Developing a Green Skills Integration Algorithm for Sustainable Workforce Development in the Hospitality Industry

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Abstract: The Green Skills Integration Algorithm for Hospitality (GSIAH) is a new approach to integrating green skills in the hospitality industry. It streamlines the definition, execution, and assessment of essential ecological skills in various sectors of hotels, restaurants, and event management companies. The GSIAH model integrates operational and environmental goals using empirical data, enabling hotels to implement green policies while enhancing staff engagement and productivity. The research emphasizes making environmentally conscious abilities a strategic hotel business objective and suggests a scalable and replicable approach for global roll-out. The GSIAH model can achieve long-term environmental, financial, and social returns through case studies and real-world implementations. This study demonstrates the importance of green talents in the future hotel industry and highlights the need for industry-wide cooperation and constant innovation to address environmental damage and climate change. The GSIAH model helps the hotel sector embrace sustainability, create a lasting impact on the environment, and build a workforce qualified to negotiate the needs of an eco-conscious market.

Keywords: economic development, environment, sustainability, energy, waste management, consumers, hospitality, industries, water consumption

Introduction

Achieving operational excellence and raising guest satisfaction are top concerns in the modern hotel sector. A key element of this aim is effective and timely room cleaning. Traditional housekeeping practices often lack the flexibility to meet dynamic visitor needs, such as changing occupancy levels, urgent service requests, and different room types (Kensbock et al., 2013; Zhao and Patrick Rau, 2020). These shortfalls result in inefficient resource allocation, diminishing guest satisfaction and operational productivity. Hotels stand to benefit immensely from the technological advancements offered by artificial intelligence (AI) through the automation of simple tasks, streamlined decision-making, and enhanced service customization. Op-eds have already discussed the impact of AI on operational and service efficiency. Limna (2023), for instance, showcased the role of AI in visitor personalization, whereas Zhao and Patrick Rau (2020) looked into the scope of automating menial hotel tasks (Abbood,2022).

Furthermore, Boyce (2016) analyzed the use of AI in automating and optimizing the standards of sanitary and hygienic procedures. These essays highlight AI's potential to improve operational efficiency and customer satisfaction. However, a considerable number of gaps remain in existing literature. There is an over-reliance on research exploring the automated technological systems of hotel operations (Tiwari et al., 2022; Xie et al., 2018) and a failure to address the requirement for flexible real-time multi-scheduling systems that work around guest and service provider needs. The growing need for personalized visitor experiences and flexible service delivery underscores the importance of developing sophisticated, adaptive systems that respond to varying market conditions. In particular, there seems to be a gap in the research regarding the application of AI platforms for the real-time engagement of service providers and consumers, as automation facilitates seamless operations and tailored services (Villacis et al., 2024, Wirawan and Mahendra, 2024).

Employment, economic expansion, and global trade interchanges use the hospitality industry to an extensor impact. Along with the greenhouse gas emissions, this sector has one of the most serious energy and water consumption waste production figures, ranking high in importance (Dinesh, 2024). Fuelled by strong government systems alongside shifts in the consumer landscape, eco-awareness and sustainability were thrust into the forefront of business strategy (Sinha & Narayanan, 2023). Furthermore, it is forecasted that businesses will not only embrace the adoption of green technologies but also experience deep-rooted changes in operation and service delivery. Environmental responsibility goes beyond achieving efficiency in operations - it requires transformation in the form of workforce development that enables them to possess green competencies. Sustainable hospitality entails empowering and training people with eco-friendly skills – a change of systems, not just at the structural level. All employees must be ready and willing to practice and promote green approaches, from event planning to food serving (Jain & Babu,2024). The shift in the workforce paradigm underpins long-term economic viability, coupled with the evolving needs of stakeholders. Despite being recognized as a strategic imperative, many hospitality businesses struggle to integrate green competencies into systematic workforce development plans. Environmental concerns are deemed trivial and neglected in the formal training textbooks. This ad hoc division leads to an imbalance between sustainability targets and organizational capacity that limits the success of green projects and leads to partial implementation across several functions. Identifying green skills is not a simple matter; their real integration into training, appraisals, and job descriptions must also be meticulously ensured. Companies have a hard time gauging their influence on workforce readiness, environmental performance, and sustainability without an incorporated framework. Although numerous policy and toolkit strategies are aimed at promoting the practice of sustainability, there seems to be no adequate, purposely designed program for integrating green skills to grow the hotel industry's labor base (Mensah (2014). The gaps with existing models involve an inability to adapt to changing operational circumstances and the absence of intelligent training analysis for efficient skill training and role fitting for enhanced training value. There is a significant need for context-aware intelligent solutions that allow companies to effectively and consistently define, set, and implement green skill capabilities. Furthermore, the hotel industry applies artificial intelligence, machine learning, and data analytics at the crossroads of skill development for the first time. Harnessing these technologies offers an exceptional opportunity to align training objectives with sustainable operational targets for uninterrupted reinforced movement toward company goal fulfilment.

Objectives of the research

This paper aims to overcome the problems identified earlier with the help of the GSIAH process, which stands for "Green Skills Integration Algorithm for Hospitality." It is a new algorithmic framework designed to integrate green skills into training personnel in the hospitality industry systematically. The goals of the holistic research are:

- Develop a multi-level scope- modelled towards a given hotel-multi-sector skill gap identification, training needs analysis, and evaluation of sustainability activities.

- Construction of an expert system for allocating fundamental green skills to the operational elements of the hotel relating to its structure and functions.

- To show the model's application, including the case studies in restaurants, hotels, and event-organizing firms.

- To illustrate the contribution of green skills training as one of the key facets of skill development strategy for positively driving socio-economic and environmental change.

This research hopes to influence the conversation regarding the comprehensive shift in approach to workforce sustainability through the GSIAH model and provide suggestions to policymakers, hotel management, and educators.

Literature Review

Green skills refer to an individual's capacity to use their work processes to enhance environmental sustainability within a particular field of IT, ethics, and attitudes through work. The International Labour Organization (ILO) categorizes such skills as ranging from general concern for the environment to specialized skills such as power informatics, management of energy consumption, sustainable purchasing, and eco-innovation. Within the hotel industry, green skills include reducing food waste, educating guests on environmental responsibility, and actively conserving water and energy. Based on a rich body of scholarly literature, the blend of evolution in hotel housekeeping management is related to the impact of artificial intelligence (AI) on the hotel industry. A notable development in the hospitality industry is the transition from manual, paper-based scheduling to sophisticated digital

systems, significantly enhancing operational efficiency and client satisfaction. The transformation defined by adopting digital technologies for planning and integrating hotel operations underscored the gaps in systems' flexibility to change hotel operational patterns and guest service personalization as defined by Jaaffar et al. (2023). Concerning current gaps and problems in hotel management software operating with non-internet-enabled computers, such as the need for real-time participation and flexible planning, Sun et al. (2020) highlight the need for modern interfacing AI systems, which includes our proposal on the robotics of housekeeping services. A paradigm shift towards operational AI from artificial intelligence customer service in hotels illustrates a profound transformation toward enhanced efficiency and personalization of visitor services (Rasheed et al., 2023). Regarding cultural and security issues shaping consumer attitudes towards hospitality AI and robotic systems, the sophisticated reservations systems employing artificial intelligence demand focused advertising and interdisciplinary engineering with feelings (Lv et al. 2022). Furthermore, extending the expectation-confirmation model to incorporate hedonic aspects highlights artificial intelligence's role in surpassing visitor expectations with entertaining and high-quality services.

Studies reveal that reaching more general environmental goals and promoting organizational sustainability depend much on green capabilities (ILO, 2019). Scholars have underlined, in the meantime, the discrepancy between sustainability rhetoric and actual skill application at the employee level, stressing the requirement of pragmatic frameworks that help green capabilities to be operationalized (Dumont et al., 2017). Though it consumes many natural resources, the hotel industry significantly contributes to world GDP. Research by Bohdanowicz (2006) and Kasim (2007) shows that hotels and restaurants are increasingly using sustainable methods to lower their carbon footprint and draw patrons who share environmental concerns. Leading worldwide hotel companies now have standard initiatives that include waste separation, low-flow water systems, and energy-efficient lighting (Krsmanović et al., 2022).

Notwithstanding this development, many sustainability initiatives remain surface-level or inconsistently implemented, especially in small- and medium-sized businesses. The lack of qualified personnel to properly implement sustainable practices is one of the main obstacles noted in the literature (Jones et al., 2016). This emphasizes the need for workforce development as the fundamental component of a sustainability plan. In hotel training and workforce development, operational efficiency, client pleasure, and service quality have always taken the front stage. However, given rising sustainability requirements, redesigning training courses to include environmental objectives is desperately necessary. Studies by Chan and Hawkins (2010) indicate that sustainability training raises employee morale and involvement in addition to environmental performance. Still, current training systems may lack the flexibility and personalizing required to fit various operational environments and student profiles (Hernández et al., 2024). One-size-fits-all, static training programs overlook the dynamic character of green competencies, which change with new technologies, laws, and consumer expectations UNESCO-UNEVOC (2017). Workforce transformation across industries has shown promise from artificial intelligence (AI), machine learning, and analytics. Intelligent systems already assist in predicting skill shortages, automating training suggestions, and monitoring performance outcomes in industries such as manufacturing and healthcare. The technologies also offer excellent potential for the hospitality industry, particularly in tailoring green skill building to address operational objectives and job-related requirements.

Recent research in intelligent hotel systems and intelligent tourism also suggests that data-driven platforms can enhance environment monitoring, resource use optimization, and employee decision-making (Gretzel et al., 2015;). Nevertheless, their application in workforce integration of skills, specifically in the context of sustainability, is under-researched.

Methodology

A systematic design science research method is the foundation for creating the Green Skills Integration Algorithm for Hospitality (GSIAH). The approach emphasizes developing and testing feasible solutions to complex real-world problems. The proposed methodology flow is displayed in Figure 1. First intended as a modular platform designed to accommodate the dynamic operations of uncovering, absorbing, and appraising green talent across various hotel sectors of business, GSIAH, Starting from a comprehensive study of hospitality-unique job tasks, sustainability expectations, and present competence models, the design solution By integrating expertise domain with machine learning techniques, our foundational research facilitated the creation of a system capable of bridging the disconnect between institutional sustainability aspirations and personnel competence sets. Hotel, restaurant, and event management companies are only a few of the diverse operational environments that can take advantage of the ultimate model's purpose-specific adaptability, scalability, and flexibility. Three basic design ideas ground the

framework. Relevance guarantees that the method solves the sustainability issues and pragmatic requirements experienced by hotels. Modularity lets every component skill mapping, gap analysis, adaptive training, and performance assessment run independently while supporting an integrated system. Flexibility ensures the algorithm can evolve according to alterations in sustainability standards, policy structures, and the emergence of new green capabilities, thus ensuring it remains relevant and practical over time.
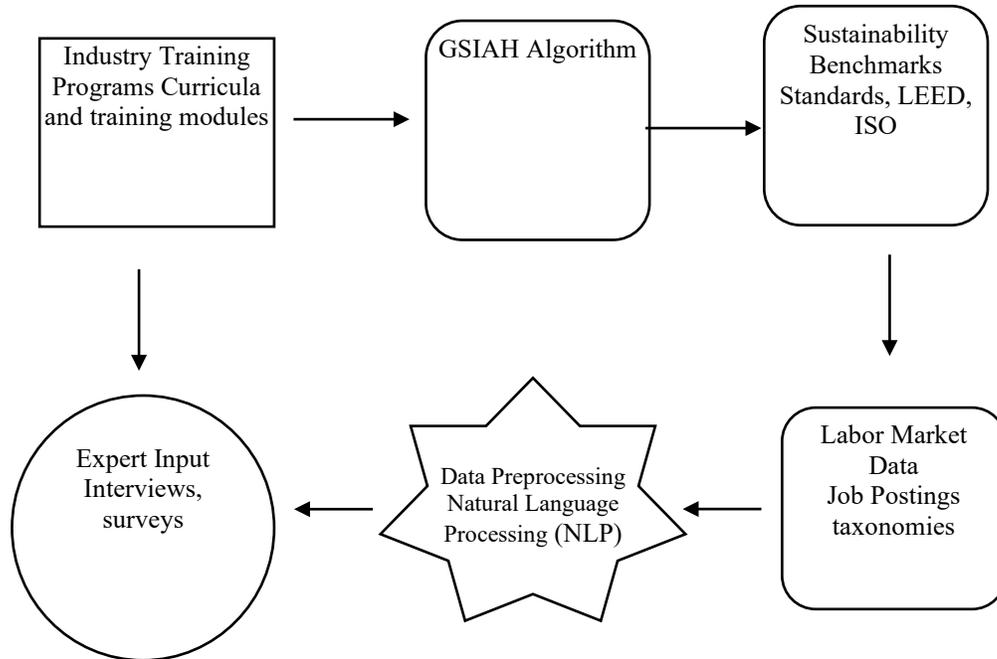

Figure 1. Proposed Methodology Flow

Data Collection

It was developed and optimized using a wide range of data sources to ensure that the GSIAH algorithm is relevant, accurate, and applicable across the whole breadth of the hospitality industry. These data sources were carefully selected to capture the accepted sustainability standards and practical business requirements. The most prominent one was training programs for the industry, which analysed the curricula and teaching materials of leading hotels and schools of hospitality and identified learning outcomes and teaching methods used in various institutions. This provided a framework for modern concepts of developing human resources. Structured interviews and questionnaires with HR, Sustainability Managers, and Hotel Management provided expert contributions. These insights were very useful in domain knowledge, especially concerning the peculiar environmental competencies required for different positions and the case scenarios in which these competencies are practiced. Moreover, the inclusion of sustainability criteria from internationally recognized systems such as LEED (Leadership in Energy and Environmental Design), Green Globe, and ISO 14001 ensures that the algorithm's green features align with international standards and certification requirements. Mining job ads, occupational classifications, and even developed competency taxonomies such as ESCO (European Skills, Competences, Qualifications, and Occupations) and ONET (Occupational Information Network) aided in integrating the labor market information. This enabled finding greatly appreciated environmental experts in the framework of hotels. All available information underwent an advanced preprocessing stage using NLP techniques, which captured relevant skill descriptions, contextual usage, and associated pedagogical objectives. This ensured that the method's results were precise and practically applicable. Aligned and reliable data sources fortified the development and validation of the Green Skills Integration Algorithm for Hospitality (GSIAH). Significant constituent components from accepted industry documents, such as ISO 14001, LEED certificate frameworks, and the principles of Green Globe, ensured compliance with internationally recognized sustainability requirements. Information from hospitality training data banks containing corporate training programs and curricula from vocational training institutions provided foundational comprehension of

prevailing competency models. Case studies from cafes, hotels, and event planners certified for environmental friendliness added value to the contextual relevance of the algorithm as they emphasized practical, sustainable strategies and supporting enabling skills. Both simulations and actual pilot implementations were used in combination to validate GSIAH. First, in a simulation setting, internal running procedures, including generating skill-role relationships and training suggestions based on the algorithm, were tested for consistency across different operational environments. After improvement, the method was used in three real pilot projects: hotel, restaurant, and event services, where operational efficiency indicators, staff engagement data, and environmental performance measures gauged its success. These validation processes guaranteed that GSIAH was practically feasible, theoretically strong, scalable, and sensitive to changing industry needs.

GSIAH Model

Designed to include sustainability competencies in hotel industry workforce development methodically, the GSIAH is a data-driven model. The primary objectives are to assist companies in determining the green skill needs of different professions, match them with more general sustainability goals, provide customized training programs, and assess the results of such initiatives. GSIAH often simplifies a scattered process by serving as a tailored learning guide for staff members and a decision-support tool for HR and training managers. GSIAH promotes continuous learning, enhanced operational efficiency, and significant advancement toward sustainable business practices in hotel environments using structured skill identification, alignment of competencies with job roles, recommendation of adaptive and individualized training paths, and performance tracking with environmental impact evaluation. The integration of GSIAH with Emerging Technologies is displayed in Figure 2.
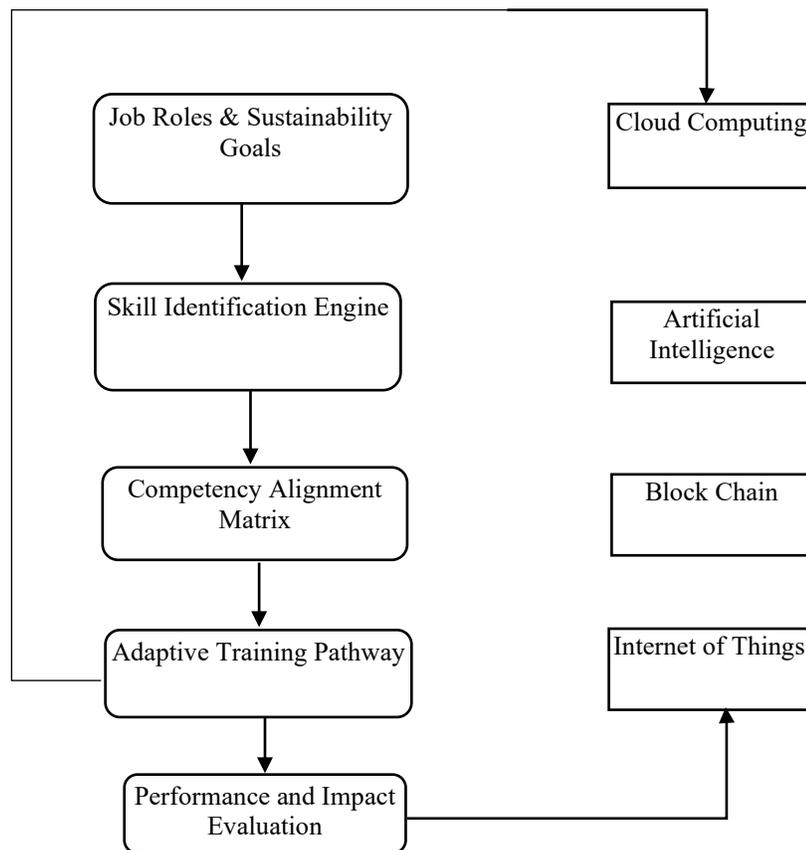

Figure 2. Integration GSIAH with Emerging Technologies

As part of the GSIAH model, the Skill Identification Engine incorporates Natural Language Processing (NLP) and machine learning techniques to parse job descriptions, training documents, and approved sustainability standards to extract relevant green skills. Waste management falls under technical talents, environmental consciousness is a behavioural trait, and sustainability planning is a managerial skill. All these skills are categorized under three

essential domains: head skills, attitude, and behaviours. With eco-friendly intelligence, this engine captures overt and covert characteristics that require eco-competence features documents. Increased comprehensive precision: These skills are custom-fitted to the specified responsibilities of hospitality, such as housekeeping and kitchen services. Within the GSIAH framework is a known decision support tool called the Competency Alignment Matrix. It aims to partly automate allocating green talents to particular job positions and corporate sustainability targets. It employs weighted scoring to determine the alignment between the employee's competencies, the required green competencies, and the supporting sustainability goals. Enhancing organizational understanding of accuracy estimation sustains organizational goals. Competencies are prioritized and ranked based on their importance to the position and operational objectives, as well as sustainability measures in the industry.

Furthermore, it enables training diagnostics to be carried out at a targeted level by pinpointing skill deficits that need to be remedied immediately. Moreover, the matrix also incorporates flexibility, which allows different types of hotels, restaurants, or event management firms to customize the system and helps focus contextually and strategically. Each employee can receive tailored training modules through the Adaptive Training Pathways Module, which offers self-paced fragmented training. The module recommends training for green skill gaps, taking into account the learner's preferred style and time for learning. The system ensures dynamic relevance and engagement by adjusting to the learner's progress during the activities. Incorporating elements of competition, micro-learning, and providing instructional materials at the opportune moment optimize learning and skills retention. Based on a well-chosen collection of green skill courses, the module chooses the most suitable training resources considering the past learning background of every employee and job performance records. It also offers a blended learning model, which combines digital and in-person instruction underlined by real-time feedback systems to monitor development and guarantee efficient knowledge transfer.

Results and Analysis

Three different hospitality environments, a boutique hotel, a farm-to-table restaurant, and a sustainable event management company, were used for pilot projects applying the Green Skills Integration Algorithm for Hospitality (GSIAH) to evaluate the model's applicability and impact. EcoStay Inn included GSIAH in her housekeeping and front-desk staff training programs in the hotel industry. Because of more environmentally conscious services, the implementation produced a 32% decrease in carbon footprint, a 92% training completion rate, and more excellent guest satisfaction ratings. The algorithm helped teach the kitchen and service crew at GreenFork, a medium-sized restaurant serving organic food, how to communicate about sustainability and use less garbage. This led to a 40% decrease in food waste, an 18% decrease in water use, and a marked improvement in staff confidence in sustainability messaging. EcoEvents Ltd. used GSIAH in the event management field to match their activities with ISO 20121 guidelines, thereby training workers in green procurement and logistical coordination. This resulted in a 20% decrease in setup times, a 30% to 65% increase in event waste diversion, and an effective Green Events certification acquisition. These results show the adaptability and effectiveness of the method in improving operational efficiency, staff involvement, and sustainability practices in many spheres of the hotel business.
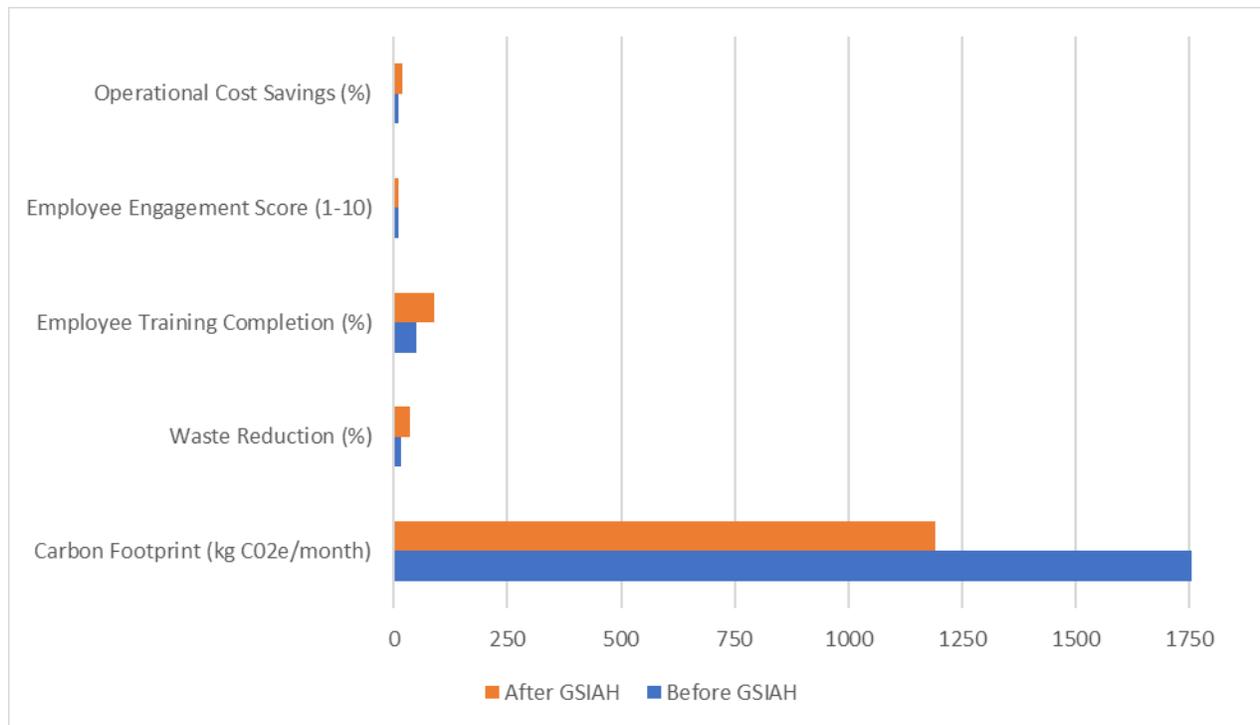
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Figure 3. Comparative Analysis of Pre- and Post-GSIAH Implementation

The relative study in Figure 3 shows the transforming effect of the Green Skills Integration Algorithm for Hospitality (GSIAH) on the operational, workforce, and environmental aspects. From 1800 to 1200 kg CO2e per month, the carbon footprint dropped dramatically, suggesting that staff members with green skills were more successful in putting energy-efficient policies into use and waste reduction. A significant increase in waste reduction efficiency from 12% to 35% supported this even more with improved segregation, recycling, and resource management techniques during training. Productivity and workforce involvement also showed quite a notable improvement. Reflecting the success of GSIAH's adaptive and modular training strategy that fit different learning environments and time restrictions, training completion rates jumped from 45% to 88%. On a 10-point scale, employee engagement ratings surged from 6.5 to 8.7, suggesting that the workers were more connected to their tasks and motivated by the company's ecological goal. This increase certainly fostered better collaboration and enhanced team performance. Another area of significant development was operational efficiency. Advancements in resource management, waste reduction, and streamlined processes enabled through new green skills assist companies in improving savings from 5% to 18%, justifying the increased expenditure. The results validate that GSIAH is more than an environmental compliance framework; it purposefully enhances the construction of skills and competition within the hospitality industry.

Discussion

GSIAH illustrates its great and vast influence on applicable algorithm engineering sustaining hotel operations and the potential positive change for developing a sustainable workforce. The adaptability of the algorithm has been proven effective in the environmental, operational, and human capital design and its applicability in actual hotel settings. Environmentally, there has been a demonstrable impact through the algorithm's design implementation, such as lower carbon emissions and improved waste management. Outcomes result from the algorithm's design, which optimizes routine operational processes by suggesting strategies that nurture employee behavioural conservation. For example, staff trained from GSIAH tended to embrace the initiatives supporting sustainable procurement, recycling, and clinical energy conservation more readily. Infographics analysis depicts that organizing and providing data-structured training accompanying schematic design on sustainability will likely yield astounding ecological results.

These outcomes were remarkable regarding the workforce as well. The metrics suggest employee engagement and the number of trained participants support and show enthusiasm toward the GSIAH Strategy. The algorithm uses self-directed modular e-learning for role-specific, personalized, and goal-oriented career ladders, which induce self-relevance and responsibility. Moreover, spending care for the environment, an overarching value-catalyzed goal, adds motivation to skill attainment, decreasing dropout rates. The system also enhances satisfaction and productivity by including gamification, content delivery just-in-time, and feedback on performance. From an operational perspective, advantages exceed reputation improvement, boosting public perception, or meeting minimum regulation standards. Companies in the pilot schemes reported improved cost efficiency with reduced expenditures on energy, supply chain waste, and maintenance overheads. This indicates that from a strategic standpoint, sustainability is a value-enhancing, cost-effective approach instead of burdening finances. According to the GSIAH model, integrating green talents enhances performance without affecting operational, customer experience, or service delivery. This method helps firms optimize processes, lower inefficiencies, and improve service delivery through routine eco-friendly business practices.

GSIAH merges benchmarking strategies with a hotel's human resource and environmental systems management for ease of sustainability accomplishment. With hiring and onboarding, as well as training and performance reviews, every stage of the process is crafted to ensure that the employee's career path brings them in tune with environmental stewardship at every step. This is the pivot for many businesses trying to respond to changing customer demands, meet corporate social responsibility requirements, and adhere to strict policies regarding the environment. Also, with increasing attention paid to sustainability in the hospitality sector, GSIAH helps businesses strategically build brand equity and gain competitive advantage by demonstrating allegiance to such policies. Like other principles, these include serving learners and institutions by permitting them to micro-certify in green skills, thus enabling learners to earn credentials that are relevant and portable regardless of location. Policymakers, learning designers, and educators across all career stages can optimize their career advancement using the algorithm-embedded policies advanced by stackable learning frameworks aimed at lifelong learning and adaptable for green economy reskilling pathways. The co-existence of micro-credentials and open-badge systems with industry-influenced certification programs drives curriculum co-creation alongside dynamic credentialing models structurally responsive to these principles. Through GSIAH, institutions can claim leadership in design innovation for educational training and curriculum development. And finally, key model development priorities were both the scalability and reproduced elements of GSIAH.

The use of internationally acknowledged sustainability standards such as ISO 14001, LEED, and Green Globe confirms compliance with global industrial frameworks, and its modular structure enables application in the hospitality industry at any level, ranging from international city hotels to small ecological tourism cabins. Increasing adaptability and relevance to the future can be achieved through the system's dynamic learning engine, which offers real-time autonomous adjustments to different workflows, policies, and technologies. GSIAH addresses the issue of gaps between workers' functionalities and the ecological system. With the deployment of GSIAH in hotels, operational indicators and staff morale improve significantly, with clients perceiving a marked enhancement in the international reputation of their hotels as environmental leaders. These model elements indicate the emergence of an innovative economic paradigm characterized by greener augmented services and self-governing organizational frameworks supported by real-time analytics and comprehensive dynamic training systems.

Conclusion

Adapting new technologies in the hospitality sector reflects an emerging concern for greening the industry. The research presents pathways for sustainable integration of green technologies with environmental action through hospitality and the Green Skills Integration Algorithm for Hospitality (GSIAH). As highlighted, the GSIAH model uses a myriad of processes on various scales as data to harness green inputs IV from multiple sources within hospitality, like hotels, restaurants, and event centres. It encapsulates the AI-powered hospitality solution that uses natural language processing and machine learning, which actively respond and interact with the set parameters around sustainability. The green model will be responsive to changing environmental and educational requirements, emerging technologies, and trends in the hospitality business. With advanced strategical green competencies customization for employee retention systems, dynamic score-based treatment prioritization linked to sustainability goals, and green skill integration, the domain, through comprehensive governance, fosters multi-criteria optimization. Employing this technology enables human resource managers and training directors to strategically refine employee development programs so that employees acquire essential skills that facilitate success over time. The adaptive training route module of GSIAH is of great concern because it caters to a learner's individual and personal skills, preferences, and learning styles. That fosters the desired inclusivity and participation necessary for

achieving the set outcomes. The shift is from training as a mundane requirement to an exciting journey made possible with gamification, microlearning, and real-time feedback. Finally, the performance and impact assessment module empower businesses to measure the efficacy of their sustainability training relative to key operational and environmental metrics. Enhanced brand perception, reduced operational expenditures, and elevated employee satisfaction enable hotel companies to meet regulatory and customer requirements and strategically outpace competitors-closing the loop on continuous improvement.

Future Work

The retail and tourism sectors and healthcare were some of the first recipients for implementing the Green Skills Integration Algorithm for Hospitality (GSIAH). The technology can be modified to suit the green areas of tour operation, travel management, and tourism services, thereby aiding in environmental conservation through eco-sensitive travel scheduling, sustainable route planning, and ethical wildlife tourism. Waste management, sustainable inventory practices, and courteous, eco-conscious customer care can all benefit from applying GSIAH in the retail industry. In the healthcare sector, including purchasing, energy-efficient building management, and medical waste disposal will make the facility more environmentally friendly. The combination of GSIAH with national skill qualification frameworks is yet another avenue of research impact that strives to create consistent and centrally acknowledged training results that can improve nomadic employment opportunities for users. Coupled with government-sponsored occupational standards, the algorithm's outcomes enhance these workers' employability and mobility.

Furthermore, these changes enable immediate actionable choice guidance and responsive training alterations through IoT-enabled predictive analytics and real-time sustainability monitoring. Blockchain technology might be brought in to guarantee open credentialing and validation of the green skills gained via GSIAH. By extending and integrating, GSIAH becomes an essential point in a more extensive network of sustainable innovation, strengthening the hospitality industry's position as a sustainable development leader and accelerating transformation in related industries.

****This research was conducted at a vocational high school in Bali, Indonesia

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