Cost Estimation of Painting Works in Nigeria Using Algorithmic Equations

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Authors' contributions

This study was carried out with the collaboration of all authors. Author SCU was responsible for supervising every stage of the research, compiled the first draft of the manuscript and articulated the work into a publishable format in accordance with the journal template/guidelines. Author OO initiated the idea/topic and managed the research design. Author OEU carried out the literature searches and performed the data acquisition and analysis. Author RCE edited the manuscript before journal submission and financed the field work. All authors read and approved the final manuscript.

Method Article

ABSTRACT

Inaccurate cost estimation of painting works often leaves a client dissatisfied and mars the professional expertise of the quantity surveyor. This is because either excess quantity of paint is left behind after completion of the work or the paints purchased and budget allotted for the project is unable to finish the work. To this end, this study developed algorithmic equations for estimating the cost (material and labour) of painting works using the common types of paints in Anambra and Enugu state of south-east Nigeria and also validated them using current market rates. This was achieved via identifying the types and peculiar features of the common paints used in the study area, determination of the average quantity of paint needed per square meter (to assess the material constant for the paints identified) and assessing the labour constant for the paints identified. Dulux, Homepride, Intercolour, Sharon (Vineyard) and Fine coat were among the common paint brands identified through market survey, interviews with the paint manufacturers, suppliers, painters and construction professionals and physical observation. Dulux was adjudged

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the most durable. Though quite expensive, it allows for creativity and flexibility and has an aesthetically pleasing outlook. The materials and labour constants were generated by physical observation, via a work study. The algorithmic equations developed are as follows: $U_p = M_c + L_c$; $M_c = YA_m \times C_p$; $L_c = Y \times L_p$ (thus: $U_p = YA_m \times C_p + YL_p$), where: U_p = painting cost, M_c = Material cost, L_c = Labour cost, Y = Area of building to be painted, A_m = Average quantity of the material per square meter (material constant), C_p = Cost of material per meter square, L_p = Cost of labour per square meter (labour constant). Validation of the model using current market rates of the last quarter of 2019 in the study area indicates that painting a wall of total area= 115.29 m^2 using Sharon texcote paint for instance will cost ₦64,500. These equations not only have time saving potentials, they are also reliable when used for costing painting works involving the brand of paints surveyed. However, their efficacy relies heavily on accurate measurement of area of walls to be painted. These models are recommended for use by practicing quantity surveyors to generate feasibility cost estimates for painting works and shorten pre-contract time for both private and public clients.

Keywords: Painting; algorithmic equation; validation; cost estimation; Nigeria.

1. INTRODUCTION

Accurate construction cost estimates are necessary for the successful completion of any project because the client has a budget he has to meet for a project. He also wants to know how much it will cost before he is willing to start. Estimates are also used to select contractors.

According to [1,2], a cost estimate helps in project planning by way of segregating the money required for different materials, procedures and labours, managing the cash flows evenly and properly as per time and requirement, arranging finances time to time and checking the financial feasibility. Painting is one of the construction work items that need utmost care, intuition and experience to estimate accurately.

Parker [3] notes that when it comes to exterior commercial painting, professional painters must be able to calculate the costs associated with labor, materials, equipment, and miscellaneous items and for the best results, estimates should be flexible and adaptable to project modifications. Thus, to come up with an accurate cost estimate, the estimator needs to assess the scope of the project along with the technical implications. According to [4], the cost estimating methods of painting includes: Benchmarking, unit price estimating, developed pricing, market pricing, and critical path scheduling. Reina further corroborates the assertion of Parker, that the first step in developing an accurate estimate for an industrial painting contract is determining the scope of work; he did not however mention algorithms as one of these methods.

An algorithm is a finite sequence of well-defined, computer-implementable instructions, typically to solve a class of problems or to perform a computation. Algorithms are always unambiguous and are used as specifications for performing calculations, data processing, automated reasoning, and other tasks. Algorithms are thus, mathematical techniques, methods or procedures or guidelines or sequence of instructions taken in other to get a task done or solve a problem or tell a computer what to do [5,6,7].

Numerous studies abound, evidencing the use of algorithms to solve some cost estimate related problems. For instance, [8] employed genetic algorithms with case-based reasoning to generate a preliminary cost estimation model. [9] used genetic algorithms to develop a cost-optimization-based design of precast concrete floors. [10] used hybrid evolutionary algorithm to achieve time/cost optimization in construction project scheduling. [11] adopted a non dominated archiving multicolony ant algorithm in time—cost trade-off optimization. Genetic algorithms and neural networks were also used to predict preliminary cost estimates by [12]. [16], however conducted a 10 year survey of various works on articles related to intelligent construction cost estimation to indentify the construction cost estimation factors were covered as a basis of the estimate preparation. The forgoing shows that algorithms play a very important role in construction project cost management, which this study built on and aligned to painting works.

Painting has its peculiarities and as such, some authors like [13] do not entirely agree that any

form of estimation technique can account for every component or element needed to produce a painting estimate. According to [13], paint estimating is more of an art than a science. There's no price that's exactly right for every job and for every bidder. That's because every painting job is unique. No single material cost, no labor estimate, no pricing system fits all types of work. And just as every job varies, so do painting companies. No two painting contractors have the same productivity rates, the same labor burden, the same overhead expense and the same profit requirements. The best paint estimates are always custom-made for a particular job. They're based on the contractor's actual productivity rate, material cost, labor cost, overhead percentage and profit expectations.

Gleason [13] asserts that no estimating book or computerized estimating system or estimating service can possibly account for all the variables that make every job and every painting company different. Only a skilled estimator using professional judgment and a proven estimating system can produce consistently reliable estimates on a wide variety of painting jobs.

From the assertion of [13] getting a 100% accurate estimate for painting works is almost impossible. This study however argues that employing algorithmic models for painting estimation will go a long way in improving the accuracy of painting works and increasing clients confidence in estimators such as quantity surveyors, but not necessarily providing a perfect estimate.

Anecdotal evidence from quantity surveying practitioners in Nigeria suggests that construction estimators do not use algorithmic equations for feasibility/approximate/preliminary estimating of their painting works. Rather, they use the popular unit rate build up which they multiply with the total wall quantity (area) to arrive at the estimate. Some others simply update old unit rates with a mark-up (depending on the gap in duration of the last and proposed project) and use it to multiply the wall area.

It is against the afore-mentioned, that this study sets out to fill the above mentioned gap by developing algorithmic painting estimating equations to improve accuracy of painting estimates, save pre-contract time and also give the client value for money. The findings of this study will prove beneficial to quantity surveyors as well as project managers, construction

professionals and painters in providing a time-saving estimation tool for their proposed painting works. Built environment researchers will also increase their knowledge base and add to the field of cost estimation literature by building on this study for their future researches.

1.1 Overview of Painting Measurement and Cost Estimation

Painting project costs are dependent on the wall area to be painted (obtainable in Nigeria's formal construction sector and government/public projects where a bill of quantity is required) or the number of rooms (obtainable in Nigeria's informal construction sector) to be painted, the type and brand paint chosen and the cost of labor [14]. These will influence the overall cost of the project and depending on what is chosen, it can either increase or decrease the project cost. If one wants want to be a little more price conscious about his painting project, there are choices he can make that will decrease overall painting project cost. Choosing a paint that is more cost-effective will be the main cost factor that will help decrease your painting cost. Both the quality and ease of application can be reflected in the price of the paint [13].

To get a rough estimate for a commercial painting project, the cost for materials and labour should be added. For a more accurate estimate, the overhead costs (power-washer rental, fuel, insurance, etc.) and additional costs (rollers, brushes, paint trays, drop cloths, etc.) are included. One important thing to keep in mind is that cost estimates increase with the size of the area to be painted. For this reason, painters price their work according to the square footage or meters as the case may be. Since certain things, such as the intricacy of trim details, difficulty of prep tasks, safety tasks and outdoor obstructions can complicate a painting job considerably, some painters also factor in these details.

The use of masonry unit walls is common in facilities such as elementary schools, prisons, carwashes, or where abuse to the facility is a concern. Unfortunately, the standard gray color of a typical masonry unit is not quite appealing especially if it makes up a large amount of the exterior wall. The requirement to paint new exterior masonry addresses the look of an unfinished product along with preserving a porous material. Adding further protection to a durable material minimizes the amount of future maintenance and increases the overall longevity of the wall. Properly painting an exterior masonry

wall often proves advantageous to the project considering the long term benefits over the initial cost [14,13].

Building Construction Cost Data [14] further states that paint is quantified by surface area; referred to as square feet, however suppliers sell and quote large amounts of painting materials by the gallon. [15] in its document entitled The Building and Engineering Standard Method of Measurement(4th edition) (BESMM4) stipulates that painting should be measured in square meters (m^2). Traditionally, paint manufacturers suggest a coverage area per gallon based on the type of paint and certain conditions. The suggested paint coverage areas typically range between 200 and 300 square feet per one gallon of paint [3]. Keep in mind that the suggested coverage areas are usually considered a "rule-of-thumb" and may not account for waste, multiple coats, and unusual surface conditions.

In respect of painting an exterior masonry wall, the amount of square feet covered by a gallon of paint is highly dependent on whether the masonry wall is comprised of smooth or "split-face" units. Another concern affecting the amount of materials used and the productivity is the method in which the paint materials are applied. The estimator must recognize the projects conditions and identify the most effective method for applying the required paint material. One gallon of paint covers approximately 400 square feet. To estimate how much paint your project requires, determine the measurements of the room you plan to paint and round it to the nearest foot. To ensure you will have enough paint, do not worry about excluding areas not to be painted, such as windows and doors. Remember that a 10% waste allowance is automatically added to the total.

The overall floor plans and exterior elevations in a set of construction documents are best used to calculate the surface area (square feet) of an exterior wall surface. The use of a digital take-off tool is ideal in measuring and keeping a total tabulation of exterior walls on a large project in a short period of time. Therefore, a digital tool eliminates extensive use of the architect's scale that requires the estimator to keep a manual tabulation. Be cautious with noted scales on the plan documents by confirming with a noted dimension.

The aerial view of a floor plan allows the estimator to accurately identify and measure the horizontal dimension (length) of all exterior walls that require painting. The floor plan allows the estimator to accurately measure curved walls along with identifying alcoves that many times do not appear on the exterior elevations. Any curved walls that do appear in the exterior elevations many times depict a foreshortened view that would cause inaccuracies in the take-off. The estimator should also view the site plans for dumpster enclosures and retaining walls that are usually constructed of masonry and require painting. The site and floor plans usually identify a masonry wall with a cross-hatching pattern. The exterior elevations are then used to determine the vertical dimension (height) of the exterior wall. In turn, the length and the height are multiplied to calculate the overall surface area (square feet) of the exterior wall. Additional areas for openings and changes in materials are gathered from the exterior elevations. If available, the estimator will need to review building sections and wall sections to help confirm wall heights and material transitions that may not be as distinct in the exterior elevations.

The estimator should recognize the amount of openings that can lead to reduced production for "masking" the openings or "cutting-in" around them. The estimate should deduct for large openings exceeding 100 square feet. In turn, reducing the amount of surface area for calculating materials can be displaced by the increase of labor cost to account for each opening. Once the surface area of the wall is known, the estimator can apply multipliers for waste or unique conditions such as type of paint, surface texture, and method of application. The use of a waste factor covers the extra materials that assist in completing the project but considered not a part of the final product. A waste factor typically accounts for color selections and stored paint materials for the owner's future use. This waste factor is applied to the original amount of calculated materials. Adjusting the manufacturer's suggested coverage areas is the preferred method to account for unique conditions. These adjustments are gathered from the estimator's previous project experience along with accurately utilizing historical data. The estimator should be cautious and carefully evaluate all project conditions that may affect one or several components of the material take-off. The calculations can then be summarized to determine the amount of paint required for the project.

1.2 Aim and Objectives of the Study

The aim of this study is to develop algorithmic equations for estimating the cost of painting works. The specific objectives are:

a) To identify and categorize the common types and brands of paints used in the study area.
b) To determine the average quantity of paint needed per square meter of wall.
c) To obtain the material and labour constants for the paints identified in 1.
d) To develop algorithmic equations for estimating unit rates of painting.
e) To validate the algorithmic equations using current market prices.

2. METHODOLOGY

2.1 Study Area

The study was carried out in Anambra and Enugu states of Nigeria. Anambra state is in south eastern Nigeria. The capital and seat of government of Anambra is Awka. Onitsha, Nnewi and Ekwulobia are the commercial and industrial cities in the State. Enugu state is equally in south eastern Nigeria. The capital and seat of government is Enugu. Enugu (urban), Nsukka, Agbani and Awgu are the commercial and industrial cities in Enugu State. These areas were chosen on account of the plethora of construction of projects where different construction professionals, painters and paint suppliers can be found.

2.2 Research Design

The study adopts a simulation research approach since it is best suited for achieving the aim of developing algorithmic models for costing painting works that can be simulated to reflect the final cost of painting works

2.3 Sources of Data Collection Sources and Procedure

Data for this study was obtained via primary sources and secondary sources (archival data) like bills of quantities of past building projects.

Data for this study was obtained via primary sources and secondary sources (archival data) like bills of quantities of past building projects (with quotations of painting works in order to investigate the extent to which painting works in buildings projects are measured), journals, online sources and related literature. Relevant stakeholders involved in the preparation bills of quantities for painting works, painting works and construction were contacted to elicit more in-depth and complimentary data on the variables of the research. Semi-structured interviews Physical observations, work study and market survey were also carried out, which comprised the primary sources.

2.4 Study Population and Sample

The population of the study comprises construction professionals which are; architects, engineers, builders, quantity surveyors as well as skilled labour (painters), paint suppliers and manufacturers practicing and based in Anambra and Enugu states. For reliability of data, purposive sampling technique was adopted based on the number of the active sites with ongoing painting works as at the time of carrying out this research. In view of this, a total of forty (40) semi structured interviews was carried out on the afore-mentioned skilled labour and professionals within the study area (*see Table 1*).

A total of 25 selected currently ongoing building project works were visited in the study area for the site based observation/work study and interviews.

2.5 Tools for Data Analysis and Presentation

Descriptive statistics such as transcription, content analysis and simple arithmetic computations were the methods adopted to analyze data collected. The data was also presented in Tables for proper elucidation and organization of results.

The methodology adopted for this study is summarized in Table 2.

Table 1. Distribution of selected respondents

Location	Painters	Quantity Surveyors	Architects	Engineers	Grand total
Anambra State	15	4	2	1	
Enugu State	12	3	3		
Total	27	7	5	1	40

Source: Researchers' field survey, 2019

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Table 2. Summary of research methodology

S/No	Objective/Activity	Research Method		
		Data collection instrument	**Data analysis tool**	**Data analysis & presentation method**
1	Identifying common paint brands in the study area.	Market survey and semi-structured interviews.	Transcription and content analysis.	Descriptive statistics; Tables
2	Determining the average quantity of paint needed per square meter of wall.	Physical observation, archival data	Transcription and content analysis.	Descriptive statistics; Tables
3	Obtaining the material and labour constants and prices for the paints.	Work study, interviews, physical observations	Arithmetic computation	Descriptive statistics; Table
4	Developing equations for predicting cost of painting works.		Algorithmic Equations formulation via data obtained from 2 and 3	

Table 3. Common types of paints used in the study area

S/N	Type of paint	Remarks
1	Dulux	It is a foreign paint that can be found in all parts of Nigeria including Anambra and Enugu states. It comes in different types like Emulsion, Matt, Silk/Satin. It is rated among the most durable and high quality paints in the world. This paint allows for creativity and flexibility which gives it an aesthetically pleasing outlook upon finish; however its price is quite high which makes it unaffordable for most prospective clients. From interviews; painters, suppliers and manufacturers regard Dulux paint as the best in all ramifications in Anambra and Enugu states.
2	Intercolour	It is a locally manufactured paint that can be found in all parts of Nigeria including Anambra and Enugu states. It has different types like Emulsion, Matt, Silk/Satin and Texcoat. It has glossy effect and dries quickly. It is also very durable and does not change colour when dry.
3	Homepride	It is locally produced in Ogidi town of Anambra state and can be found in all parts of the state. It has different types like Emulsion, Texcoat.
4	Sharon (Vineyard)	It is locally produced in Enugu urban, Enugu state and is also common used in Anambra state. It has different types like Emulsion Matte Silk/Satin Textcoat.
5	Fine coat	It is produced in Lagos state and can be readily found in Anambra and Enugu states. It has different types like Emulsion, Matte, Silk/Satin, Texcoat.

Source: Researchers' field survey, 2019

Table 4. Derivation of quantity of paint needed per square meters

S/N	Bucket(s)/room	Area (m^2)	Painting per m^2
1	1 (i.e 20L covering 1 rooms)	38.43	20 Litres/38.43 = 0.5204
2	1.5 (i.e 30L covering 1 room)	38.43	30 Litres/38.43 = 0.7806
3	1 (i.e 20L covering 2 rooms)	76.86	20 Litres/76.86 = 0.2602
4	1 (i.e 20L covering 3 rooms)	115.29	20 Litres/115.29 = 0.1735

Source: Researchers' field survey, 2019

3. RESULTS AND DISCUSSION

3.1 Brands of Paints Commonly Used in the Study Area

Content transcription of semi-structured interviews from professional painters, suppliers and manufacturers yielded Table 3. Dulux, Intercolour, Homepride, Sharon (Vineyard) and Fine coat were the identified brands of paints found within Anambra and Enugu state.

From Table 3, assessing the quality of the paints in a hierarchical order shows that dulux paint though of high quality, is regarded as the most expensive brand of paint in the study area. This is closely followed by intercolour, homepride, sharon and fine coat being the least. The foregoing implies that the choice of any of these identified paint brands can affect the estimate of the painting work, hence care must be taken by the estimator to input the appropriate price of paint into the equation. This does not however mean that there aren't clients who have preference for the most expensive brand, it all depends on the individual's choice. But while selecting, it should be noted that a highly durable paint may be expensive at the initial stages of construction, but will be economical in the long run due to lesser maintenance costs.

3.2 Quantity of Paints Needed per Square Meter

To obtain these quantities, a site-based painter's estimate for painting of a standard room size [(3.6 m x 3.6 m x 3 m high) with one door (0.9 m x 2.1 m high) and 2 windows (each of 1.2 m x 1.2 m high)] was used and yielded the following calculations:

Girth (perimeter) of the room = 3.6 m x 4 sides = 14.4 m

Area to be painted = 14.4 m x 3 m high = 43.2 m^2 Deduct door opening area (0.9 m x 2.1 m high = 1.89 m^2) and 2 windows opening area (1.2 m x 1.2 m high x 2 = 2.88 m^2): Thus; 43.2 m^2 – (1.89 m^2 +2.88 m^2) = 38.43 m^2

Therefore, 38.43m^2 = Estimated total area of one standard room

- **N/B**: One bucket of paint = 20litres

As shown in Table 4, the standard or basis for the validation of algorithmic equation developed (sub-section 4.4) is a coverage of 3 rooms, totaling 115.29m^2, which yielded 0.1735m^2 as the number of litres per square meter of wall.

Table 5 further summarizes the average materials needed per square meters according to the brand and type of paint, obtained via physical observation and responses from paint suppliers and painters. It is still based on the computation of Table 5, but here, all the specific types and brands of paints surveyed were allotted their coverage quantities.

3.3 The Algorithmic Equations for Estimating Painting Cost

The generic equation proposed by this study for costing painting works is expressed as shown below. However, before the development of the equations, the material and labour constants were first obtained as follows:

$$Up = Mc + Lc \qquad (1)$$

Where:

Up = Cost of painting
Mc = Material cost
Lc = Labour cost

$$Mc = YAm \times Cp \qquad (2)$$

Where:

Am = Average quantity of the material per square meter (material constant)
Cp = Cost of material per meter square
Y = Area of building to be painted

Labour cost = Y x Cost of paint/m^2

$$Lc = Y \times Lp; Lc = YLp \qquad (3)$$

Where:

Y = Area of the building to be painted
Lp = Cost of labour/m^2 (labour constant)

Therefore, Up = Mc+ Lc
Up = YAm x Cp + YLp

Where;

Up = Unit cost
Am = Average quantity of the material per square meter
Cp = Cost of material per metre square
Lp = Cost of labour/m^2
Y = Area of the building to be painted

The following equations as shown in Table 6 are thus advanced for different types of paints.

The algorithms developed as shown in Table 6 has numerous benefits. First is that it can help improve the efficiency of painting cost management by creating a platform where the equations can be input into a computer programme to solve problems relating to painting estimates via production of accurate results and saving of time spent on manual estimating. The equations are very flexible to adapt to the nature of project and ensure accuracy of estimates because other estimating variables such as project scope and design, fluctuations in resource prices like materials and labour can be factored in. Secondly, it can help in proper utilization of resources such as money and time spent in manual estimation.

The nature and potential of the model developed is akin to the findings of [16] who conducted a 10 year survey of various works on articles related to construction cost estimation to indentify amongst other issues, which construction cost estimation factors were covered as a basis of the estimate preparation. The findings of [16] revealed that factors such as (i) estimator specific factors (individual estimator may customizing pricing based upon best local practice) (ii) project size(as the number of labour increases, the cost estimation of some items may have some biases and become more plausible e.g., production rate estimation or tasks scheduling) (iii) type of project(Undertaking particular types of projects requires a suitable choice of technology and equipment used, as well as suitable work methods. This can limit the choice of materials and size of crew to be employed; consequently, this will affect the project budget). In our case, the labour constants can be adjusted to suit the particular type of paint because labour constants vary across types of paints.

Furthermore, other factors as identified by [16] which is strongly applicable to the developed model includes (iv) type of client (as each construction project has its own client ideas, roles, and objectives, the characteristics of the contract and bidding behaviour are mainly affected by client type) In our case, profit margins can be decided by the type of client, be it a (v) material cost (the material type and availability can significantly impact on the cost estimation of construction projects. Any methods used to estimate the material cost accurately will reduce wastage and improve the project's cost and time benefits) In the case of the developed model, the price of the paint can be inputted and the afore-mentioned benefit accruable to the client.

3.4 Validation of the Algorithmic Equations

To validate the model; assuming a three room space needs to be painted of total wall area = $115.29m^2$, inserting the total square meters needed to be painted (Y) into the equations developed, the cost of using various paint brands is derived as indicated in Table 7.

Table 5. Summary of average quantity of various paint types needed per square meter of wall

S/No	Paint brand	Paint types	Average material (Per 1 m^2)
1	Dulux	Emulsion	$0.2602/m^2$
		Matte	$0.1735/m^2$
		Silk/Satin	$0.1735/m^2$
2	Intercolour	Emulsion	$0.2602/m^2$
		Matte	$0.1735/m^2$
		Silk/Satin	$0.1735/m^2$
		Texcoat	$0.7806/m^2$
3	Homepride	Emulsion	$0.7806/m^2$
		Texcoat	$0.2602/m^2$
4	Sharon (Vineyard)	Emulsion	$0.5204/m^2$
		Matte	$0.2602/m^2$
		Silk/Satin	$0.2602/m^2$
		Textcoat	$0.7806/m^2$
5	Fine coat	Emulsion	$0.5204/m^2$
		Matte	$0.1735/m^2$
		Silk/Satin	$0.1735/m^2$
		Textcoat	$0.7806/m^2$

Source: Researchers' computation, 2019

Table 6. Painting material and labour constants and proposed algorithmic equations

S/N	Paint brand	Paint type	Location	Average material (L) per 1 m²(Am)	Painters Rate/Time per room	Labour amount per 1 m² (Lp)	Cost of paint 20 L	Cost of paint per 1 L (Cp)	Proposed equations (Up = YAm x Cp + YLp)
1	Dulux	Emulsion	Anambra	0.2602/m²	4,000/4-5hrs	104	15,000	750	Y0.2602 x 750+Y104
		Matte	Enugu	0.1735/m²	4,000/4-5hrs	104	28,000	1400	Y0.1735 x 1400+Y104
		Silk/Satin		0.1735/m²	4,000/4-5hrs	104	45,600	2280	Y0.1735 x 2280+Y104
2	Intercolour	Emulsion	Anambra	0.2602/m²	4,000/4-5hrs	104	12,000	600	Y0.2602 x 600+Y104
		Matte	Enugu	0.1735/m²	4,000/4-5hrs	104	19,000	950	Y0.1735 x 950+Y104
		Silk/Satin		0.1735/m²	4,000/4-5hrs	104	28,500	1425	Y0.1735 x 1425+Y104
		Texcoat		0.7806/m²	5,000/3-4hrs	130	14,000	700	Y0.7806 x 700+Y130
3	Homepride	Emulsion	Anambra	0.7806/m²	4,000/4-5hrs	104	3,500	175	Y0.7806 x 175+Y104
		Texcoat	Enugu	0.2602/m²	5,000/3-4hrs	130	4,700	235	Y0.2602 x 235+Y130
4	Sharon (Vineyard)	Emulsion	Anambra	0.5204/m²	4,000/4-5hrs	104	4,700	235	Y0.5204 x 235+Y104
		Matte	Enugu	0.2602/m²	4,000/4-5hrs	104	12,000	600	Y0.2602 x 600+Y104
		Silk/Satin		0.2602/m²	4,000/4-5hrs	104	28,000	1400	Y0.2602 x 1400+Y104
		Textcoat		0.7806/m²	5,000/3-4hrs	130	11,000	550	Y0.7806 x 550+Y130
5	Fine coat	Emulsion	Anambra	0.5204/m²	4,000/4-5hrs	104	5,000	250	Y0.5204 x 250+Y104
		Matte	Enugu	0.1735/m²	4,000/4-5hrs	104	13,500	675	Y0.1735 x 675+Y104
		Silk/Satin		0.1735/m²	4,000/4-5hrs	104	32,000	1600	Y0.1735x1600+Y104
		Textcoat		0.7806/m²	5,000/3-4hrs	130	14,000	700	Y0.7806 x 700+Y130

Source: Researchers' field survey and computation, 2019

UP= Cost of painting; Y= Area to be painted; Am= Average quantity of material per square meter; C_p= Cost of material per square meter; L_p= Cost of labour per square meter

Table 7. Cost of painting with different paint brands using the proposed model

S/N	Paint brand	Paint type	Proposed equations (Up = YAm x Cp + YLp)	Total cost (material and labour) (₦)
1	Dulux	Emulsion	Y0.2602 x 750+Y104	34,500
		Matte	Y0.1735 x 1400+Y104	40,000
		Silk/Satin	Y0.1735 x 2280+Y104	57,600
		Texcote		
2	Intercolour	Emulsion	Y0.2602 x 600+Y104	30,000
		Matte	Y0.1735 x 950+Y104	31,000
		Silk/Satin	Y0.1735 x 1425+Y104	40,500
		Texcoat	Y0.7806 x 700+Y130	78,000
3	Homepride	Emulsion	Y0.7806 x 175+Y104	27,750
		Texcoat	Y0.2602 x 235+Y130	22,050
4	Sharon (Vineyard)	Emulsion	Y0.5204 x 235+Y104	26,100
		Matte	Y0.2602 x 600+Y104	30,000
		Silk/Satin	Y0.2602 x 1400+Y104	54,000
		Textcoat	Y0.7806 x 550+Y130	64,500
5	Fine coat	Emulsion	Y0.5204 x 250+Y104	27,000
		Matte	Y0.1735 x 675+Y104	25,500
		Silk/Satin	Y0.1735x1600+Y104Y0.7806x	44,000
		Textcoat	700+Y130	78,000

Source: Researchers' computation, 2019
UP= Cost of painting; Y= Area to be painted; Am= Average quantity of material per square meter; C_p= Cost of material per square meter; L_p= Cost of labour per square meter

As observed in the validated model, each paint brand has two or three varieties with their corresponding estimates. For instance, Dulux has Emulsion, silk and texcote painting estimates ranging from N34, 500 to N57,600. This can serve as a guide for a client or contractor painting a wall area of 115.29 m^2. It should be noted that the prices inserted in the equation are 2019 prices; hence the prices are not static. The equations can also vary based on change of prices of the various types and categories of paints identified and labour cost. The changed cost can be inserted to get updated equations. Furthermore, profit and overhead can be added to the total cost generated by the model to obtain the grand total cost of the painting, if it is to be used for a competitive bid.

4. CONCLUSION

Algorithmic equations for estimating painting works developed will aid estimators of building painting works including quantity surveyors and other building professionals, painters, suppliers, manufacturers and even the clients to have a quick glimpse of what a proposed cost of a painting work will be. Its accuracy however, lies heavily on the ability of the user to input the correct material and labour prices via a detailed market survey.

From the findings of the study, there is need to adopt algorithmic equations for estimating painting works so as to reduce the risk of price uncertainty and give the client better value for his money. To this end, the study advances the following:

a) The developed algorithmic equations for estimating painting works should be regularly updated to reflect change in prices of paints and labour.

b) There should be a concerted effort from industry stakeholders and academics to resolve some pedagogical issues on estimation of painting works.

c) Estimation relies heavily on accurate measurements, therefore, the measurements of wall areas should be deemed correct before applying the algorithmic equations.

d) The developed equations should be considered for use by practicing quantity surveyors, professional painters and other building professionals to generate realistic feasibility estimates of painting in building projects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/55109