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ANDROID-BASED ESTIMATING APP FOR BUILDERS ON CONSTRUCTION SITES

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ABSTRACT

The discrepancies between the estimated quantities of building materials and the final quantities used during the construction process requires the need to use more accurate techniques in estimating building materials. The study aimed at developing an android-based estimating app for builders on construction sites with the view of increasing accuracy of estimated building materials. The study was carried out in two stages, whereby one part required a survey to ascertain existing practices while the other helped to develop the android application. A survey research design was utilized on Builders in Lagos state in the south-west of Nigeria. Mean scores and correlation matrix was used for the descriptive and inferential statistics. For the design of the android estimation application for Builders, an android studio and Java programming language was used in developing the app. The developed android app was run via the android emulator. The descriptive data revealed that most of the techniques presently used by builders in estimating building materials were traditional methods which were drawn from either manual-based or use of experiential knowledge. Using these techniques were hinged on several factors as identified in the study. An android-based estimating app was developed for Builders with the aim of estimating for concrete works, sandcrete blocks, ceramic tiles and mortar during the construction process. The study recommended the use of information and communication technologies (ICTs) in obtaining accurate building quantities needed during the construction process.

Key words: Android, Builders, Building Materials, Construction Industry, Estimating.

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1. INTRODUCTION

In the Nigerian construction industry, the issues of cost overrun is most times prevalent. This is a case whereby, the final construction cost is relatively higher compared with the initial estimated construction sum at the beginning of the construction project [1]. Even with a properly prepared bill of quantities used during the contract stage, it is with disbelief that construction clients have to pay much higher than the estimated sum. This has been a challenge to the image of the Nigerian construction industry with different strategies being put

in place to tackle such discrepancies. However, these strategies have not been able to curtail these discrepancies. Many of the discrepancies have been attributed to the use of construction materials [2]. Either the materials were not properly estimated during the construction project to aid the accurate supply of the needed building materials, issues of theft and vandalism, high waste generated during the construction process and so on [3]. The effect of building materials on the final total cost can be felt with it contributing an average of over 60 percent to the cost of construction projects. The notion of construction materials waste been a major challenge contributing to cost overrun is supported in the study by [4]. The study noted that the consequence of high construction materials waste can be felt in the low contractor's profit, poor image of the construction industry, client having to pay more, cost overrun and environmental pollution. It is difficult to measure the amount of waste contributed from construction, although a high degree of waste is assumed to exist in the construction industry [3]. Building waste is not just important from the view of efficiency, but also concern with issues of climate change and high spate of landfills with unused construction materials, due to the difficulty in recycling them which is attributed to the heterogeneity nature of construction materials.

Most often, there is no sufficient space to dispose the waste. [5] reported that some of the origins attribute to construction waste can be mismanagement of supplied materials, complexity of building designs, damage caused by rain and other atmospheric conditions, poor storage infrastructure, materials damaged due to weather and when not stored appropriately, incompetence of professionals/skilled labour handling materials, inadequate delivery system, sabotage of stored materials, revision of work done, lack of recording of materials available and in accurate calculation of quantities of materials used. Therefore, it is important that to reduce material waste and ensure that plus or minus the initial estimated construction sum is reliable as a contract document, adequate and efficient estimating of materials needs to done during the construction process. Estimation in the business scene is to forecast, plan or guesstimate the required quantities based on experiential knowledge and/or available information from known or unknown specifications. Estimating according to [6], can involve manual calculations involving mathematical equations and variables based on the entities required. Estimation can sometimes involve some probabilities and human assessment of different possible scenarios. However, estimation of building materials can be made precise leaving out any form of errors. The estimating process during site work has most times been achieved in a traditional-based process. This is mainly paper-based or experience-based as the Nigerian construction industry continuously tries to adapt. Various other strategies for estimating building materials during the construction process by builders are leveraging on experience from completed projects to estimate the building materials that would be needed for supply, manual-based estimation which requires paper and technical calculations which may be prone to errors due to the step-by-step nature of estimating building materials and so on. But the use of information and communication technologies (ICTs) offers better, easier and accurate estimating process. Using ICT-based systems involves the use of web-based systems, specialized software and apps on smart devices. Softwares such as the Microsoft Excel have mostly been used on desktop systems while some connect to the internet to input construction data to estimate the materials needed. For the latter, most construction sites are locatedin harsh conditions that may reduce the bandwidth to connect to the internet necessitating the need for an offline solution in estimating. Due to the traditional nature of the Nigerian construction industry, the evolvement of some of these ICT solutions for estimating building materials has not received full implementation and delivery by most Builders. This can be attributed to the notion that ICT-based estimating techniques are complex to understand and it is not flexible. Rather, the Nigerian construction industry including the stakeholders need to be more flexible to try less-error prone solutions such as the use of ICT

applications. With the advent of different ICT startups involved in coding and developing apps for several industries, this study opined that an android estimating app that compares to the use a mobile calculator can ensure the use of ICT for estimating building materials on construction sites. Many Nigerian professional builders have adapted to the use of smart phones which would help to spur the use of the estimating app once installed on their phones [7]. The outline of the objectives of the study are to;

- Identify on-site estimating techniques used by builders for estimating selected building materials.
- Examine the factors influencing the estimation process of selected building materials.
- Develop an android-based estimating app for builders on construction sites.

2. RESEARCH METHOD

The study was carried out in two stages, whereby one part required a survey to ascertain existing practices while the other helped to develop the android-based app. In this study, an assessment method using questionnaire-instrument was adopted which helped to elicit information on the first two outlined objectives. Specifically, a cross-sectional research design was used to draw from the population of study and an experimental design for the android estimation application. The population comprised of registered and unregistered builders working on construction sites. The study area selected was Lagos state in the south-west of Nigeria. This state has many ongoing construction projects and professional builders working within the construction industry. Lagos state also generates large amount of waste including construction waste which makes it paramount to examine the estimation techniques used within the state. During estimating of building materials for the construction works to be carried out, Builders are most times responsible for this actions [8]. After, the Builders calculations instructions are given to release materials from the construction store house or for labourers to bring the calculated quantity to the work space. Their experience in this light would help to understand the concept of estimating during the construction process. The study's questionnaire-instrument was prepared and shared to registered and unregistered Builders on selected construction sites within the study area. A convenience sampling technique, which is a non-probabilistic sampling technique, was adopted for the study which helped select a total of thirty (30) Builders who participated in the survey. Mean scores and correlation matrix was used for the descriptive and inferential statistics. For the design of the android estimation application for Builders, an android studio and Java programming language was used in developing the app. The developed android app was run via the android emulator.

3. RESULTS AND DISCUSSION OF FINDINGS

This section presents and discusses the results from the questionnaire survey and the development of the android application. The first section analysed the background information of the builders that participated in the study. Figure 1 showed the grouped background information of the respondents in the study. Figure 1 comprised on the highest academic qualification of the Builders, grade of membership, work industry experience, size of their organization and the type of organization they worked with. In Figure 1, the highest academic qualification of the respondents showed that 8 (22.9%) had Diploma Degrees, 19 (54.3%) had a Bachelor's degree, 6 (17.1%) had attained a Master's degree and only 1 (2.9%) had a Doctorate degree. This showed that the respondents had some form of education and are well informed to contribute efficiently to the subject of the study. Furthermore, the grade of membership showed that 5 (14.3%) were at the Probation stage, 18 (51.4%) were Graduate

members and 11 (31.4%) were at the Corporate membership grade of the Nigerian Institute of Building (NIOB). The result revealed that most of the Builder needed to be more proficient in their duties by ensuring they proceeded in further registering their presence in their professional body which would show some form of continuous development. The work industry of the Builders in the construction sector showed that 23 (65.7%) of the Builders had a work industry experience of 1-10years, 9 (25.7%) had 11-20years work experience, 2 (5.7%) had 21-30years work experience and 1 (2.9%) had 31-40 years industry work experience. The size of their organizations in Figure 1 were broken down into small scale, medium scale and large scale which had 7 (20%), 16 (45.7%) and 12 (34.3%) respectively. The breakdown of the type of organizations showed that the Builders worked with consulting, contracting, client and government organizations.

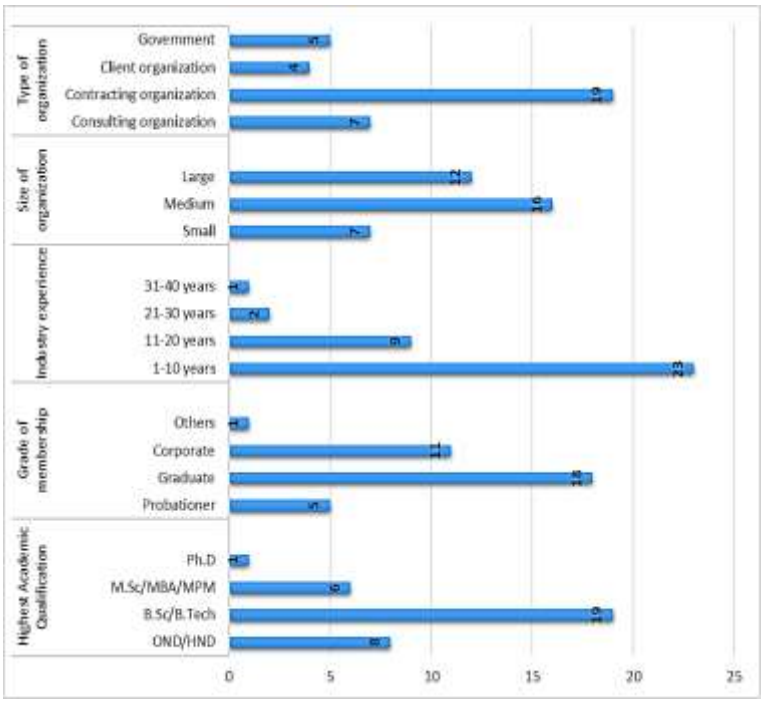


Figure 1. Background information of Construction Builders

3.1. On-site estimating techniques used by Builder

Professional Builders on construction sites are responsible for estimating the right quantities of building materials needed for the next activity during the construction process. Depending on several factors, the professional builder has different options of estimating to choose from. Table 1 showed the on-site estimating techniques used by Builder on construction sites. The level of use of the onsite estimating techniques were measured using a 5-point Likert scale of 5 = Always, 4 = Very often, 3 = Sometimes, 2 = Rarely and 1 = Never. In Table, the mean score of the onsite estimating techniques revealed that Builders used deriving quantities specification details in contract drawings (Mean Score = 4.23), manual calculations of required quantities (Mean Score = 4.17), drawing inferences from similar or previous works done (Mean Score = 3.91), reading from already prepared construction material schedule (Mean Score = 3.89), calculations done through Microsoft Excel (Mean Score = 3.66), buying building materials in bulk and storing (Mean Score = 3.54), use of Building Information Modelling (BIM) (Mean Score = 2.54), use of an offline estimating application (Mean Score = 2.43) and use of an internet-based application (Mean Score = 2.31). By understanding the present stand point of Builders in the use of these techniques, an ICT based solution can be integrated as an alternative to estimating better, quicker and accurately. The result revealed

Builders mostly depend on the traditional methods which are calculation based or guess work which is prone to several errors leading to the challenges faced in the construction industry. Builder need to be intentional and scientific in their activities by ensuring that the techniques used are reliable. The use of ICT-based techniques offers high level of accuracy which can reduce errors and high wastage that result from using the traditional methods. Even though Builders very often use Microsoft excel in their estimating purposes, it still pose some challenges to some construction sites. A computer Microsoft spreadsheet is the same as doing an estimate manually (by hand). It takes a little longer to set up at first, but after it is created, all of the estimates that you do subsequently can be done in a fraction of the time. It requires a desktop, whereas Builders have more smartphones than desktop/laptops installed on their construction sites. Other challenges associated to the low use of ICT for estimating are high complexity of available softwares, high cost and poor accessibility. Therefore, for estimating apps to be readily embraced in the Nigerian construction industry, ICT startups must think of solutions that are cheap, user friendly and easily accessible. These features are incorporated into the android-based app developed in this study.

Table 1. On-site estimating techniques used by Builder

Onsite estimating techniques	Mean Score	Std. Deviation	Remark
Deriving quantities specification details in contract drawings	4.23	.843	Very Often
Manual calculations of required quantities	4.17	.985	Very Often
Drawing inferences from similar or previous works done	3.91	1.173	Very Often
Reading from already prepared construction material schedule	3.89	1.022	Very Often
Calculations done through Microsoft Excel	3.66	1.083	Very Often
Buying building materials in bulk and storing	3.54	.919	Very Often
Use of Building Information Modelling (BIM)	2.54	1.067	Sometimes
Use of an offline estimating application	2.43	1.170	Rarely
Use of an internet-based application	2.31	.993	Rarely

3.2. Factors influencing the onsite estimation process

In order to foster the use of ICT-based tools in estimating building materials during the construction process, it is necessary to understand the rationale for which Builders choose either methods of estimating. These factors are related to the construction project, the organization, the experience of the Builder. The study posit that these factors may spur or reduce the use of either the manual or ICT-based estimating techniques. Using Correlation Matrix, the study identified relationships that exist between factors that may influence the choice of a particular method of estimating during the construction process. Table 2 showed the Correlation Matrix of factors influencing the use of an on-site estimating technique. From Table 2, it is observed that some level of relationship exist between some of the identified methods of estimating building materials and factors influence the choice of choosing them. It can be deduced that Builders choose different estimating tools for different reasons. None of the factors had a relationship with most of the ICT tools such as the use of Building Information Modelling (BIM), Internet-based apps and offline estimating apps. This means that this factors cannot explain what could ensure or foster their use. However, it could explain for most of the traditional methods of estimating building materials and for the use of Microsoft Excel.

Table 2. Correlation Matrix of factors influencing the use of an on-site estimating technique

Factors		BIM	Microsoft Excel	Manual Calculations	Building drawing specification details	Experiential Knowledge	Internet-based apps	Offline Estimating Apps	Building materials schedule	Bulk purchase
Complexity of project drawings	Pearson Correlation	-.280	.367*	.028	.364*	.432**	-.064	.039	-.194	.118
	Sig. (2-tailed)	.104	.030	.875	.031	.010	.716	.826	.263	.499
	N	35	35	35	35	35	35	35	35	35
Accuracy of project drawings	Pearson Correlation	-.088	.325	-.015	.342*	.264	.020	.054	-.003	.029
	Sig. (2-tailed)	.614	.057	.931	.044	.126	.911	.758	.985	.870
	N	35	35	35	35	35	35	35	35	35
Nature of selected building materials	Pearson Correlation	.010	.056	.076	-.202	.109	-.209	-.187	.069	.208
	Sig. (2-tailed)	.953	.749	.666	.244	.534	.227	.283	.695	.231
	N	35	35	35	35	35	35	35	35	35
Availability of ICT tools for estimation	Pearson Correlation	.156	-.101	.070	-.250	-.090	.237	.183	.408*	-.004
	Sig. (2-tailed)	.372	.564	.690	.148	.608	.171	.291	.015	.980
	N	35	35	35	35	35	35	35	35	35
Experience of estimator	Pearson Correlation	-.160	.249	.132	.374*	.472**	.009	.173	.295	.045
	Sig. (2-tailed)	.359	.149	.449	.027	.004	.958	.322	.085	.797
	N	35	35	35	35	35	35	35	35	35
Availability of fund	Pearson Correlation	-.259	.213	-.068	.241	.167	-.189	-.032	.075	.053
	Sig. (2-tailed)	.133	.219	.699	.163	.338	.278	.856	.667	.764
	N	35	35	35	35	35	35	35	35	35
Price of the building materials	Pearson Correlation	-.171	.186	.154	.090	.285	-.006	.027	.148	-.062
	Sig. (2-tailed)	.325	.284	.378	.608	.097	.971	.878	.396	.724
	N	35	35	35	35	35	35	35	35	35
quantity of the building material needed	Pearson Correlation	-.194	.240	-.117	.087	.125	-.163	-.195	-.137	-.096
	Sig. (2-tailed)	.265	.165	.504	.618	.475	.350	.261	.431	.584
	N	35	35	35	35	35	35	35	35	35
duration of the project	Pearson Correlation	-.070	.336*	-.118	-.111	.218	-.034	.055	.187	.061
	Sig. (2-tailed)	.688	.048	.499	.524	.209	.846	.756	.281	.726
	N	35	35	35	35	35	35	35	35	35
size of the project	Pearson Correlation	-.016	.414*	.051	.219	.363*	-.006	.158	.120	-.061
	Sig. (2-tailed)	.928	.014	.770	.206	.032	.974	.365	.491	.728
	N	35	35	35	35	35	35	35	35	35
size of organization	Pearson Correlation	-.106	.078	-.116	-.047	.295	.048	.209	.302	.113
	Sig. (2-tailed)	.545	.658	.507	.787	.085	.785	.229	.078	.518
	N	35	35	35	35	35	35	35	35	35
educational background of estimator	Pearson Correlation	.028	.118	.069	.013	.352*	-.008	.055	.239	-.168
	Sig. (2-tailed)	.872	.500	.695	.939	.038	.966	.756	.167	.336
	N	35	35	35	35	35	35	35	35	35
Availability of storage space	Pearson Correlation	-.007	.412*	.189	.304	.485**	.122	.223	.240	.018
	Sig. (2-tailed)	.968	.014	.276	.075	.003	.485	.197	.166	.918
	N	35	35	35	35	35	35	35	35	35

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

3.3. Android-based estimating app for builders

The study posits that most Builders on construction sites make use of Smart phones and the use of an app would be appropriate such as using a calculator. In developing the android-based estimating app, a hierarchy structure of the application was designed as shown in Figure 2. The structure in Figure 2 focused on four (4) major components in the construction process namely; concrete works, sandcrete blocks, ceramic tiles and mortar. This means that Builders can use the android app to estimate building materials that fall within the category of these activities. For concrete works, the Builder estimates the volume of concrete to use, thereby breaking the components down into cement, sand and granite. The most common variants of concrete mix used are 1:2:4 and 1:3:6. Once the thickness, length and width of the concrete element to be cast, the Builder is able to estimate the constituent materials to use due to the algorithm which has been inputted using Java programming. The same process follows for estimating the required quantities of sandcrete blocks needed during the construction process. In every $1m^2$ of blockwall there are 10 pieces of sandcrete blocks needed. Therefore, the estimating app is inputted with the height and breadth of the walls to be constructed and the total number of blocks required is calculated. The calculations are also done for estimating ceramic tiles which come in different sizes and mortar which come in different mixes. The java programming helped to configure the estimating app to deliver the accurate output of building materials needed. The android application was designed using android studio, emulator and java programming. An emulator (nexus 5) was used to run the application. Figure 3 showed the final layout of the android-based estimating app for builders on construction sites. The view groups of concrete, sandcrete blocks, mortar, concrete and reinforcement is shown which are thereafter broken into view classes in Figure 4 – 6. In Figure 4 – 6, the view classes in Figure 4 are inputted with the required dimensions as in working drawings and the android-based app helps to calculate the required quantities needed as shown in Figure 6. Figure 7 provided the sample source codes of each of the building materials –concrete, tiles, mortar and sandcrete blocks in the android-based estimator.

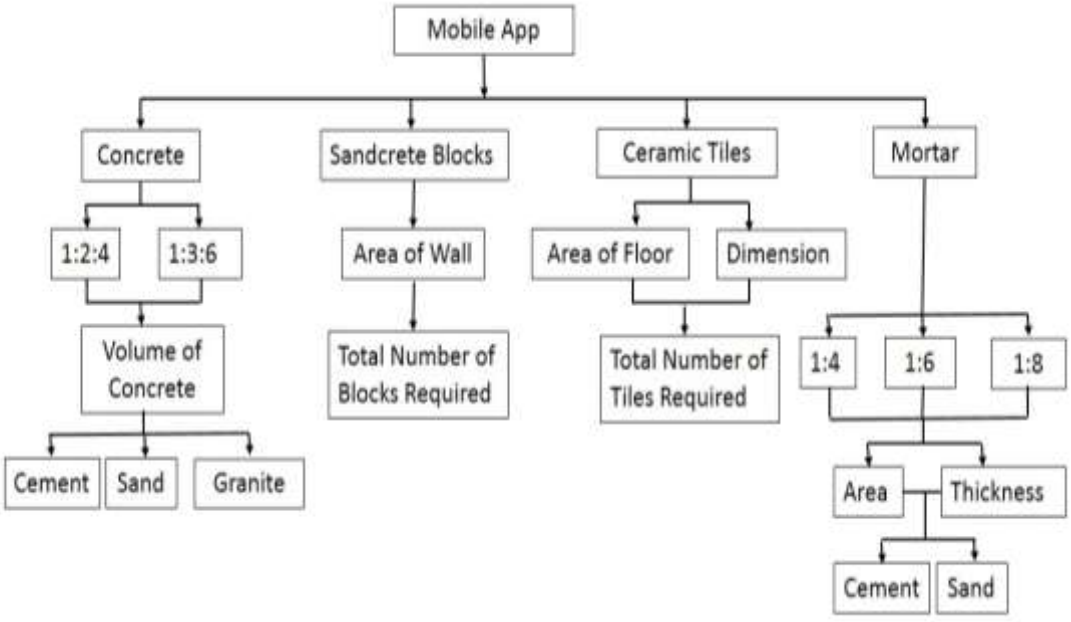


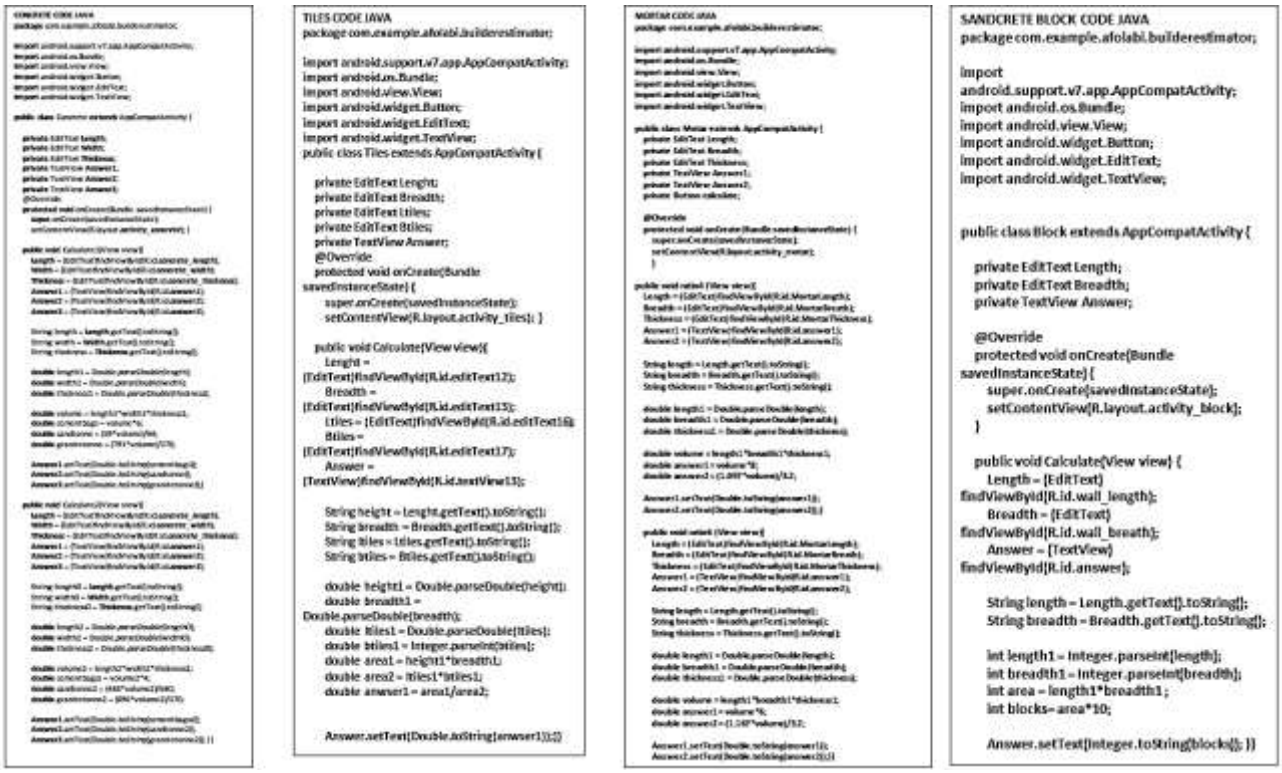
Figure 2. Hierarchy layout of the Android-based Estimating App

Figure 3. Screenshot of the layout of the Android-based Estimating App

Figure 4. Screen shot of View Classes of the Android-based Estimating App

Figure 5. Input of Dimensions in the Android-based Estimating App

Figure 6. Estimated Quantities View in the Android-based Estimating App



```
TILES CODE JAVA
package com.example.afolabi.builderestimator;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.TextView;
public class Tiles extends AppCompatActivity {

    private EditText Lenght;
    private EditText Breadth;
    private EditText ltiles;
    private EditText btiles;
    private TextView Answer;
    @Override
    protected void onCreate(Bundle
savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_tiles); }

    public void Calculate(View view){
        Lenght =
(EditText)findViewById(R.id.editText12);
        Breadth =
(EditText)findViewById(R.id.editText13);
        ltiles = (EditText)findViewById(R.id.editText16);
        Btiles =
(EditText)findViewById(R.id.editText17);
        Answer =
(TextView)findViewById(R.id.textView13);

        String height = Lenght.getText().toString();
        String breadth = Breadth.getText().toString();
        String ltiles = ltiles.getText().toString();
        String btiles = Btiles.getText().toString();

        double height1 = Double.parseDouble(height);
        double breadth1 =
Double.parseDouble(breadth);
        double ltiles1 = Double.parseDouble(ltiles);
        double btiles1 = Integer.parseInt(btiles);
        double area1 = height1*breadth1;
        double area2 = ltiles1*btiles1;
        double answer1 = area1/area2;


        Answer.setText(Double.toString(answer1));}}
```

```
SANDCRETE BLOCK CODE JAVA
package com.example.afolabi.builderestimator;

import
android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.view.View;
import android.widget.Button;
import android.widget.EditText;
import android.widget.TextView;


public class Block extends AppCompatActivity {

    private EditText Length;
    private EditText Breadth;
    private TextView Answer;

    @Override
    protected void onCreate(Bundle
savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_block);
    }

    public void Calculate(View view) {
        Length = (EditText)
findViewById(R.id.wall_length);
        Breadth = (EditText)
findViewById(R.id.wall_breath);
        Answer = (TextView)
findViewById(R.id.answer);

        String length = Length.getText().toString();
        String breadth = Breadth.getText().toString();

        int length1 = Integer.parseInt(length);
        int breadth1 = Integer.parseInt(breadth);
        int area = length1*breadth1;
        int blocks= area*10;

        Answer.setText(Integer.toString(blocks)); }}
```

Figure 7. Source Codes in Java for the Android-based Estimator

4. CONCLUSION AND RECOMMENDATIONS

The study aimed at developing an android-based estimating app for builders on construction sites with the view of increasing accuracy of estimated building materials. The study revealed the most utilized estimating techniques as deriving quantities specification details in contract drawings, manual calculations of required quantities and drawing inferences from similar or previous works done. These are mostly traditional or manual-based estimating methods. The critical factors that may influence the use of most of these estimating techniques identified in the study include the complexity of the project drawings, accuracy of project drawings, availability of ICT tools, experience of the estimator, duration of the project, size of the project, educational background of the estimator and availability of storage spaces for the building materials. In conclusion, the study was able to design and develop an android-based estimating app for Builders using an android studio. In future studies, the accuracy of using

ICT-based tools should be measured against the manual-based methods. It is recommended that in order to reduce the discrepancies in the cost accompanied with building materials, the use of ICT-based estimating tools should be adequately explored. In cases where there is inadequate training or low awareness, ICT tools should be simplified and user-friendly to encourage the use of ICT-based estimating tools.

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