costs.
Successful Completion	:	1. User checked on one of the designer charges structure. 2. User enter the values for calculation. 3. User click on "Confirm" button.
Alternative	:	None
Pre-Condition	:	Total costs value is not null.
Post-Condition	:	None
Exception Conditions	:	Input string is entered to the values for calculation.

5-1 Software Used

5-1-1 Microsoft Visual Studio 2013 Pro: Window Presentation Foundation (WPF)

WPF is chosen over WinForm due to its data binding capabilities as well as highly customizable UI component. In WPF, adding a binding between the source and the destination UI element is much simpler. Also, UI component is based on XAML, allowing a complete customization on its look and behaviour which is separated from its logic. Somehow, c# language is being used to program the code for its logic. Most important, WPF supports graphics, making it possible to work with 3D objects and shapes.

5-1-2 E-IceBlue: Spire.Doc for WPF

Spire.Doc for WPF is an MS Word component on WPF platform. It is being used to generate document, set up print document as well as save document either in docx or pdf format. Also, it is totally independent component as it does not required Microsoft Office Word to be installed to access the word document processing tasks.

5-1-3 SQL Server Express LocalDB

SQL Server Express LocalDB engine is used to access the database file (.mdf) after created a service-based database in Visual Studio 2013. It is being used because it can program similarly to SQL Server database but in a lightweight version. Also, by using the designers in Visual Studio 2013, tables and other database objects can be created in ease. In additional, it runs in user mode, hence fewer prerequisites and no configuration during installation. Whereas, LINQ is being used to deal with the data in the database.

5-2 Hardware Used

The hardware details being used to develop the application are shown in Table 5-2-T1.

Hardware	**Description**
Windows	Windows 8.1
Processor	Intel(R) Pentium(R) CPU 997 @ 1.60ghZ
RAM	2.00 GB
System Type	64-bit Operating System, x64-based processor

Table 5-2-T1 Hardware Details

5-3 Algorithms

5-3-1 Cost Estimation

Cost for individual item is estimated by its base price and percentage of mark up as illustrated by the equation below:

Total Cost = (% of Mark-Up x Base Price) + Base Price

To accurately estimate the cost price of the item, additional charges such as shipping charges, assembly or installation charges, and electrical wiring charges can be added to individual item.

5-3-2 Designer Charges Calculation

The structure of designer charges can be categorized into; Hourly Rate, Fixed Rate, Cost Plus and lastly Per Square Foot. The calculation for each of the category is illustrated in Table 5-3-2-T1.

Category	**Equation**
Hourly Rate	Total Charges = Rate Per Hour x Total Hours
Fixed Rate	Total Charges = Fixed Rate
Cost Plus	Total Charges = % of Cost Plus x Total Costs
Per Square Foot	Total Charges = Width x Length x Cost Per Square Foot

Table 5-3-2-T1 Designer Charges Structure

5-3-3 Spire.Doc

Figure 5-3-3-F1 shows the code snippet to create a Spire.Doc document, saving it as .XPS file and opening it at Document Viewer control. While, Figure 5-3-3-F1 shows the code snippet to replace text of the template in Word Document file (E-IceBlue 2017).

```
Spire.Doc.Document doc = new Spire.Doc.Document();
doc.LoadFromFile(TEMPLATE_PATH + "Template_ML.docx");

Dictionary<string, string> dictReplace = GetReplaceDictionary();
foreach (KeyValuePair<string, string> kvp in dictReplace)
{
    doc.Replace(kvp.Key, kvp.Value, true, true);
}

LoadMaterialList(doc);
doc.SaveToFile(TEMPLATE_PATH + "temporaryXPS.xps", FileFormat.XPS);
doc.Close();

XpsDocument xpsDoc = new XpsDocument(TEMPLATE_PATH + "temporaryXPS.xps", FileAccess.Read);
docViewer.Document = xpsDoc.GetFixedDocumentSequence();
```

Figure 5-3-3-F1 Code Snippet of Spire.Doc Document

```
Dictionary<string, string> GetReplaceDictionary()
{
    Dictionary<string, string> replaceDict = new Dictionary<string, string>();

    replaceDict.Add("#companyName#", thisCompany.getCompanyName());
    replaceDict.Add("#add_street#", thisCompany.getCompanyStreet());
    replaceDict.Add("#add_zipCode#", thisCompany.getCompanyZipCode());
    replaceDict.Add("#add_city#", thisCompany.getCompanyCity());
    replaceDict.Add("#add_state#", thisCompany.getCompanyState());
    replaceDict.Add("#add_country#", thisCompany.getCompanyCountry());
    replaceDict.Add("#tel_no#", thisCompany.getCompanyPhone());
    replaceDict.Add("#fax_no#", thisCompany.getCompanyFax());
    replaceDict.Add("#email#", thisCompany.getCompanyEmail());

    return replaceDict;
}
```

Figure 5-3-3-F2 Code Snippet of Replacing Text to Template

5-4 Graphical User Interface (GUI)

5-4-1 User Interface of Main Window

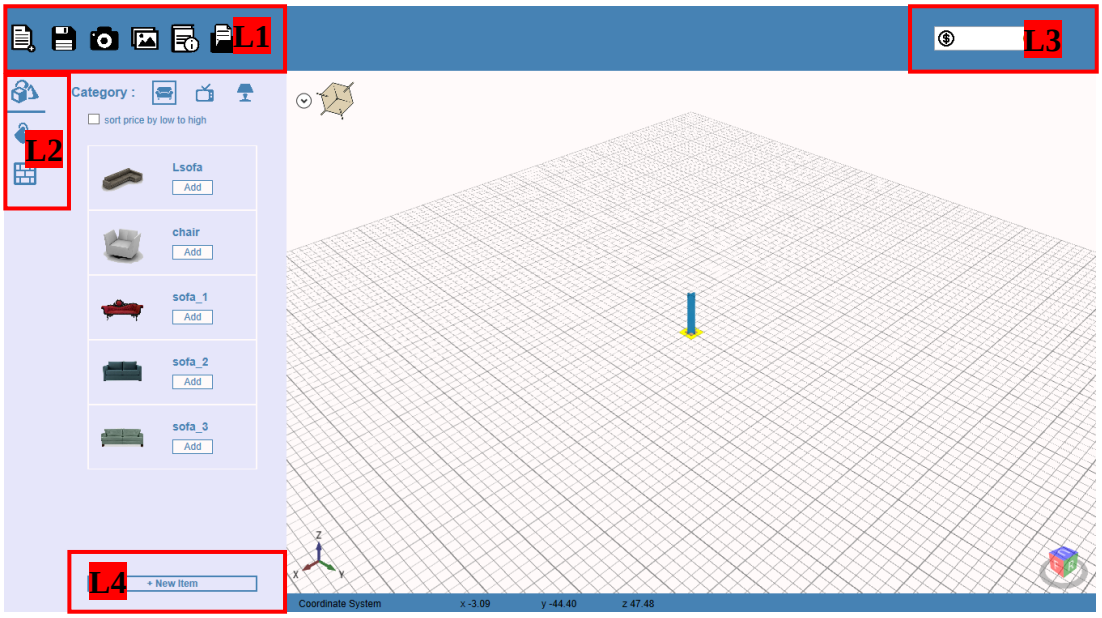


Figure 5-4-1-F1 Main Window

Label	Description
L1	Menu Bar. Containing functions including restore default, save project, screenshot, show gallery, show tutorial and open design folder.
L2	Tool Bar. Containing tools including load all items, changing the texture as well as adjusting the wall and floor.
L3	Displaying the total costs. If the total costs exceeded the budget amount, the total costs will be displayed in red colour to create alert to user. Also, navigating towards budget management window.
L4	Navigating towards add new item window.

Table 5-4-1-T1 Descriptions of User Interface of Main Window

5-4-2 User Interface of New Item/ Item Window

If new item button is clicked, new item window as in Figure 5-4-2-F1 will be prompted to user, allowing user to add a new item. Else if, user clicked on an existing item, item window as in Figure 5-4-2-F2 will be prompted to user with the particular item details, allowing user to either edit or delete the specific item.

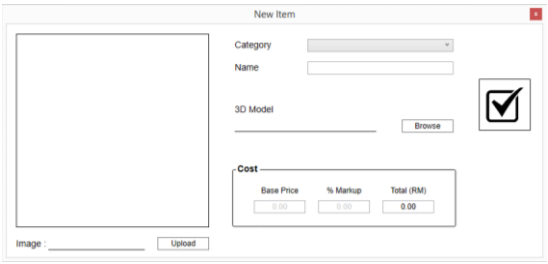


Figure 5-4-2-F1 New Item Window

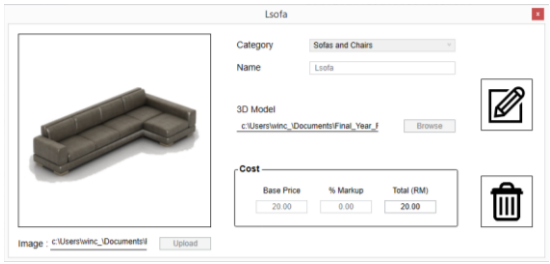


Figure 5-4-2-F2 Item Window

5-4-3 User Interface of Design Window

Design window as in Figure 5-4-3-F1 displays the details of the particular design being opened by the user. As well as, allowing user to further add details to the design and generate documents such as invoice and material list for the design.

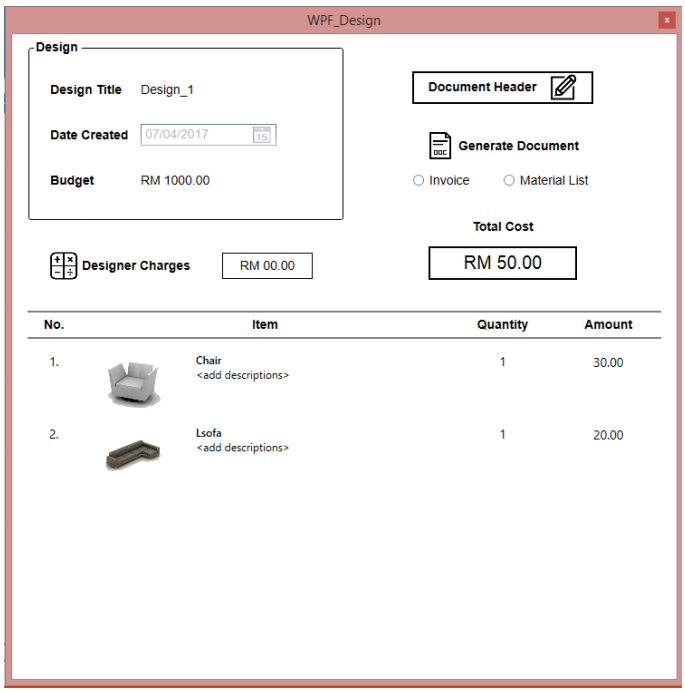


Figure 5-4-3-F1 Design Window

5-4-4 User Interface of Designer Charges Calculator Window

Designer charges calculator window as in Figure 5-4-4-F1 allows user to calculate the total amount of designer charges by selecting on one of the fee structure.

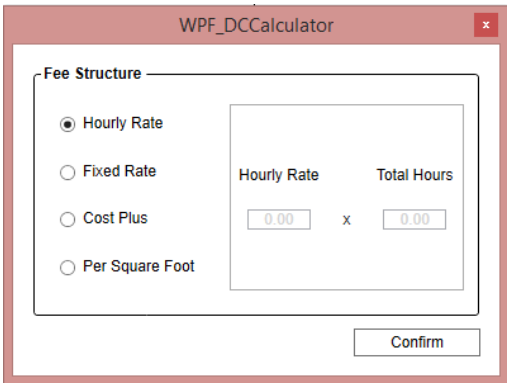


Figure 5-4-4-F1 Designer Charges Calculator Window

5-4-5 User Interface of Document Viewer Window

Document viewer window as in Figure 5-4-5-F1 generate either invoice or material list document based on user selection. Also, user may save the document as docx or pdf file as well as send the document through email.

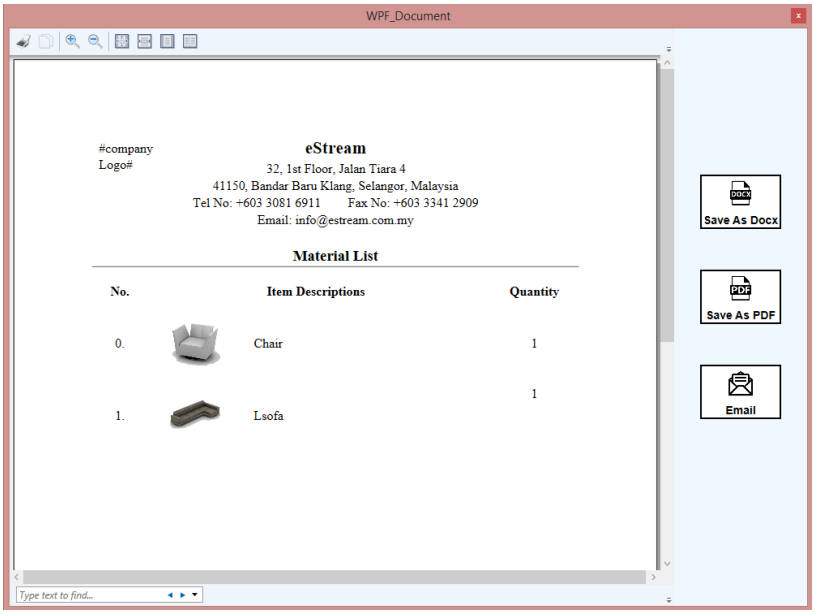


Figure 5-4-5-F1 Document Viewer Window

5-4-6 User Interface of Budget Window

Both Figure 5-4-6-F1 and Figure 5-4-6-F2 shows the budget window, where user set their budget. The unused budget will be displayed in green, used budget in blue and over budget in red.

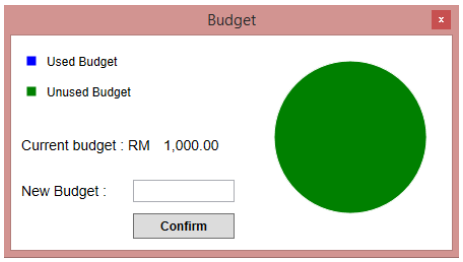


Figure 5-4-6-F1 Budget Window

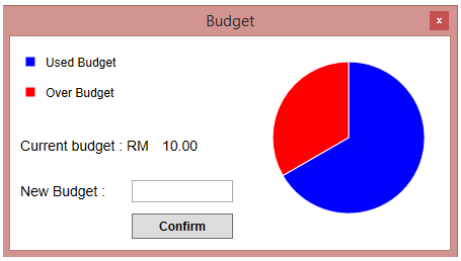


Figure 5-4-6-F2 Budget Window

5-5 Testing

5-5-1 Usability Testing

A survey has been conducted in the form of questionnaire with the sample size of 10 people who age ranged from 20 to 25 to determine whether the proposed application meets the usability criteria. Referring to Appendix D, it should attached with the template of the questionnaire.

For the first question on whether the respondent is able to complete the given tasks, all the 10 of them are able to complete the given tasks. Whereas for the second question, many of them responded that they would like to move the object model freely in the workspace. Also, when more items are added into the workspace, it becomes less responsive. While, some stated that they could not identify the button that navigating towards budget management. In the third question, respondents were asked to suggest any functions that is relevant to cost management. Unfortunately, most of them ignored the question because they are unclear to cost management. Somehow, two of them suggested to include GST.

The result of the following part of the questionnaire are tabulated in Table 5-5-1-T1. Based on the result, the respondents think that the proposed prototype is not simple and easy to use. All components are clearly labelled yet the image buttons sometimes may cause confusion. The navigation buttons are consistent and easily identified in which located next to one another at the most top. Also, the respondents tend to stay neutral on the statement that error message is well handled and inform user clearly on how to fix the problems because they do not hit any error message. Lastly, majority agreed that the functions of the application are useful and relevant as well as satisfied with the overall user interface design.

(1 – Strongly Disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 – Strongly Agree)

	1	2	3	4	5
1. The application is simple and easy to use.	-	**4**	**6**	-	-
2. All components are clearly labelled.	-	**3**	**3**	**3**	**1**
3. Navigation buttons are consistent and easy to be identified.	-	**1**	**3**	**6**	-
4. Error message is well handled and inform me clearly how to fix the problems.	-	**4**	**5**	**1**	-
5. The functions of the application are useful and relevant.	-	-	**4**	**6**	-
6. I am satisfied with the overall user interface design of the application.	-	-	**1**	**9**	-

Table 5-5-1-T1 Usability Testing Result

5-5-2 Black-box Testing

Functional Testing			
Case	**Test Action**	**Test Result**	**Status**
1.	Set a new budget amount.	New budget amount is set. Pie chart of total cost over budget amount is reloaded.	Pass
2.	Item is added or removed from the workspace.	Total costs is updated and checked if it exceeded the budget amount. If yes, total costs is displayed in red color.	Pass
3.	Designer Charges Calculator – Hourly Rate	Total designer charges: RM 50.00	Pass

	checked. Total hours: 10 hours Hourly rate: RM 5/hour		
4.	Designer Charges Calculator – Fixed Rate checked. Fixed rate: RM 300	Total designer charges: RM 300.00	Pass
5.	Designer Charges Calculator – Cost Plus checked. Cost plus: 10 % Total costs: RM 1000	Total designer charges: RM 100.00	Pass
6.	Designer Charges Calculator – Per Square Foot Width: 10 Height: 10 Cost per square: RM 10	Total designer charges: RM 100.00	Pass
7.	Calculate total additional cost for the individual item when more than one additional cost is checked.	Correct addition.	Pass
8.	None document header is selected for the current design.	Message “Please select a document header” is prompted to user.	Pass
9.	Neither invoice nor material is checked before “Generate Document” button is clicked.	Message “Either invoice or material list must be checked.” is prompted to user.	Pass

Table 5-5-2-T1 Black-box Testing Functional Testing

Window Control Testing			
Case	**Test Action**	**Test Result**	**Status**
1.	Mouse over button.	- Background color changes. - Tooltip appears. - Cursor changes to hand cursor	Pass
2.	Textbox hint.	- Hint disappears when text box is focused or new value entered. - Hint reappears when null or empty value entered.	Pass
3.	Read only textbox.	Arrow cursor appears when mouse over it.	Pass
4.	Numeric textbox.	Error message is prompted when input string is entered.	Pass
5.	Open file dialog.	Initial directory and filter are set appropriately.	Pass

Table 5-5-2-T2 Black-box Testing Window Control Testing

6-1 Conclusion

To conclude, the proposed application is aimed to shorten the overall interior design procedure, hence reducing the risks of unnecessary increase in costs and time. This can be achieved by implementing cost management in the designing phase itself. Therefore, in this project, the features which include real-time costs update, budget management, detailed cost estimation and generating material list for quotation are being proposed as solutions towards this matter. These features are derived based on the existing solutions by existing similar software, particularly real-time cost update by IKEA Planning Tools, material list generation by Home Designer Pro as well as managing design business by Logic Design.

6-2 Discussion

The main difficult issue and challenge in the implementation is lack of knowledge in this application area. This is because it covers over wide areas involving 3D environments, interior design as well as cost management. Therefore, much of the time and efforts is required to study them in details in order to develop a solution towards combinations of these areas.

There are many existing 3D Interior Design software available, however only a few of them include cost management module. Most common solution of these software towards costs is through generating a material list at the end of the project as like IKEA Planning Tools and Home Designer Pro. To further improve on the existing solution, the proposed application should support a real-time cost update in the designing phase itself. Somehow, the difficult issue and challenge of this proposed solution is that it requires real-time data of price information. This is because real-time data of price information is the major factor controlling the accuracy of cost estimation. Unlike, Designer Logic, it has a different portal which allows suppliers and contractors to list their own products or services. Thus, to overcome this, the database of price information is required to be updated constantly and manually.

6-3 Future Work

Recommended features or functionality that can be enhance in future work:

- Supporting multiusers

  Currently, only interior designer is being supported. Like Designer Logic, suppliers or contractors and clients are directly included through separate portals so that products or services can be maintain by suppliers or contractors themselves whereas client can approve or decline the project after reviewing through the application.

- Project comparison

  Graphical presentation of the comparison between two different projects allow client to make decision more wisely. At the same time, more presentable for the interior designer to their client.

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