ARCHITECTURE

Exploring the Principles of Daylighting in the Design of a Skills Acquisition Centre in Jos East, Plateau State, Nigeria

Bitrus Solomon Babangida, Usman B. Wakawa, Haruna Abdul Usman, Salviya Tarfa Yakubu, Yakubu Yau Gital

Abubakar Tafawa Balewa University

Published November 2026

Abstract

Daylighting is central to the environmental performance of skills-acquisition facilities. Workshops and learning spaces depend on sufficient, well-distributed illumination to support practical activities and safe task performance. This article examines daylighting strategies in four vocational and skills-training facilities and considers their implications for the architectural design of a proposed skills acquisition centre in Jos East, Plateau State, Nigeria. It adopts an exploratory multiple-case-study approach based on documented site observations, photographs, sketches, descriptive appraisals, checklist records and workshop illuminance readings. The cases comprise the Women in Agriculture and Youth Empowerment Foundation in Jos, Government Science and Technical School in Bukuru, Sani Abacha Youth Centre in Kano, and Gebhard Müller Vocational Training School in Germany. The comparative appraisal considers orientation, window configuration, skylights, clerestories, roof monitors, light shelves, solar tubes, internal surface reflectance, shading and glare control. Recalculation of the reported illuminance readings gives mean values across the four cases of approximately 384 lx at window zones, 319 lx at mid-room zones and 278 lx at rear zones. These figures show a progressive reduction in measured illuminance with increasing distance from the window wall. The international case documents a more integrated combination of atria, skylights, high-level openings and automated external shading. By comparison, the Nigerian cases rely mainly on side-lighting, indicating scope to improve daylight distribution and solar control. The available documentation, however, does not fully identify the measurement instrument, its calibration, sensor height, measurement dates, sky conditions, electric-lighting status or checklist scoring rules. The illuminance values are therefore treated as descriptive spot readings, not evidence of compliance with a lighting standard; the inconsistent checklist percentages are likewise excluded as validated performance scores. The article recommends climate-responsive orientation, carefully designed bilateral and high-level openings, selective top-lighting, external shading, reflective matte finishes, and formal daylight simulation followed by field verification for the proposed centre.

Keywords: daylighting; passive design; skills acquisition centre; vocational education; illuminance; visual comfort; Jos East; Nigeria

1 Introduction

Vocational and technical education develops practical competencies, improves employability and supports self-reliance. In Nigeria, persistent youth unemployment has heightened the importance of institutions that prepare learners for technical occupations and skilled trades. Their effectiveness depends not only on curricula, instructors and equipment, but also on the quality of the physical

learning environment. Workshops, laboratories and classrooms must allow safe movement, clear visibility, concentration and the completion of practical tasks.

Daylight is an important environmental resource in educational and workplace buildings. When it is admitted and distributed appropriately, it can illuminate interior spaces, maintain a visual connection with the outdoors and reduce reliance on electric lighting when daylight is sufficient. Its availability is variable, however, and uncontrolled daylight can cause glare, excessive luminance contrast and unwanted solar heat. Effective daylighting therefore requires control over the amount, distribution and quality of natural light; simply increasing window area is not an adequate design response (Galatioto and Beccali, 2016; Tregenza and Mardaljevic, 2018).

Daylighting performance is shaped by the interaction of several architectural factors, including building orientation and massing; the size, position and orientation of openings; room depth and ceiling height; glazing properties; internal surface reflectance; external obstructions; and shading provision. Side-lighting is widely used, but its effectiveness generally decreases with distance from the façade. High-level windows, bilateral openings, clerestories, roof monitors, skylights, courtyards and atria can extend daylight into deeper areas when designed in response to the local climate and the visual tasks taking place (Lim et al., 2012; Galatioto and Beccali, 2016).

The case-study observations identify inadequate or poorly controlled daylight as a concern in some skills-acquisition facilities. Some buildings were not originally designed for vocational activities, while workshop depth, opening placement and limited shading may contribute to uneven illumination. This is particularly relevant where practical instruction involves detailed work, machinery, tools or materials with different visual characteristics. A workshop may therefore receive substantial daylight near its windows while its central and rear working areas remain comparatively dim.

Although daylighting principles are well established in building science and architectural practice, their application in skills-acquisition centres must account for the activities and trades accommodated. A tailoring studio, computer laboratory, welding workshop, carpentry space and automobile-mechanics workshop do not necessarily share the same lighting requirements or environmental constraints. Design decisions should reflect the visual tasks and operating conditions of each space.

This article examines four selected vocational facilities in Nigeria and Germany to identify the daylighting approaches documented in each case and assess the reported patterns of workshop illuminance. It explores principles that may inform the architectural design of a skills acquisition centre in Jos East, Plateau State. The objectives are to: (i) identify architectural options for integrating passive daylighting elements; (ii) examine orientation and spatial-planning considerations that affect daylight access; (iii) analyse the reported distribution of illuminance across workshop zones; and (iv) develop climate-responsive design recommendations for the proposed centre.

The research is guided by four questions: What are the principal aims of passive daylighting? How can passive daylighting techniques be incorporated into vocational-building design? Which architectural and environmental factors influence the amount and distribution of daylight? What design implications emerge from the comparative assessment of the selected facilities?

2 Literature review and analytical framework

2.1 Daylighting as an architectural strategy

Daylighting is the intentional use of natural light to illuminate interior spaces. Available daylight includes direct sunlight, diffuse skylight and light reflected from the ground and surrounding surfaces. These components change with solar position, weather, season, sky condition and the geometry of the site and building. Passive daylighting relies on architectural form and material properties—including windows, clerestories, skylights, roof monitors, light shelves, courtyards, atria and reflective finishes—to admit, redirect, diffuse or control natural light (Krasić et al., 2013; Galatioto and Beccali, 2016).

The appropriate strategy depends on building use, plan depth, orientation, climate and the visual tasks performed. Single-sided side-lighting often creates a pronounced difference between the area near the window and the rear of a room. Bilateral or multilateral openings can improve distribution, while high-level openings may carry daylight farther into occupied areas. Top-lighting can be effective in large-span workshops, but its design must address solar heat gain, glare, rain protection, structural coordination and maintenance.

2.2 Visual comfort, glare and task illuminance

Visual comfort depends on more than illuminance. Uniformity, luminance contrast, glare, colour rendering, viewing direction and task type also influence how well occupants can see and work. Direct sunlight, or a bright window within an otherwise dark room, can cause discomfort and impair visual performance. External shading intercepts solar radiation before it passes through the glazing and can therefore limit solar heat gain more effectively than internal blinds alone. Matte, light-coloured interior finishes help distribute reflected light, whereas highly glossy surfaces may produce distracting reflections (Lim et al., 2013; Tregenza and Mardaljevic, 2018).

Workplace-lighting standards set requirements for particular activities and task areas; they do not prescribe one illuminance range for every workshop. EN 12464-1:2021, for example, relates maintained illuminance to the task or activity area and also addresses visual comfort, uniformity and glare-related factors. The 300–750 lx range used in the initial assessment is therefore not treated in this article as a universal compliance criterion. The appropriate maintained illuminance must be selected for each trade and task with reference to the applicable standard and national requirements (British Standards Institution, 2021; European Committee for Standardization, 2021).

2.3 Daylight performance metrics

A point illuminance reading, expressed in lux, records the illuminance at a specific location and time. On its own, it does not establish annual daylight availability, glare risk or the overall quality of a room's visual environment. The daylight factor compares indoor illuminance with simultaneous outdoor horizontal illuminance under a defined overcast-sky condition. Climate-based metrics, including spatial daylight autonomy (sDA) and annual sunlight exposure (ASE), use annual weather data and simulation to assess the temporal distribution of daylight and exposure to direct sunlight. These approaches complement, rather than replace, properly documented field measurements (Kalaimathy et al., 2023; Illuminating Engineering Society, 2023; Ticleanu et al., 2023).

2.4 Analytical variables used in this study

The case-study appraisal uses the eleven daylighting variables adopted in the research: (1) building orientation; (2) window size and placement; (3) window-to-wall ratio; (4) skylights; (5) clerestory windows; (6) roof monitors; (7) light shelves; (8) solar tubes or light pipes; (9) internal surface reflection; (10) shading devices; and (11) glare control. These variables are examined descriptively because the available checklist contains incomplete and inconsistent entries and does not set out a sufficiently transparent scoring procedure for a validated composite performance index.

3 Research methodology

3.1 Research design

The research uses an exploratory qualitative multiple-case-study design. Its empirical basis consists of documented site visits, observations, photographs, sketches, document reviews and consultations involving administrators, technicians, tutors, students and heads of departments. For this article, the available records were re-examined, and the numerical illuminance values were recalculated from the time-specific readings reported in the case-study tables. No additional field measurements or interviews were conducted for this article.

3.2 Case selection and study facilities

The four facilities were selected because of their relevance to vocational training and their architectural planning. Three are in Nigeria and one is in Germany, providing a local and international basis for comparison.

Table 1. Case-study facilities and documented features.

Case	Location	Documented programme and architectural features
Women in Agriculture and Youth Empowerment Foundation (WAYE)	Doi Village, Jos South, Plateau State	Vocational training, workshops, classrooms, laboratories, ICT, hostel and administration; courtyard and side-lighting described.
Government Science and Technical School (GSTS)	Bukuru, Plateau State	Multiple technical trades in separate departmental buildings; high-level windows and skylights in selected workshops.
Sani Abacha Youth Centre (SAYC)	Panshekara Road, Kano, Kano State	Workshops, classrooms, multipurpose hall, hostel and recreational facilities; high-level workshop windows.
Gebhard Muller Vocational Training School (GMVT)	Landkreis Biberach, Germany	Classrooms, workshops, corridors, sports facilities and cafeteria; two atria, skylights, solar-control glazing and automated external blinds.

3.3 Data sources and collection

The research draws on observations, photographs, field notes, sketches, available drawings, document analysis, interviews and group discussions. Architects, technicians and administrators are identified as the principal informant groups; tutors, students and heads of departments are also listed as relevant participants. The available documentation does not state the number of participants, include the interview guide or verbatim transcripts, describe consent procedures, or explain a systematic qualitative coding process. Interview material is consequently used only as contextual background. No numerical findings or direct participant quotations are attributed to it.

3.4 Daylighting checklist

The eleven variables listed in the analytical framework above were used to record whether daylighting features were present and how adequate they appeared. In editing the article, the case-level checklist tables were checked against the consolidated comparison table. Their entries and reported percentages do not consistently agree. Some tables leave variables unmarked; others record both the presence and absence, or both adequate and inadequate provision, of the same feature. The consolidated table also applies a 5.5-point increment without explaining its basis. The checklist is therefore retained as a qualitative inventory, while composite scores and percentage rankings are excluded from the validated findings.

3.5 Illuminance readings and recalculation

For each of the four cases, the reported illuminance readings cover three workshop locations—the window zone, mid-room and rear zone—at 9:00 a.m., 12:00 noon and 3:00 p.m. The mean for each location was recalculated as the arithmetic mean of its three time-specific readings. The overall mean for each zone was then calculated from the four case means. The analysis is descriptive; no inferential statistics are applied.

The available records do not identify the lux-meter make or model, calibration status, sensor orientation or height, exact measurement coordinates, measurement dates, weather or sky conditions, external horizontal illuminance, electric-lighting status, or whether readings were repeated. These omissions prevent calculation of the daylight factor, estimation of annual daylight autonomy, quantification of measurement uncertainty and verification of compliance with a workplace-lighting standard. The reported values are therefore treated as documented spot measurements, not as the outcome of a fully reproducible daylight-measurement campaign.

3.6 Study area and design context

The proposed facility is situated in Jos East Local Government Area, Plateau State. The research describes the wider Jos area as experiencing wet and dry seasons and identifies rainfall, wind, temperature, humidity, cloud cover and topography as relevant site and climatic factors. These conditions should inform building orientation, shading, rain protection, natural ventilation and the selection of daylight openings. Site-specific weather files and measured microclimatic data were not available for this analysis.

4 Results

4.1 Architectural daylighting observations

4.1.1 WAYE Foundation, Jos

The WAYE case concerns a vocational empowerment facility established in 2009. Its accommodation includes workshops, classrooms, laboratories, ICT facilities, hostel accommodation, administration, a multipurpose hall and a restaurant. The documented daylighting approaches are courtyard lighting and side-lighting through glazed openings. Light-coloured interior finishes are also identified as a means of improving internal reflection. The appraisal notes that the window openings are relatively small and that external shading is absent. Although the courtyard may provide a useful daylighting opportunity, the available records do not give its dimensions or quantify its contribution to indoor daylight.

4.1.2 Government Science and Technical School, Bukuru

GSTS accommodates several technical departments, including building, agricultural mechanization, motor mechanics, radio and television, electrical installation, refrigeration and air-conditioning, welding and fabrication, furniture craft, plumbing, carpentry and joinery, and hairdressing. The case records describe departmental buildings containing workshops, classrooms, staff offices and stores. High-level windows and skylights are identified in selected workshop roofs. The observations also describe generous workshop areas and headroom, but note limited shading, shortcomings in rain protection and inadequate landscape provision.

4.1.3 Sani Abacha Youth Centre, Kano

SAYC contains workshops, classrooms, a multipurpose conference hall, hostel accommodation, an open-air theatre, restaurant, swimming pool and sports facilities. Its vocational programmes include carpentry, welding, automobile mechanics, electrical installation, refrigeration and air-conditioning, leatherwork, printing, livestock production, mobile-phone repairs, computer training and handicrafts. The observations record long, high-level workshop windows and lower-level openings serving offices and stores. Daylight is reported to be stronger near the workshop sides than at the centre, raising the possibility of investigating skylights as a supplementary strategy. Courtyards and landscaped recreational areas are also documented.

4.1.4 Gebhard Müller Vocational Training School, Germany

GMVT is a three-storey complex arranged around a central hall. It contains two atria, classrooms, workshops, corridors, sports halls, a cafeteria, conference spaces and stores. The case records describe daylight entering through the atria, skylights and high-level windows, alongside a façade system with light-diverting elements. They also identify solar-protection glazing with a stated g-value of 0.21, internal fabric sun protection in the atria and automatically controlled external blinds. Together, these features suggest a coordinated approach to admitting daylight while controlling solar exposure. The observations also note long corridors and the distance of some conveniences from workshops and classrooms.

4.2 Recalculated illuminance results

Table 2 reports the recalculated arithmetic means, rounded to the nearest whole lux. Each case-specific mean is based on the nine readings shown in the source tables: three measurement times at each of three positions.

Table 2. Recalculated mean illuminance by workshop zone.

Case study	Window zone (lx)	Mid-room (lx)	Rear zone (lx)	Case mean (lx)
WAYE Foundation, Jos	360	297	237	298
GSTS, Bukuru	413	330	277	340
Sani Abacha Youth Centre, Kano	330	300	267	299
Gebhard Muller Vocational Training School	433	350	330	371
Mean across four cases	384	319	278	327

Across the four facilities, mean reported illuminance falls from approximately 384 lx at the window zone to 319 lx at mid-room and 278 lx at the rear. The difference between the window-zone and rear-

zone averages is approximately 28%. This pattern occurs in all four case studies: in each facility, the rear-zone mean is lower than the corresponding window-zone mean.

4.3 Checklist and feature inventory

The checklist records show that orientation, window size and placement, and internal surface reflection were considered across the cases, while the provision of top-lighting and solar-control elements differed. The consolidated assessment table assigns 5.5 points to each marked feature and reports totals of 16.5, 27.5, 22.0 and 38.5 for WAYE, GSTS, SAYC and GMVT, respectively, although it labels these totals as percentages. Because neither the scoring denominator nor the rationale is stated, and because the individual case tables contain conflicting entries, these totals cannot be treated as valid percentages or comparative performance scores. The qualitative evidence instead indicates that GMVT documents a more integrated combination of atria, skylights and shading measures. The Nigerian cases rely mainly on side-lighting, with high-level windows and skylights in some facilities.

4.4 Summary of results

- All four cases show a decrease in reported illuminance from the window zone to the rear zone.
- Side-lighting is identified as a common daylighting strategy across the Nigerian case studies.
- Selected high-level openings and skylights are described at GSTS and SAYC; the WAYE case includes a courtyard strategy.
- GMVT documents the most integrated combination of atria, skylights, high-level openings, solar-control glazing and automated external blinds.
- Checklist percentages and the 5.5-point comparative score are internally inconsistent and are not used as validated performance indicators.

5 Discussion

5.1 Interpretation of the illuminance gradient

The consistent decline in mean illuminance from the window zone to the middle and rear of each workshop points to a key design issue: side-lighting on its own may not distribute light evenly across deep workshop plans. The mean across the four cases decreases from 384 lx near the windows to 278 lx at the rear. In the reported snapshots, therefore, the rear working areas received substantially less measured light. This pattern accords with established daylighting research, which shows that illuminance commonly decreases with distance from a side-light aperture (Galatioto and Beccali, 2016; Tregenza and Mardaljevic, 2018). The findings must still be read cautiously because the measurement conditions and instrument details were not recorded.

The 300–750 lx range used in the initial assessment should not be applied as a universal standard across all trades and workshops. EN 12464-1:2021 specifies maintained illuminance according to the task or activity area and also addresses uniformity, visual comfort and glare. For that reason, this article does not use the reported readings to classify any space as compliant or non-compliant. A future assessment should identify the visual tasks undertaken in each trade and compare measured and simulated results with the relevant task-specific criteria (British Standards Institution, 2021; European Committee for Standardization, 2021).

5.2 Comparative lessons from the four facilities

The WAYE case illustrates how courtyards may bring daylight and environmental relief into a building complex. However, the relatively small openings and absence of documented external shading point to opportunities for improvement. GSTS demonstrates the use of high-level openings and selected skylights in technical workshops, although the records also note a lack of shading. SAYC relies on high-level side windows; its workshop perimeter is reported to be brighter than the centre. These observations suggest that top-lighting or additional bilateral openings could be assessed, provided glare and heat gain are controlled.

GMVT provides a useful example of combining daylighting strategies rather than relying on a single device. Atria can admit daylight into shared internal spaces, while skylights and high-level openings may serve deeper areas. Automated external blinds and solar-control glazing help manage direct solar exposure. The full system should not necessarily be transferred to Jos East as a package. Its relevance lies in the broader design principle: daylight admission needs to be coordinated with solar control, building geometry and user requirements.

5.3 Architectural implications for the proposed centre in Jos East

The proposed centre is planned to accommodate sixteen trades: catering; knitting; tailoring and fashion design; soap and pomade production; automobile mechanics; welding and fabrication; woodwork and joinery; agricultural mechanization; electrical and electronics work; phone and laptop repairs; bags and leatherwork; shoemaking; interior decoration; beauty services; bead making; and computer training. The source also classifies the functions into quiet, semi-quiet, semi-noisy and noisy zones. Daylighting decisions should follow this functional arrangement and take account of the equipment, work surfaces and safety requirements associated with each trade.

- Orient and arrange building blocks after a site-specific sun-path and obstruction study. Do not rely on an unqualified rule that one orientation is always best.
- Design workshop depth and window-head height together. High-level openings can improve penetration while preserving wall area for benches, storage and equipment.
- Use bilateral or multilateral side-lighting where site conditions permit, especially in deeper spaces where single-sided openings create strong gradients.
- Consider roof monitors, clerestories or skylights in large-span workshops only after assessing direct sun, glare, solar heat gain, rain protection, maintenance access and structural coordination.
- Provide external shading selected by façade orientation; horizontal overhangs, vertical fins, louvers or adjustable blinds should be selected through sun-path analysis.
- Use light-coloured matte ceilings and walls to support diffuse reflection, while avoiding glossy work surfaces that may create reflections.
- Use courtyards or light wells where they can serve internal zones without creating excessive heat, rainwater or security problems.
- Coordinate daylight openings with task layouts so that critical work surfaces are not placed in direct glare zones or permanent shadow.
- Use task-specific maintained illuminance, uniformity and glare criteria for each trade rather than applying a single illuminance range to all rooms.
- Undertake climate-based daylight simulation using a representative weather file for Jos, followed by on-site verification when the building is constructed.

5.4 Recommended validation protocol for the design stage

A reproducible assessment of the proposed design should use a calibrated lux meter, with its sensor positioned horizontally at the work-plane height appropriate to the task. A measurement grid should cover the full task area and its immediate surroundings; grid spacing and point locations should be recorded on a plan. Where daylight factor is to be calculated, indoor illuminance should be measured at the same time as outdoor horizontal illuminance. Each measurement record should state the date, local time, sky condition, external obstructions, window and blind positions, electric-lighting status, sensor orientation and instrument calibration details. Measurements should be repeated under representative sky conditions and, where practicable, in more than one season. Annual daylight performance should be assessed through climate-based simulation using hourly weather data and clearly documented assumptions.

5.5 Contribution to architectural knowledge and practice

This article offers a context-specific synthesis of daylighting considerations for vocational-training architecture in Jos East. Its main contribution is not a validated ranking of the four case studies. Rather, it identifies a recurring issue in workshop daylight distribution and translates comparative architectural observations into design guidance. It also shows why transparent measurement procedures and clearly defined checklist scoring are necessary when daylight performance is compared across buildings.

6 Conclusion

The article examined daylighting principles relevant to a skills acquisition centre in Jos East through a qualitative comparison of four vocational training facilities. The reported illuminance readings show a consistent decline from window zones to mid-room and rear zones. Across the cases, the recalculated means are approximately 384 lx at the window zone, 319 lx at mid-room and 278 lx at the rear. The case descriptions indicate that the Nigerian facilities rely mainly on side-lighting, with selected high-level openings, skylights and courtyard features. The German facility combines atria, skylights, high-level openings and automated external shading.

The findings point to the value of an integrated architectural approach in which orientation, room depth, fenestration, top-lighting, surface reflectance and shading are designed as a coordinated system. However, the available records do not contain enough measurement metadata to establish compliance with a lighting standard or determine annual daylight performance. Inconsistencies in the checklist scores also prevent a reliable quantitative ranking of the cases. The findings should therefore be understood as descriptive and design-oriented, not as a definitive evaluation of building performance.

7 Recommendations

1. Adopt task-specific lighting criteria for each workshop and learning space in accordance with the applicable workplace-lighting standard and relevant Nigerian requirements.
2. Develop a daylighting strategy for each functional zone, based on trade activities, equipment layouts, room geometry and solar exposure.
3. Use simulation and documented field measurements to assess illuminance distribution, uniformity, glare and annual daylight availability.

4. Prioritize external solar control and high-level or bilateral daylight openings where appropriate to reduce the window-to-rear illuminance gradient.
5. Retain full measurement logs, instrument calibration records, site plans, photographs and interview documentation for research transparency.
6. Revisit the checklist and scoring system before any further quantitative comparison; define each indicator, response category, weighting and denominator.

8 Limitations

This article draws on the empirical records available for the research and does not report new field measurements. The documentation omits key details about the illuminance instrument, calibration, sensor height, precise measurement locations, dates, sky conditions, electric-lighting status and repetition of readings. The checklist tables also contain missing and conflicting entries, while the consolidated scoring method is insufficiently explained. Because the cases were selected purposively, they cannot be regarded as statistically representative of all vocational facilities. The research did not test a causal relationship between daylight exposure and trainee productivity. These limitations restrict the conclusions that can be drawn about standards compliance, comparative ranking and generalisability.

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