Assessing the Level of Implementation of Cost Reduction Techniques on Educational Building Projects in Public Tertiary Institutions in Southwestern Nigeria

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Abstract. In the face of limited financial resources, public tertiary institutions are pressured to optimize expenditure on educational building projects. Effective cost reduction techniques can help bridge the gap between limited budgets and the need for quality infrastructure. This research investigates cost reduction techniques implemented on educational building projects in public tertiary institutions in southwestern Nigeria and its relationship with the type of tertiary institution. A quantitative research method was employed in the study using a questionnaire survey. The building projects considered were those completed between the years 2012-2022. 133 projects from 15 public tertiary institutions in southwestern Nigeria were surveyed using purposive sampling techniques. The mean item score and the Kruskal-Wallis test were employed for data analysis. The findings showed that amongst the 16 various cost reduction techniques investigated, value analysis/engineering, supply chain management, target value design, and budget control were top-ranked and used on many elements of the projects. At the same time, automation and circular economy were the least ranked cost reduction techniques used. The study further showed significant differences in implementing 7 of the techniques in the various tertiary institutions. It is concluded that integrating cost reduction techniques into existing policies and guidelines will facilitate the development of a standardized framework for their implementation across public tertiary institutions, promoting broad adoption and ensuring consistency in their application.

1 Introduction

The number of students enrolled in higher institutions has increased significantly in Nigeria over the past three decades, and new institutions have been established [1, 2]. The rising number of students who apply for admission to higher institutions annually creates the need

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for increased infrastructure across all institutions. Educational infrastructures play a crucial role in producing the desired results for the education system [3]. According to Alao et al. [4], inadequate infrastructure would reduce the institution's value to its end users and other stakeholders in tertiary institutions. These infrastructures could take the form of new or renovated construction.

Following the execution of several intervention programs like the Universal Primary Education, the Universal Basic Education, the issuance of scholarships, the formation of the Educational Trust Fund, currently known as the Tertiary Education Trust Fund (TETFund), and the requirement that businesses operating in Nigeria contribute 2% of their profits as a tax, the government has played a significant role in advancing public education in Nigeria. However, Famade et al. [5] reported that the government has acknowledged that it can no longer fund tertiary institutions in Nigeria alone due to increased demand for higher education. Construction projects in these institutions must be finished within the allocated and available funds because public tertiary institutions' funding is shrinking, and they have infrastructure demands. However, cost overruns occur frequently in public construction projects worldwide, and the Nigerian construction industry is no exception [6-7].

Cost-reduction techniques are essential to overcoming the financial difficulties public tertiary institutions in Nigeria face to maximize funding for project implementation. Cost reduction is the process of reducing a product or service unit cost of production without compromising the quality of the output [8]. In other words, cost reduction is achieving a significant drop in the unit cost of goods produced or services rendered without sacrificing the quality or acceptability of the final product for its intended use. Cost reduction was described by Asaolu and Nassar [9] as a deliberate and proactive strategy for increasing productivity. These definitions highlight that cost reduction can be understood in various contexts, including boosting production and eliminating waste. Meanwhile, Mahadik [10] and Esangbedo and Ealefoh [11] added that the building industry should strive to reduce costs.

The Nigerian construction sector employs a variety of cost-reduction strategies. Some construction professionals use a traditional approach, while others have adopted a digital cost-reduction technique. In the latter, Oyegoke et al. [12] highlighted that digitalisation has significantly impacted how cost-reduction techniques are applied. Cost reduction techniques like Supply Chain Management, Target Value Design, Simplification and Standardization of units, Activity-Based Costing, Value Analysis, Market Research, Earned Value Analysis, Target Costing, Material and Process Substitution, Budget control, On-site project resource control techniques, Kaizen Costing, Standard Costing, Automation, Cost Benefit Analysis, and Circular Economy were identified from prior studies [13-17]. Despite the availability of these techniques, many construction projects still fall short of their cost targets [6, 11, 18].

Previous research focused on causes of cost overruns, cost prediction, cost management and mitigating factors to cost and time control [19-20]. Hence, knowledge in the area of cost reduction techniques used on public tertiary educational projects is currently insufficient, this therefore underpins the core rationale of this study. According to Alshuwaikhat et al. [21], one of the main issues tertiary institutions encounters is financial sustainability. Thus, identifying and evaluating cost reduction techniques employed on public tertiary educational projects have become crucial. Evaluating cost reduction techniques can lead to improved financial management, enhanced sustainability, and efficient use of resources in the education sector.

1.1 Cost Reduction Techniques

Despite high costs and budget overruns, the construction sector plays a significant role in the world’s economy. These challenges influence organizational profitability and project success

[22]. One of the key objectives of any construction project is cost, though other objectives lke time, quality and customer satisfaction are key, cost is regarded as the primary determinant of the success of the project [18]. This implies that projects depend on the cost to meet other objectives. It can also be said that ineffective management of project costs can also lead to setbacks, poor performance and project delivery. Therefore, effective cost-reduction techniques have become crucial for construction companies to remain competitive and sustainable.

The construction industry is characterized by its complex nature, involving the management of risks, numerous stakeholders, intricate processes, and substantial resource requirements [23, 24]. Cost overruns and budget overruns are common challenges faced by construction projects, often leading to financial losses, delays, and disputes [6, 11, 25]. According to a study by Flyvbjerg et al. [26], approximately 90% of construction projects experience cost overruns, with an average overrun of 28% above the initial budget estimates. These statistics highlight the pressing need for effectively managing construction and the adoption of cost-reduction techniques.

The studies of [27-28] noted that several cost-reduction techniques have been widely employed in the construction industry globally, indicating the sector's moves towards mitigating the challenges of cost overrun. Value Engineering (VE) is one of the most prominent approaches and has been explored [29-30]. VE systematically analyses project requirements, functions, and associated costs to optimize the cost-to-function ratio by identifying opportunities for cost savings without compromising essential project requirements. In his assessment, Tohidi [30] found that VE was able to save about 38% in direct material after implementation. Akinola et al. [31] supported this, asserting in their review the importance of VE in cost reduction. Their study posited that applying value engineering to projects minimizes cost without reducing quality or performance.

Other techniques widely used in the industry include Supply Chain Management, which has been implemented to optimize the flow of materials, information, and finances from suppliers to the end customer, contributing to overall cost reduction [32]. Target Value Design, similar to target costing, involves setting a cost target based on market conditions and customer requirements and designing the project to meet that target [33]. This approach, along with Budget Control and Cost Benefit Analysis, has been widely used to monitor expenses and evaluate the potential returns on investments. The Onsite Project Resource Control Technique helps manage resources efficiently at the construction site, while Earned Value Analysis objectively measures project performance and progress [34]. These techniques work in tandem with market research, which aids in understanding customer needs and market trends and enables more cost-effective decision making. Simplification and Standardization of units have been adopted to reduce complexity and increase efficiency [35]. This approach complements Standard Costing, which provides a benchmark for comparing actual costs, and Activity-based Based Costing, which offers a more accurate cost allocation method. Kaizen Costing, focused on continuous improvement, has been implemented to gradually reduce costs over time [36]. This aligns well with Material and Process Substitution techniques, which have been used to find more cost-effective alternatives without compromising quality. Automation has been increasingly adopted to reduce labour costs and improve efficiency [34]. This trend towards technological solutions is further exemplified by the principles of Circular Economy, which have been applied to minimize waste and maximize resource utilization, leading to long-term cost savings [35].

These techniques have shown varying degrees of effectiveness in reducing costs. However, their implementation often faces challenges such as resistance to change, lack of expertise, and limited stakeholder engagement [36]. Despite these obstacles, the construction industry continues to explore and refine these cost-reduction techniques to improve project outcomes and organizational profitability [34-36].

2 Materials and methods

The study investigated cost reduction techniques used on public tertiary educational building projects in Southwestern Nigeria. The Southwestern part of the country comprises six states with a total of 50 public tertiary institutions (universities, polytechnics and colleges of education only) however, Oyo, Ogun, Osun and Lagos state were the states considered in this investigation because it houses the majority of the tertiary institutions within its borders totalling 37. However, 15 tertiary institutions were purposely sampled and eventually, 133 building projects completed within the year 2012-2022 for which the required information was available were investigated.

A questionnaire survey was used in the study's quantitative research methodology obtain data. As posited by Brant et al. [37], questionnaires with numerical rated scales are effective for collecting and analysing data obtained from survey research. The stakeholders who took part in the identified educational building projects within the institutions responded to the survey. Information on each project was obtained to understand the project complexity, type of building project, procurement method used, and source of funding. The questionnaire sampled the usage of 16 identified cost reduction techniques on a five-point Likert scale with 5 = All elements of the project, 4 = Many elements of the project, 3 = Some elements of the project, 2 = Few elements of the project, 1 = Not used in any element of the project. A brief description of the identified techniques was provided in the questionnaire to ensure that respondents comprehended the information and prevented misunderstandings.

Using the Statistical Package for Social Science (SPSS) version 21.0, descriptive and inferential statistics were used to analyze the questionnaire data. Frequency, percentage, and mean item score are descriptive statistics, while the Kruskal Wallis-H test is used to draw inferences. The data was examined for internal consistency using Cronbach's Alpha Coefficient. According to Pallant [38], a reliability coefficient 0.7 is considered adequate for Cronbach's Alpha values, which range from 0 to 1. The survey instrument's reliability and validity were demonstrated by the study's Cronbach's Alpha value, which was 0.849.

3 Results and discussion

3.1 Information on project characteristics

The survey of tertiary educational building projects revealed diverse characteristics across various institutions, project complexities, building types, procurement methods, and funding sources. As shown in Table 1, the distribution of projects among institutions is as follows: Federal Polytechnics accounted for the largest share at 30.1% (40 projects), followed by State Polytechnics at 22.6% (30 projects), Federal Universities at 18.8% (25 projects), Federal Colleges of Education at 14.3% (19 projects), State Universities at 8.3% (11 projects), and State Colleges of Education at 6.0% (8 projects). The project complexity showed that 45.9% (61) are low-rise buildings, 34.6% (46) are one-level buildings, 16.5% (22) are medium-rise buildings, and 3.0% (4) are high-rise buildings.

Table 1 also showed the type of educational building projects to include 36.1% (48) faculty/departmental buildings, 14.3% (19) lecture theatres, 12.0% (16) administrative and classrooms buildings, 7.5% (10) laboratories/workshops and other building functions, 5.3% (7) are used as hostels, 2.3% (3) health facilities. In comparison, 1.5% (2) are libraries and staff accommodations. The result on the method used in procuring the buildings indicated that 60.2% (80) were procured using the traditional method, 24.8% (33) represented the management contracting method, and 10.5% (14) used the design and build method. In

comparison, 3.8% (5) and 0.8% (1) used other procurement methods and Public/ Private Partnership (PPP), respectively.

Regarding the source of financing the projects, 70.7% (94) were funded by TETFund, 15.8% (21) were funded through revenue generated from the institutions, 9.0% (12) were obtained through capital allocations from the government and 4.5% (6) were funded by donations from a private individual. This result buttresses the submission by [5] that the government is the principal financier of construction work in public tertiary institutions. The results of the project characteristics revealed a broader coverage of all building types, complexity, and financing. As such is an excellent representation to be considered suitable for the survey.

Table 1. Characteristics of educational building projects surveyed

Project Characteristics	**Frequency**	**Percentage**
Institution		
Federal University	25	18.8
State University	11	8.3
Federal Polytechnic	40	30.1
State Polytechnic	30	22.6
Federal College of Education	19	14.3
State College of Education	8	6.0
Project Complexity		
One level building	46	34.6
Low-rise building (1-2 floors)	61	45.9
Medium rise (3-4 floors)	22	16.5
High rise (above 4 floors)	4	3.0
Type of Education Building Project		
Faculty/Departmental building	48	36.1
Lecture theatre	19	14.3
Hostel	7	5.3
Administrative building	16	12.0
Library	2	1.5
Classrooms	16	12.0
Laboratories/Workshop	10	7.5
Health Facility	3	2.3
Staff accommodation	2	1.5
Other	10	7.5
Procurement method		
Traditional	80	60.2
Design and build	14	10.5
Management Contracting	33	24.8
Public/Private Partnership	1	0.8
Other	5	3.8
Source of funding		
TETFund	94	70.7
Capital project	12	9.0
Internally Generated Revenue	21	15.8
Donation	6	4.5

3.2 Cost reduction techniques implemented on Public tertiary educational building projects in Nigeria

The study examined the utilization of cost-reduction techniques in educational building projects at public tertiary institutions across Southwestern Nigeria. Sixteen cost reduction techniques, identified from the literature, were evaluated using a five-point Likert scale with ''5 = All elements of the project'' to ''1 = Not used on any element of the project''. Table 2 shows the result of this finding which was interpreted using an adopted mean value range of ''1-1.49 = Not used on any element of the project'', ''1.50-2.49 = Used on few elements of the project'', ''2.50-3.49 = Used on some elements of the project'', ''3.50-4.49 = Used on many elements of the project'', ''4.50-5.00 = Used on all elements of the project''. The result of this investigation is presented in Table 2.

Table 2 revealed varying implementation levels across different institution types, with Value Analysis/Engineering emerging as the most widely implemented technique, followed by Supply Chain Management, Target Value Design, and Budget Control. Interestingly, usage patterns differed among institution types. Federal Universities showed high implementation rates for most techniques, while State Universities demonstrated similar patterns with a few exceptions. Federal Polytechnics uniquely applied value analysis/engineering to all project elements, whereas State Polytechnics consistently used all sixteen techniques in many project elements. Federal and state colleges of education exhibited diverse usage patterns, with some techniques applied more extensively than others. For instance, federal universities implemented cost reduction techniques on many elements of the projects carried out except standard costing, material and process substitution and automation, which were used on some elements of the projects. In state universities, target value design and simplification and standardization of units were used in some elements of the projects, while other cost reduction techniques were used in many elements of the projects.

Table 2. Cost reduction techniques implemented on public tertiary educational building projects

Cost Reduction Techniques	Federal Uni.	Remark	State Uni.	Remark	Federal Poly.	Remark	State Poly.	Remark	Fed. College of Edu.	Remark	State College of Edu.	Remark	Avg. Mean Score	Overall Rank	General Remark
Value Analysis/Engineering	4.28	Many	4.36	Many	4.53	All	4.23	Many	4.05	Many	4.13	Many	4.31	1	Many
Supply Chain Management	4.40	Many	3.73	Many	4.23	Many	4.30	Many	4.26	Many	4.63	All	4.26	2	Many
Target Value Design	4.08	Many	3.45	Some	4.43	Many	4.40	Many	4.58	All	3.50	Many	4.24	3	Many
Budget Control	4.24	Many	4.27	Many	3.55	Many	4.37	Many	4.26	Many	4.63	All	4.09	4	Many
Cost Benefit Analysis	4.04	Many	4.00	Many	4.03	Many	4.00	Many	4.00	Many	4.50	All	4.05	5	Many
Onsite Project Resource Control Technique	4.00	Many	4.09	Many	3.45	Some	4.33	Many	4.16	Many	4.13	Many	3.95	6	Many
Earned Value Analysis	3.84	Many	4.09	Many	3.95	Many	3.97	Many	4.21	Many	3.25	Some	3.94	7	Many
Target Costing	3.60	Many	4.27	Many	3.90	Many	4.00	Many	3.95	Many	3.50	Many	3.88	8	Many
Market Research	3.80	Many	4.18	Many	3.58	Many	4.00	Many	3.68	Many	4.00	Many	3.80	9	Many
Simplification and Standardization of units	3.56	Many	3.36	Some	3.60	Many	3.87	Many	4.00	Many	4.00	Many	3.71	10	Many
Standard Costing	3.36	Some	4.45	Many	3.35	Some	3.87	Many	3.95	Many	3.88	Many	3.68	11	Many
Activity Based Costing	3.52	Many	3.82	Many	3.45	Some	4.00	Many	3.79	Many	3.13	Some	3.65	12	Many
Kaizen Costing	3.64	Many	4.00	Many	3.23	Some	3.87	Many	3.79	Many	3.13	Some	3.59	13	Many
Material and Process Substitution	3.48	Some	4.27	Many	3.05	Some	3.97	Many	3.26	Some	4.50	All	3.56	14	Many
Automation	3.16	Some	4.09	Many	3.13	Some	3.67	Many	3.32	Some	3.00	Some	3.35	15	Some
Circular Economy	3.60	Many	4.18	Many	2.78	Some	3.77	Many	3.21	Some	2.88	Some	3.34	16	Some

In federal polytechnics, value analysis/engineering was used on all elements of the project, supply chain management, target value design, budget control, cost-benefit analysis, earned value analysis, target costing, market research and simplification and standardization of units were used in many elements of the project while techniques used on some elements of the project are onsite project resource control, standard costing, activity based costing, kaizen costing, material and process substitution, automation and circular economy. In the state polytechnics, however, results revealed that all the 16 techniques considered were used in many elements of the projects.

For Federal Colleges of Education, the result in Table 2 depicts that target value design was used on all elements of the project while other techniques were used on many elements

of the project except material and process substitution, automation and circular economy which were used in some elements of the projects. In the State Colleges of Education, cost reduction techniques used on all elements of the projects are supply chain management, budget control, cost-benefit analysis and material and process substitution. Activity-based costing, kaizen costing, automation and circular economy were techniques used on some elements of the project while other techniques were used on many elements of the project. Notably, Automation and Circular Economy ranked lowest in overall usage across all institutions, being employed only on "some elements of the projects". The overall mean item score across the institutions showed that all the cost reduction techniques were used on many elements of the project except automation and circular economy.

Value analysis/engineering (4.31), supply chain management (4.26), target value design (4.24) and budget control (4.09) were the top-ranked cost reduction techniques used on building projects in public tertiary institutions, while automation (3.35) and circular economy (3.34) were the least ranked techniques in terms of usage. The studies of [29-30] affirms that value engineering is one of the cost-saving techniques which has been tested for success over the years. However, this result is not consistent with the findings of Oyegoke et al. [12] who discovered in their study that value engineering is one of the least used techniques in the UK construction industry but agrees with their discovery on budgeting as a top-ranked technique for cost reduction. The discrepancy in the result could be attributed to differences in location and economy. Also, the study's focus was on cost control as against cost reduction which this present study considered. The study, however, agrees with Tohidi [30], who discovered value engineering as a significant strategy for reducing building costs. On the usage of automation, the result of this study agrees with Delgado et al. [39], who confirms low adoption of the technique in the industry despite its usefulness in reducing the cost of labour and increasing efficiency and quality in the industry. Lekan et al. [40] however, submitted that cost is a major determinant in the adoption of new techniques. Meanwhile, Akinola et al. [41] concluded that cost is not only the determinant factor in the implementation of cost reduction techniques but there are 31 other significant barriers. In like manner, Hossain et al. [16] discovered that mentions of circular economy in literature are concentrated in Europe, Asia, Oceanic and North America, which explains its low ranking discovered in the result of this study.

3.3 Difference in the usage of cost reduction techniques between institutions

Table 3 shows the Kruskal-Wallis H-test, a non-parametric test used to determine the significant difference in the usage of cost-reduction techniques in public tertiary institutions.

Table 3. Difference in usage of cost reduction techniques in public tertiary institutions.

	Kruskal Wallis Test		
Cost Reduction Techniques	**Chi-Square**	**Df**	**Asymp. Sig.**
Supply Chain Management	8.507	5	0.130
Target Value Design	27.498	5	0.000*
Budget Control	16.595	5	0.005*
Earned Value Analysis	3.969	5	0.554
Value Analysis/Engineering	7.930	5	0.160
Target Costing	6.660	5	0.247
Cost-benefit Analysis	2.000	5	0.849
Onsite Project Resource Control Technique	19.201	5	0.002*
Simplification and Standardization of	4.835	5	0.436

units			
Market Research	6.654	5	0.248
Activity Based Costing	8.539	5	0.129
Material and Process Substitution	22.145	5	0.000*
Standard Costing	14.923	5	0.011*
Kaizen Costing	15.497	5	0.008*
Automation	9.813	5	0.081
Circular Economy	17.447	5	0.004*

Using a 95% confidence level, the result of the Kruskal-Wallis test shows that 7 of the assessed cost-reduction techniques usage in the institutions has a significant p-value below 0.05. A significant difference exist in usage of target value design (Chi-square = 27.498, df = 5, p = 0.000), budget control (Chi-square = 16.595, df = 5, p = 0.005), onsite project resource control techniques(Chi-square = 19.201, df = 5, p = 0.002), material and process substitution (Chi-square = 22.145, df = 5, p = 0.000), standard costing (Chi-square = 14.923, df = 5, p = 0.011), kaizen costing (Chi-square = 15.497, df = 5, p = 0.008) and circular economy (Chi-square = 17.447, df = 5, p = 0.004). Meanwhile, there is no significance in the usage of the remaining 9 cost reduction techniques in the various institutions as their p-value is greater than 0.05.

4 Conclusion

The study investigated the level of implementation of cost reduction techniques on public tertiary educational building projects. 16 cost-reduction techniques identified from the literature were analysed through a questionnaire survey administered to stakeholders that participated in the construction of the identified educational building projects completed within the tertiary institutions between the years 2012-2022. The data was analysed using descriptive and inferential statistics. The results revealed slightly varying responses regarding the usage of cost reduction techniques on tertiary education building projects in various institutions. Value analysis/engineering, supply chain management, target value design and budget control were the top-ranked cost reduction techniques. It was also revealed that automation and circular economy were the least-ranked techniques in terms of usage. Automation entails utilizing advanced technology and robotics to simplify construction procedures, boost output and save labour expenses. Implementing automation in public educational construction projects may still be relatively uncommon due to variables like initial investment costs and the requirement for specialized skills, even if it can potentially increase efficiency and cost-effectiveness in the long run. On the other hand, the circular economy technique encourages the reuse, recycling and repurposing of materials throughout the lifecycle of a building to reduce waste output and increase efficiency. Although this technique can support environmental advantages and sustainable development, its application in public educational building projects may necessitate careful planning, coordination and stakeholder participation. The findings of this study can inform the development of a theoretical framework for cost reduction in educational settings. The study recommends establishing a cost reduction committee to oversee and coordinate implementation efforts. In addition, it fosters collaboration and knowledge sharing among institutions to identify best practices.

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