Spatial Documentation of Traditional Coppersmithing Workshops in Patan, Nepal: A Comparative Study

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Abstract

This research documents traditional copper smithing practices in Patan, Nepal, focusing on the methods, techniques, and spatial requirements of this craft. Traditional metal crafting is an essential facet of Nepal's cultural heritage, as exemplified by the ornate Hindu and Buddhist temples and intricate metalwork found in the country. The study emphasizes the repousse technique, which involves shaping thin sheets of metals such as copper, silver, and gold into intricate relief patterns using hammering and specialized techniques. Through comparative documentation of a residential-scale workshop and an industrial-scale facility in Patan, this research examines spatial arrangements, environmental conditions, and safety provisions. While general building codes and occupational health standards exist in Nepal, these do not provide specific guidelines for traditional craft workshops. The study explores the occupational challenges faced by craftsmen working in workshop spaces that have evolved organically within existing structures. This research has certain limitations as it focuses exclusively on coppersmiths workshops using the repousse technique, and concentrates on spatial requirements rather than broader socioeconomic and cultural factors. Nevertheless, this study establishes foundational spatial documentation that can inform future development of appropriate guidelines for traditional metal craft workshop design.

Keywords: Copper smithing, Repousse Technique, Spatial Requirements, Traditional Technology, Exploratory Study, Workspace Architecture

1. Introduction

Nepal is a country that impresses with its wealth of Hindu and Buddhist temples, monasteries, and small shrines adorned with extensive metalwork crafts in copper, brass, and bronze. Traditional metal crafting can be done by casting, hammering (repousse technique), or a combination of both techniques, producing ornamental or utilitarian objects [1].

The repoussé technique involves shaping thin sheets of ductile metals such as copper, silver, gold, into intricate relief patterns through hammering, chasing, and embossing, requiring specialized tools, stable work surfaces, and sequential heating and cooling processes [2], [3].

In the Kathmandu Valley, copper smithing is primarily practiced by the Newar community, with workshops concentrated in traditional areas like Patan, Bhaktapur, and parts of Kathmandu city. These workshops are typically established within residential compounds as ground-floor extensions or in separate structures adjacent to family homes, allowing craftsmen to maintain their traditional lifestyle while practicing their hereditary craft. While the technical mastery and cultural significance of copper smithing have been well-documented in Nepal [4], [3], the spatial and occupational conditions under which contemporary artisans practice this craft remain largely unstudied.

Traditional workshops often operate in constrained spaces with limited consideration for modern safety standards, ventilation requirements, or ergonomic workspace design [5]. Understanding the spatial requirements and operational conditions of these workshops is essential for documenting this heritage craft practice and the environments in which artisans work.

1.1 Study Area

The study area was limited to Patan in Kathmandu Valley, where workshops capable of conducting comprehensive copper smithing procedures including shaping, repousse hammering, welding, assembly, and finishing stages, were selected for analysis.

1.2 Research Problem

Traditional copper smithing workshops in Kathmandu Valley have evolved organically within residential compounds and existing structures, resulting in spatial arrangements that were not intentionally designed for industrial metalworking activities. Preliminary observations reveal that most local workshops lack systematic spatial organization, with workstations for different processes often intermixed without clear functional zoning or adequate circulation space.

Studies of metalworkers in Nepal reveal significant occupational health concerns, with 99.2% of workers experiencing accidents and injuries, and 98.4% suffering eye and ear problems [5]. Research indicates that 97.1% of metal workshops do not have safety guidelines, and most lack adequate safety equipment and emergency provisions. These health and safety challenges are directly linked to spatial conditions: constrained working areas, insufficient ventilation for fume-generating processes, inadequate lighting for precision work, and poorly organized layouts that compromise both worker safety and production efficiency.

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However, systematic documentation of how traditional copper smithing workshops are spatially organized and how artisans work within these spaces remains largely absent, creating a knowledge gap regarding the actual spatial characteristics and operational requirements of this heritage craft.

1.3 Research Aim and Objectives

The major aim of this research is to gain insight into the methods and techniques used in copper smithing in Kathmandu Valley and document the spatial characteristics of traditional copper smithing workshops.

The key objectives that this research focuses on are as follows:

- To document the process of traditional metal crafting (copper smithing) and the spatial arrangements of coppersmiths' workshops in Patan, Nepal.
- To explore spatial and operational characteristics through comparative observation of workshops operating at different scales.

1.4 Importance of Study

This research contributes to preserving traditional copper smithing knowledge by systematically documenting the processes and workspace arrangements associated with this heritage craft. By providing baseline documentation of spatial characteristics and working conditions in contemporary copper smithing workshops, this study addresses a significant knowledge gap regarding how traditional craft spaces are organized and how artisans work within them. Such documentation is essential for informing future efforts to support this heritage craft, whether through educational facility design, workshop planning, or the development of appropriate guidelines for traditional metal craft spaces.

1.5 Scope and Limitation

Scope: This research documents the procedures and techniques involved in traditional copper smithing and the spatial arrangements of workshops in Patan, Kathmandu Valley. The study focuses on comparative observation of residential-scale and industrial-scale operations, documenting their spatial characteristics and using available building codes and workplace guidelines as reference frameworks to interpret observations.

Limitations: This research focuses specifically on the repousse technique used in copper smithing as practiced by the Newar community in Kathmandu Valley, and does not encompass other metal crafting techniques such as casting or forging. The study is limited to spatial and operational aspects of workshop organization and does not address broader socioeconomic and cultural factors influencing workshop arrangements.

The findings are derived from detailed observation of two workshops selected to represent different operational scales, and should be understood as exploratory documentation rather than statistically generalizable conclusions. Environmental conditions such as lighting and ventilation were assessed through qualitative observation rather than quantitative measurement with specialized instruments. This study establishes a foundation for future comprehensive documentation of traditional craft workshop conditions in Nepal.

2. Literature Review

2.1 The technique of hammering "en repoussé"

The repoussé work is completed in multiple stages: first, the raw metal is hammered into a domed or hollow shape on anvils; second, the metal surfaces are chased and embossed to generate fine reliefs. This work is done on a warm base of "chaser's pitch" which is a viscous mixture created from tree tar, brick powder, resin, wax, and oil, heated and blended according to each workshop's formula in large iron pans.

As shown in Figure 1, the metal piece is fixed to heated chaser's pitch and weighted down with stones or metal until cooled to prevent separation. Light chiseling-hammers then drive hand-guided punches to shape the metal into relief patterns [4], [3]. This process requires stable work surfaces and adequate space for both the pitch-embedded workpiece and the array of specialized tools used by artisans.

Figure 1. Repoussé Hammering on a Traditional Anvil

The sheets are worked on specific anvils known as Chalasin and Khalu (Figure 2), or hammered into wooden negative molds. These anvils must be very heavy or fastened directly to the workshop floor in large wooden bases since they are subjected to millions of hammer blows [3], requiring stable flooring and sufficient clearance space around each workstation for the craftsman's movement during hammering.

Because hammering hardens the metal and makes it brittle, the piece must be repeatedly heated until it reaches a dark red glow, then cooled quickly in water or sand. This "intermediate annealing" causes recrystallization, making the metal soft and workable again [4], [6]. This repeated heating and cooling cycle necessitates furnaces or heating equipment and water/sand quenching areas within the workshop space.

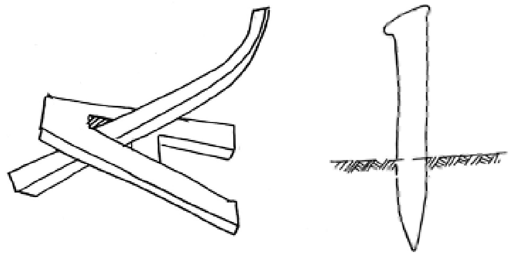

Figure 2. Chalasin (left) and Khalu (right)

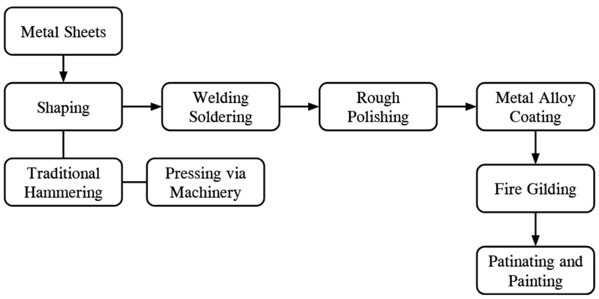

Figure 3. Work Procedure in Copper smithing Workshops

The copper smithing process follows a sequential workflow from raw material processing through final finishing (Figure 3). This production sequence has direct implications for spatial organization: effective workshop layouts position workstations to minimize backtracking and facilitate material flow from one processing stage to the next. The spatial assessment in this study considers whether existing workshop layouts support or hinder this operational logic.

2.2 Assembly and Joining Processes

Larger or complex copperware pieces are constructed from multiple components that are shaped separately and then assembled. The separate portions are joined together through various techniques including riveting, soldering, flanging (folding edges together), and in contemporary practice, welding [7].

Heavy or large objects may require internal iron frames for additional support and stability. These assembly and joining processes require dedicated workspace within the workshop, as they involve different equipment and safety considerations compared to hammering and shaping activities. Welding and soldering workstations require adequate ventilation due to fumes generated during the heating process, proper lighting for precision work, and separation from other work areas to manage heat and fire safety risks.

2.3 Industrial Workshop Spatial Standards

While craft-specific workshop standards are limited in architectural literature, established principles for industrial workspace design provide useful reference points for understanding spatial requirements in metalworking environments. Neufert's architectural standards for metal workshops offer insights into functional organization and spatial allocation that can be adapted to traditional copper smithing contexts, given the operational similarities between these metalworking practices [8].

Sheet metal workshops share fundamental processes with copper smithing facilities: cutting and shaping raw materials, hammering and forming metal, joining components through welding or soldering, and finishing through grinding and polishing as shown in Figure 4. Both types of workshops require dedicated zones for different activities, careful consideration of workflow sequences, and attention to safety requirements associated with heat, noise, and material handling. The technical similarities in these metalworking processes make industrial workshop standards relevant comparative reference points for understanding traditional craft workshop spatial arrangements.

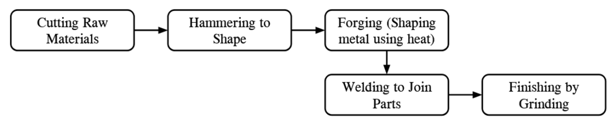

Figure 4. Work Process in Sheet Metal Workshop

According to Neufert (2012), a functional metalworking workshop requires distinct spatial zones for different activities, including raw material storage, primary working areas, machine or equipment spaces, heating or forging facilities, assembly areas, and finished product storage. Spatial allocation guidelines suggest that storage areas should constitute 20-30% of total workshop area, while primary metalworking space should occupy 30-35% of the facility. Activities involving heat, such as welding and forging, should be grouped adjacently or segregated to consolidate fire safety measures and ventilation systems.

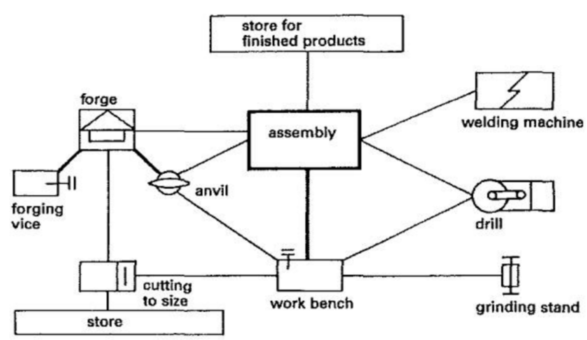

Figure 5. Spatial Arrangement in Metalworking Workshops [8]

Circulation and clearance requirements emphasize adequate space between workstations to prevent workflow interference and allow safe movement of materials and equipment. The positioning of heavy equipment, such as anvils, forges, and pressing machines, requires stable flooring and sufficient clearance for operator movement and tool access.

These general principles, while derived from modern industrial contexts, offer adaptable frameworks for understanding how traditional coppersmithing workshops can be spatially organized. The spatial and functional requirements identified in industrial metalworking contexts provide a foundation for interpreting the spatial characteristics observed in traditional craft workshop settings.

2.4 Nepal Building Code Requirements

The Nepal National Building Code (NBC 206) provides architectural design requirements for various building types, including industrial facilities. Under this code, copper smithing workshops are classified as Group G (Cottage and small industries), defined as buildings or structures where products or materials are fabricated, assembled, manufactured, or processed.

While NBC 206 establishes baseline spatial and environmental requirements for industrial buildings, these standards do not specifically address the unique operational characteristics of traditional craft workshops. Table 1 summarizes relevant NBC 206 parameters that provide reference points for understanding functional workspace requirements in metalworking environments.

These building code provisions establish baseline spatial and environmental requirements against which traditional craft workshop conditions can be contextualized [9].

2.5 Occupational Health and Safety Standards

The Government of Nepal has established Occupational Health and Safety (OHS) standards addressing workplace conditions, including regulations for lighting, noise exposure, and personal protective equipment. These standards provide reference points for understanding functional requirements in metalworking environments, though they are not specifically tailored to traditional craft workshop contexts.

Lighting standards establish recommended illumination levels based on task precision requirements. For precision tasks such as jewelry and watch manufacturing, the OHS standard specifies 1000 lux (comparable to daylight on an overcast day), a benchmark directly applicable to repousse metalwork where artisans execute intricate chasing and embossing requiring high visual acuity. The OHS standards also specify noise exposure limits based on duration (ranging from 90 dBA for 8-hour exposure to 115 dBA for 15 minutes), recognizing that hammering and grinding operations in metalworking generate significant noise levels requiring workplace management.

Table 1. Relevant NBC 206 Parameters for Industrial Buildings

S.No.	Parameter	Requirement
1.	Min. ceiling height (hilly/mountainous regions)	3.2 meters
2.	Occupancy load standard	Maximum 9 sq.m per occupant
3.	Min. corridor width	1.25 meters
4.	Max. travel distance to exits	30 meters (extendable to 40m with external corridors $\geq$ 15m)
5.	Exit door dimensions (min.)	1.0m width × 2.1m height
6.	Natural light and ventilation	Recommended for habitable rooms

Personal protective equipment (PPE) requirements are defined based on specific workplace hazards. Table 2 summarizes mandated PPE for operations commonly found in copper smithing workshops.

Table 2. OHS Personal Protective Equipment Requirements

S.No.	Operation Type	Required PPE
1.	Welding and grinding	Welding screens/goggles, steel-toed safety shoes, leather gloves, aprons, leg guards
2.	Working with hazardous chemicals (acids, finishing agents)	Respiratory masks, chemical-resistant rubber gloves, chemical-resistant boots, safety helmets, safety goggles

Beyond equipment provisions, the OHS framework emphasizes workplace welfare facilities including first aid provisions, adequate rest areas, access to clean drinking water, and proper sanitation facilities. Employers are responsible for providing appropriate PPE at no cost to workers and ensuring proper training in equipment use [10]. These occupational health standards provide reference frameworks for contextualizing working conditions observed in traditional craft workshops.

3. Methodology

This research employs a qualitative comparative case study approach to document spatial requirements and operational characteristics of copper smithing workshops in Patan, Kathmandu Valley.

Data Collection: Two copper smithing workshops in Patan were selected through purposive sampling based on the following criteria:

1) **Comprehensive production capability**: Workshops capable of executing the complete copper smithing process from raw material shaping through finishing, as many small-scale workshops specialize in only specific stages of production.
2) **Scale diversity**: Selection of one residential-scale workshop and one industrial-scale workshop to enable comparative observation across different operational contexts
3) **Accessibility**: Willingness of workshop owners to grant access for observation and data collection.
4) **Operational status**: Actively functioning workshops with employed craftsmen performing daily operations

Field visits involved direct observation, spatial measurements, visual documentation, and informal interviews with artisans to gain insights on their perspectives of working in traditional workshop environments. Case Study I required two visits (3-4 hours total) due to operational schedules, while Case Study II was documented in a single 3-hour visit. Data collected included workstation dimensions, circulation patterns, zoning arrangements, ventilation and lighting conditions, safety provisions, and artisan experiences regarding spatial adequacy and occupational challenges.

Data Analysis: The collected data were analyzed by comparing spatial arrangements, workstation dimensions, circulation patterns, environmental conditions, and safety measures between the two workshops. Nepal Building Code (NBC 206), Occupational Health and Safety (OHS) standards, and industrial workshop design principles [8] were used as reference frameworks to interpret observations and contextualize spatial characteristics. Environmental conditions such as illumination and ventilation were assessed through qualitative observation based on visibility for precision tasks, presence of natural light sources, type and distribution of artificial lighting, and observed air circulation patterns.

4. Case Studies

4.1 National Case Study I: Residential-Scale Workshop

1) Workshop Context and Scale

The first case study was conducted in a modest-scale workshop located in a residential area of Lagankhel, Patan, positioned 50 meters east of Batuk Bhairav Temple and approximately 500 meters north of Patan Industrial Estate. Spanning an area of 158 square meters, the workshop operates on the ground level of a residential building and accommodates up to 12 craftsmen working simultaneously. This workshop represents the residential-scale typology where copper smithing operations are integrated within family residential compounds, reflecting the traditional practice of hereditary craft transmission within domestic settings.

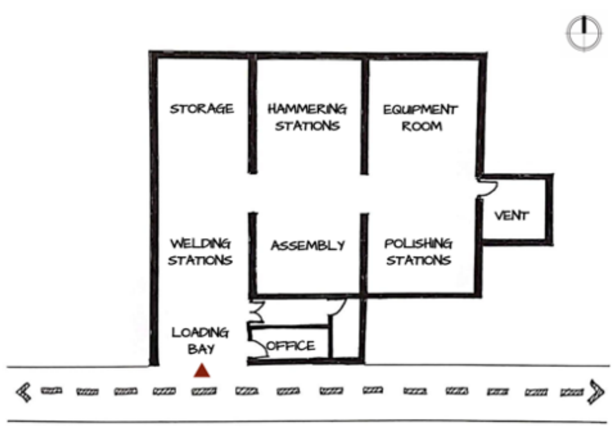

Figure 6. Spatial Layout of Workshop (Case Study I)

2) Spatial Characteristics and Organization

The workshop exhibits a haphazard spatial arrangement with no clear zoning of different work activities. Workstations for hammering, welding, and polishing are intermixed without designated functional areas, creating workflow overlaps. The layout lacks systematic organization of production stages, with the welding station positioned centrally, blocking access to other workstations and impeding circulation.

Ceiling height throughout most of the workshop measures 3.0 meters. The metal alloy coating area, located at the periphery of the workshop, is open to the sky and measures 2.6 meters by 2.6 meters, providing natural ventilation for this heat-intensive process. Circulation paths within the workshop are narrow, measuring approximately 1.2 meters in width. These constrained pathways create difficulties in moving materials and equipment between workstations.

Ventilation throughout the workshop is severely limited, with most areas having only a single ventilation shaft and minimal window openings. The shaping area, which houses the lathe machine (1.8 meters by 0.36 meters), is particularly poorly ventilated with only one door for air circulation and no windows. Artificial lighting is the primary illumination source, consisting of single bulb fixtures in each work area. Visual observation indicated extremely dim conditions with inadequate task lighting at workstations.

Individual workstations are minimally sized. The welding station occupies only 1.5 meters by 1.5 meters for a single person, while polishing stations measure 1.5 meters by 1.8 meters. These compact dimensions provide limited space for tool storage and operator movement. Workstations are separated only by a 100mm raised platform with no physical barriers between different activities.

Safety provisions are minimal. Workers use gloves for handling materials and goggles during welding and soldering operations, but no other protective equipment is provided. A single fire extinguisher is present, but the workshop lacks designated emergency exits, or dedicated rest areas for workers.

3) Artisan Perspectives and Working Conditions

The workshop employs artisans ranging from 18 to 45 years of age, operating through an informal mentoring system where younger craftsmen learn from experienced elder workers. This proximity-based knowledge transfer represents traditional generational skill transmission within the craft.

Regarding spatial adequacy, artisans expressed general satisfaction with compact workstation dimensions, noting that most products manufactured are limited to 1-2 feet in height, making the available workspace functionally sufficient for their production needs. Several craftsmen indicated preference for traditional ground-level working positions using conventional anvils, though this practice was associated with complaints of back and spine pain from prolonged stooped postures.

Occupational health concerns centered primarily on noise exposure, with artisans reporting hearing difficulties after working eight-hour shifts in the hammering-intensive environment. Minor accidents occur during welding, grinding, cutting, and hammering operations, with artisans emphasizing their careful approach to handling heat and hazardous materials.

Regarding personal protective equipment use, artisans demonstrated selective adoption based on task requirements. Gloves and goggles are used during machine operations, welding, heating processes and general sanding activities. However, craftsmen expressed reluctance to use PPE during intricate hammering and precision detailing work, stating that gloves interfere with the tactile sensitivity required for fine repoussé techniques.

4.2 National Case Study II: Industrial-Scale Workshop

1) Workshop Context and Scale

The second case study was conducted at a workshop located within Patan Industrial Estate, established in 2025 BS. Occupying 255 square meters, this facility specializes in producing singing bowls, bells, and hammered gongs, primarily for export markets. The workshop accommodates 18 craftsmen and includes both production spaces and a showroom for retail sales. This workshop represents the industrial-scale typology with purpose-built facilities designed to accommodate comprehensive metalworking operations within a dedicated manufacturing environment.

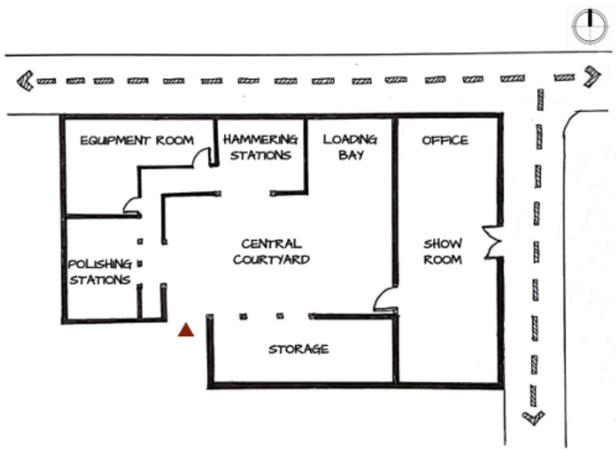

Figure 7. Spatial Layout of Workshop (Case II)

*2) **Spatial Characteristics and Organization***

The workshop demonstrates significantly better spatial organization compared to Case Study I, with clear functional zoning of different work activities. The facility is organized around a central open courtyard that serves as both a circulation hub and natural ventilation source. Workstations are segregated into distinct zones for hand-crafting activities and machinery operations, with semi-open areas providing adequate airflow throughout the workspace.

Ceiling heights vary according to functional requirements. Hammering stations and general work areas have ceiling heights of 3.6 meters, providing excellent air circulation. Heat-related areas, including forging and heating spaces, feature ceiling heights of 12 meters to accommodate thermal convection and prevent heat accumulation. Circulation paths measure 2.0 meters in width, allowing easy movement of materials, equipment, and personnel. The central courtyard acts as a circulation spine and spillover area during busy production periods, preventing congestion and workflow conflicts.

Individual workstations are more generously sized. Hammering stations measure 1.8 meters by 1.8 meters, providing adequate space for tool arrangement and craftsman movement. Welding stations occupy 2.4 meters by 2.4 meters, while polishing and finishing stations each measure 2.0 meters by 2.0 meters. The finishing area, where products are dipped in mild acid, has smaller workstations of 1.5 meters by 1.5 meters positioned near polishing stations with proper ventilation.

The metal press machine (2.75 meters by 2 meters, 2.75 meters height) is positioned below ground level to control excessive vibration. Lathe machines are kept in a separate area from the artisan's workspace, controlling noise levels while providing comfortable space. Welding areas and gas storage are segregated with concrete partitions for fire safety. Fire extinguishers and water hydrants are in place, and emergency exit routes are clearly identified. Storage areas are well organized and occupy approximately 25% of the workshop space.

*3) **Artisan Perspectives and Working Conditions***

The workshop employs artisans ranging from 18 to 50 years of age. Craftsmen expressed high satisfaction with lighting and ventilation conditions, attributing this to the large central courtyard that provides natural light and air circulation throughout the workspace. Several artisans noted that the courtyard design helps buffer noise concerns from hammering operations.

Artisans reported having optimized their workstations according to personal preference, working either on traditional ground-level anvils or elevated seats. Compared to Case Study I, craftsmen reported fewer complaints regarding back and spine pain, suggesting that larger workstation dimensions and flexibility in working position contribute to ergonomic comfort. The larger workstation sizes were noted as appropriate for manufacturing bigger products such as bells and gongs.

Artisans acknowledged risks of suffocation during acid finishing and consistently used masks and gloves for protection. For heat-related work, they wore PPE such as heat-resistant gloves and safety glasses, though these sometimes slightly hindered precision.

Minor injuries occur despite protective measures, but accidents are rare. When burns or other injuries happen, first aid is given on-site for minor cases, with nearby hospitals available for serious injuries. Artisans showed greater awareness of occupational hazards and safety protocols than those in the residential-scale workshop, though communication was more task-focused than the mentoring observed in Case Study I.

5. Findings

Comparative documentation of the two workshops reveals distinct spatial characteristics reflecting their different operational scales and contexts. The residential-scale workshop operates within constrained domestic architecture, while the industrial-scale facility benefits from purpose-built infrastructure. The following observations are organized thematically, with available building codes and workplace guidelines used as reference frameworks to interpret functional implications of observed spatial conditions.

Artisan perspectives revealed important insights regarding spatial adequacy and occupational conditions. In Case Study I, craftsmen working in compact stations expressed satisfaction for small-product manufacturing, though reported back and spine pain from ground-level work on traditional anvils. The informal mentoring system facilitated knowledge transfer through close proximity. Noise exposure over eight-hour shifts was identified as a primary health concern, with artisans reporting hearing difficulties. Craftsmen demonstrated reluctance to use PPE during intricate hammering, prioritizing tactile sensitivity required for precision repoussé work over safety equipment.

In Case Study II, artisans reported high satisfaction with lighting and ventilation provided by the central courtyard design, which also helps buffer noise from hammering operations. Larger workstations allowed craftsmen to optimize working positions according to personal preference (ground-level anvils or elevated seats), correlating with fewer reports of back pain. Artisans demonstrated greater safety awareness, consistently using masks and gloves for chemical handling and heat-resistant PPE for annealing processes, though acknowledged that protective equipment causes slight interference with precision work. Communication patterns appeared more task-focused compared to the mentoring relationships observed in the residential-scale workshop.

The dimensional analysis demonstrates that while both workshops nominally meet NBC 206's 9 sq.m per occupant standard, functional workspace adequacy depends significantly on spatial organization rather than total area alone. Case Study I's haphazard layout reduces usable space despite meeting nominal requirements, while Case Study II's organized zoning creates genuinely functional workspace for each craftsman. The central courtyard in Case Study II serves multiple functions such as circulation, ventilation, lighting, noise buffering, and spillover workspace, illustrating how architectural design can address multiple operational requirements simultaneously. A key insight from this comparison is that spatial adequacy depends more on organizational quality than total area. Although both workshops meet NBC 206's occupancy standard, workspace sufficiency varies greatly with how space is arranged, zoned, and aligned with workflow.

6. Discussion

This research documented traditional copper smithing practices in Patan and explored spatial characteristics of workshops operating at different scales. The comparative observations reveal that workshop spatial organization reflects complex interactions between operational scale, physical context, product requirements, and artisan preferences.

6.1 Spatial Characteristics Across Workshop Scales

The two workshops represent fundamentally different typologies rather than points on a quality continuum. The residential-scale workshop operates within existing domestic architecture where copper smithing has been integrated through organic adaptation. Compact workstations reflect this evolutionary development and suit the small products (1-2 feet) manufactured there. Artisans expressed satisfaction with constrained dimensions while acknowledging occupational challenges including back pain from ground-level work and hearing difficulties from prolonged noise exposure. The close proximity facilitates informal mentoring and generational knowledge transfer.

The industrial-scale workshop demonstrates how intentional spatial planning addresses multiple requirements simultaneously. The central courtyard functions as circulation hub, ventilation source, lighting conduit, and noise buffer. Larger workstations accommodate bigger products while allowing artisans to optimize working positions, correlating with fewer ergonomic complaints. However, working relationships appear more task-focused rather than mentorship-oriented.

Both groups express reluctance to use PPE during precision work, citing interference with tactile sensitivity required for intricate repoussé techniques. This tension between safety standards and craft technical requirements transcends workshop scale.

6.2 Traditional Practice and Available Standards

In the absence of craft-specific workplace standards, this study used NBC 206, OHS standards, and Neufert's industrial principles as reference frameworks. These provided useful benchmarks, such as the relationship between ceiling height and air circulation, or illumination levels for precision work, while revealing important limitations.

Industrial standards do not capture spatial nuances of traditional craft practice. Both workshops nominally meet NBC 206's occupancy standard, yet exhibit vastly different spatial functionality. The residential workshop's area becomes compromised by haphazard layout, while the industrial facility's organized zoning creates genuinely usable space. This demonstrates that adequacy depends on organizational quality, not area alone.

The lighting benchmark and noise exposure standards helped interpret why artisans reported different experiences across workshops, even without quantitative measurement. These frameworks contextualized observations while highlighting the need for craft-specific guidelines that account for traditional metalworking's unique requirements: stable flooring for hammering, clearance for hand-forging movements, spaces for annealing cycles, and appropriately lit zones for precision detailing.

6.3 Study Limitations and Future Research

This exploratory study provides baseline documentation through detailed observation of two facilities. Several limitations shape interpretation of findings. The research is based on two purposively selected workshops and should be understood as preliminary documentation rather than comprehensive assessment. Environmental conditions were assessed qualitatively without instrumentation, though comparative evaluation enabled identification of substantially different conditions between workshops. While informal artisan conversations provided valuable insights, structured interviews would yield more systematic understanding of worker perspectives.

This study focused on spatial and operational aspects without addressing broader socioeconomic factors such as financial constraints, regulatory frameworks, or market pressures influencing workshop design. Future research should include systematic documentation of additional workshops, quantitative environmental measurements, structured artisan interviews centering worker perspectives, investigation of economic factors, and participatory development of craft-specific workplace guidelines balancing traditional practice with contemporary

Table 3. Observed Spatial and Environmental Conditions

S.No	Aspect	Case Study I (Residential Scale Workshop)	Case Study II (Industrial Scale Workshop)	Reference Standards
1	Workshop Area and Occupancy	158 sqm, 12 workers (13.2 sqm per worker)	255 sqm, 18 workers (14.2 sqm per worker)	NBC 206: 9 sqm per occupant minimum
2	Spatial Zoning	Intermixed activities; welding station blocks circulation	Functional zones around central courtyard; heat activities isolated	Spatial separation improves workflow and safety
3	Ceiling Height	3.0m (most areas); open to sky in coating area	3.6m (general work); 12m (heat-related zones)	NBC 206: 3.2m minimum; higher ceilings aid air circulation
4	Circulation Paths	1.2m wide, equipment creates obstructions	2.0m wide with central courtyard as circulation hub and spillover area	NBC 206 requires minimum 1.25m corridor width; wider paths accommodate material movement and reduce congestion
5	Ventilation	Single ventilation shaft with minimal window openings; machine area enclosed with one door	Open courtyard design with semi-open structures and north-facing openings provide continuous passive airflow	Adequate ventilation essential for fume-generating processes, artisans in Case II reported satisfaction with air quality
6	Lighting	Single incandescent bulb fixtures; machine area has no natural light; observably dim conditions	North-facing windows with multiple overhead fixtures; natural light through courtyard	OHS: 1000 lux (overcast daylight) for precision work; Case II reported adequate visibility
7	Noise	Artisans report hearing difficulties after 8-hour shifts	Courtyard buffers noise; artisans note reduced impact	OHS: 90-115 dBA limits based on duration; hammering generates significant exposure
8	Storage Organization	15% of total area, intermixed with active work zones	25% of total area, clearly delineated near entry/exit points	Industrial workshop guidelines suggest 20-30% allocation for combined storage
9	PPE	Gloves/goggles for welding only; resistance to use in precision work	Masks, gloves for chemicals/heat; acknowledged interference with precision	OHS mandates PPE; both workshops report craft-safety tension
10	Fire Safety	Single extinguisher; no designated exits	Multiple extinguishers; segregated gas storage	NBC 206: 30m max exit distance in case of emergency

safety requirements.

7. Conclusion

This research documented traditional copper smithing practices in Patan, Nepal, exploring the spatial characteristics of workshops operating at different scales. Through comparative observation of a residential-scale workshop and an industrial-scale facility, this study examined how spatial arrangements, environmental conditions, and artisan experiences differ across operational contexts.

The findings reveal that workshop spatial organization reflects complex interactions between scale, physical context, product requirements, and artisan preferences rather than simple adherence to standardized guidelines. The residential-scale workshop, integrated within domestic architecture, operates through organic spatial adaptation that facilitates craft transmission and suits small-product manufacturing despite occupational challenges. The industrial-scale workshop demonstrates how intentional planning can address multiple operational requirements through functional zoning and environmental design. Both contexts present distinct advantages and constraints shaped by their operational realities.

While general building codes and occupational health standards exist in Nepal, these do not provide specific guidelines for traditional craft workshops. This study used available standards as reference frameworks to interpret observed spatial conditions, revealing both useful insights and limitations when applying industrial benchmarks to traditional craft contexts. The tension between safety equipment requirements and craft precision needs, evident across both workshops, illustrates complexities that craft-specific guidelines have yet to address.

This exploratory study provides baseline documentation of copper smithing workshop spatial characteristics in Patan. In the absence of craft-specific workplace standards, this documentation contributes initial observations that can inform future work. The findings suggest that appropriate guidelines for traditional metalcraft spaces would need to balance heritage craft preservation with safety considerations while accounting for artisan preferences and the technical requirements of handcraft precision. This documentation may prove useful for educational facility design, further workshop studies, and the development of workplace guidelines that support both artisan wellbeing and the continuation of traditional metalworking practices.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Considerations

To protect the privacy and confidentiality of the participating organizations, and in accordance with their consent agreements, the case study sites have been anonymized and are referred to as National Case Study I and National Case Study II throughout this research.

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