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Chief Editor's Note

The New Curriculum for 'Viksit Bharat'

A paradigm shift is occurring in Indias educational system with the National Education Policy (NEP) 2020 at its center. In order to revitalize the country's educational landscape the NEP places a strong emphasis on skill development vocational education and competency integration. Achieving this goal will primarily depend on preparing students for a more diverse labor market and integrating education with the demands of the modern workforce. Programs for vocational education must be designed with local industries and needs in mind. Vocational education can be successfully incorporated into rigorous and integrated curricula in countries like Germany and Switzerland which have dual educational systems. Students are prepared for both employment and entrepreneurial endeavors by these systems which strike a balance between learning objectives and hands-on training. India can take inspiration from these models and modify them to fit its particular social and economic situation. Quality assurance is crucial for Indian skill-training institutions. Students learning experiences and results are greatly influenced by the rubric-based assessment that is used to evaluate their competencies. There may be gaps in training as a result of the fact that many rubrics do not currently adequately represent the skills needed in the workforce. To make sure that these rubrics reflect the skills that employers are looking for and the demands of the industry they must be thoroughly reviewed. By matching these rubrics to current job roles and industry requirements graduates employability will be improved and workforce transformation will be aided. The setting in which training programs take place is an important but frequently disregarded component. The physical technological and social training environment has a significant impact on the efficacy of vocational education programs. The relationship between the variables influencing training and its results is found to be moderated by the training environment according to research. Access to up-to-date resources encouraging mentors and facilities that meet industry standards can all significantly raise the standard of education. Students home environments have a significant impact on their career goals especially in underrepresented communities. Many families choose academic streams even when their children are more suited for practical work because they are unaware of the benefits of skill education and how it can lead to fulfilling lucrative careers. This emphasizes the necessity of awareness-raising initiatives that stress the value of skill development and the variety of career options. Schools should also work with local businesses to involve families and help them make decisions about their childrens futures. To ensure high standards of hygiene and patient care in the healthcare setting training for hospital cleaning and nursing staff is essential. Training delivery has changed dramatically as a result of the explosive growth of digital media especially social media platforms. Social media has an impact on training program delivery and content according to a study examining hospital staff training requirements.

The aforementioned studies provide ideal pathways for skill development as the top choice for a future career.

(Deepak Paliwal)
Editor In Chief
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Artificial Intelligence and Vocational Education in India Bridging Policy Aspirations and Practice Realities

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Abstract

Artificial Intelligence (AI) is not only reshaping vocational education but also redefining how curricula, pedagogy, and assessments can be restructured to meet the demands of future work. While much of the existing literature emphasizes AI's potential, this paper adva nces the discussion by (i) mapping AI applications across different stages of vocational education in India as framed by NEP 2020 and NCFSE 2023, (ii) presenting a structured framework of AI tools that teachers and students can practically adopt for lesson planning, student engagement, assessment, and career support, and (iii) examining India's unique position in the global AI ecosystem to show how these trends inform vocational education policy and practice. Unlike prior reviews, this study integrates policy analysis, market data, and classroom-level applications to offer a holistic perspective. It also proposes a roadmap for responsible AI adoption that balances industry alignment with ethical considerations, reskilling needs, and human-centred learning. By doing so, the paper provides both a conceptual and practical contribution to advancing AI-driven vocational education beyond theoretical possibilities.

Keywords: Artificial Intelligence; Vocational Education; Adaptive Learning; Skill Development; Augmented Reality & Virtual Reality; AI-Driven Assessments; Industry Alignment.

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Introduction

Artificial Intelligence (AI) is transforming education by making learning more personalized, efficient, and accessible[1]. In vocational education, AI enables skill-based training through adaptive learning, virtual simulations, and smart content delivery[2,3]. The National Education Policy[4] (NEP) 2020 and the National Curriculum Framework for School Education[5] (NCFSE) 2023 emphasize the integration of AI in education to enhance learning experiences and develop future-ready skills. These policies advocate for AI-driven pedagogies that foster innovation, critical thinking, and industry-aligned competencies. This article explores the role of AI in vocational education and how it is shaping the future of skill development.

Methodology

This paper adopts a qualitative approach that combines policy analysis and thematic review of literature to examine the role of Artificial Intelligence (AI) in vocational education. The analysis draws on three main sources:

Policy Documents: Key frameworks such as the National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCFSE) 2023 were critically examined to identify how AI integration is positioned within the Indian vocational education system.

Market Reports and Statistical Data: Secondary data from global and Indian AI market studies were used to contextualize vocational education within broader AI adoption trends.

Scholarly Literature: Peer-reviewed studies, edited volumes, and recent systematic reviews were thematically analysed to identify recurring themes in AI-enabled teaching, learning, assessment, and skill development.

The literature was screened for relevance based on publication date (2020–2025), focus on AI in education or industry-aligned skill development, and policy implications. A thematic analysis approach was applied, categorizing findings into themes such as personalized learning, industry alignment, ethical challenges, and teacher professional development.

This combined methodology ensures that the paper not only synthesizes existing knowledge but also situates it within India's policy landscape and global AI market dynamics, thereby offering original insights into vocational education reforms.

Artificial Intelligence Market Size

The Artificial Intelligence (AI) market is witnessing remarkable growth both globally and in India, fuelled by rapid technological advancements and increasing adoption across industries. As of 2024, the global AI market was valued at approximately USD 214 billion and is projected to reach around USD 863.79 billion by 2030, growing at a CAGR of 32.19%. Key drivers of this growth include improvements in computational power, data availability, and widespread AI integration in sectors such as healthcare, finance, and manufacturing. Market segmentation indicates that software dominates the AI landscape, followed by hardware and services, with major technologies including machine learning, natural language processing, and computer vision. In India, the AI market was valued at around USD 1.25 billion in 2024 and is expected to grow to approximately USD 12.43 billion by 2033, at a CAGR of 27.6%. Manufacturing leads AI adoption, followed by healthcare, automotive, and retail, as industries leverage AI for operational efficiency and cost reduction. Software remains the dominant segment, with machine learning as the leading technology. Regionally, South India holds the largest market share, supported by a skilled workforce and government initiatives promoting AI development.

AI Market Comparison: India vs. Other Countries

India's Artificial Intelligence (AI) market is rapidly evolving, but it still faces significant competition from leading nations like the United States and China. Here's a comparison of India's AI market with other countries:

Current Standing

Global Ranking: As of December 2023, India ranks 15th among the top 25 AI nations, according to research by Tufts University, which emphasizes its potential for growth compared to countries like the US, China, the UK, Japan, and Germany.
Market Size: India's AI market is projected to reach approximately $8 billion by 2025, growing at a CAGR of over 40% from 2020 to 20251. In contrast, the US AI market is significantly larger, with investments surpassing $25 billion annually.

Comparative Insights

Investment Levels: In 2019, private equity investments in Indian AI companies ranged between $900 million to $1.2 billion, which was substantially lower than the US and China's investments of $25 billion and $5 billion, respectively. However, India's investment growth rate was notable, nearly tripling in that year.
Research Output: India is recognized for producing high-quality AI research and ranks

third globally in AI publications. However, it still lags behind countries like Taiwan and Germany in patent applications related to AI technologies.

Future Potential

Growth Projections: By 2030, India's AI market is expected to expand significantly, potentially reaching around $28.36 billion, driven by increasing digital adoption and innovation in sectors such as healthcare and manufacturing.
Talent Pool: India boasts a strong talent base with approximately 420,000 employees working in AI roles. The country has seen a 14 times growth in individuals skilled in AI over the past seven years, indicating a robust pipeline for future development.

What is Artificial Intelligence

AI refers to computer systems that can perform tasks requiring human intelligence, such as problem-solving, decision-making, and pattern recognition. Machine Learning (ML) is a subset of AI that enables systems to learn from data without explicit programming. Deep Learning, a branch of ML, uses neural networks to process vast amounts of information, mimicking human cognition.

How Does Artificial Intelligence Work

AI functions through algorithms that process large datasets, recognize patterns, and make decisions. One key AI technology is Natural Language Processing (NLP), which allows computers to understand and generate human language. This enables AI-powered chatbots, automated grading, and language translation tools to enhance vocational training.

Artificial Intelligence in Vocational Education

Customized Learning Outcome-Based Vocational Curriculum: AI can design personalized curricula based on students' skills, interests, and learning pace. It can recommend courses and resources, ensuring that vocational education aligns with industry requirements.
***Personalized Learning*:** AI adapts learning content to individual student needs, providing real-time feedback and personalized skill development plans. Adaptive learning platforms analyse student performance and tailor lessons accordingly.

***Artificial Intelligence Teacher/Trainer*:** AI-powered virtual tutors assist students by providing on-demand explanations, practice exercises, and assessments. These AI teachers complement human instructors, enhancing the overall learning experience.
Smart Content: AI enables the creation of dynamic educational content, including

interactive simulations, augmented reality experiences, and AI-generated lesson plans. Text-to-speech and speech-to-text tools improve accessibility.

***Smart Classroom*:** AI-powered smart classrooms utilize digital whiteboards, AI teaching assistants, and cloud-based collaboration tools to facilitate interactive learning and teamwork.

***Gamification*:** Gamification in AI-driven vocational training makes learning engaging through rewards, leader boards, and interactive challenges. AI analyses student progress and adapts difficulty levels accordingly.

***Virtual Laboratory*:** AI-powered virtual labs enable students to conduct experiments in simulated environments, reducing costs while ensuring hands-on experience in fields such as healthcare, engineering, and agriculture.

***Interactive Simulations*:** Simulations powered by AI provide realistic practice scenarios, allowing students to develop job-specific skills in a risk-free setting.

***Augmented Reality (AR) and Virtual Reality (VR)*:** AI-driven AR and VR create immersive learning experiences, enhancing skill training in areas such as manufacturing, medical procedures, and construction.

***Intelligent Competency-Based Assessment*:** AI-driven assessments evaluate students based on competency rather than traditional exams, ensuring they acquire practical skills essential for their professions.

***Artificial Intelligence-Based Supervision System*:** AI monitors student progress and engagement, providing real-time feedback and identifying areas for improvement in vocational training.

***Intelligent Student Support System*:** AI chatbots and virtual assistants offer guidance on course selection, career pathways, and skill development, providing personalized support to students.

***Artificial Intelligence in Research*:** AI enhances research capabilities in vocational education by analysing data, identifying trends, and generating insights that improve training methodologies and industry alignment.

Disadvantages of AI

AI presents several challenges, including job replacement due to automation, requiring workers to reskill and adapt to AI-driven industries. Privacy concerns arise

as AI systems collect and process large amounts of data, raising issues of data security and potential breaches. Ethical issues, such as bias in AI decision-making, can impact fairness in assessments and job opportunities. Additionally, AI models consume significant computational power, contributing to high energy consumption and environmental costs. The high cost of AI implementation poses financial barriers for vocational institutions. Moreover, over-reliance on AI in education may reduce human interaction, impacting the development of soft skills and critical thinking abilities.

AI Applications across Sectors and Implications for Vocational Education

Artificial Intelligence is being adopted rapidly across diverse industries, reshaping the skills required in the workforce. In healthcare, AI supports diagnostic imaging, personalized treatment, and drug discovery. Retail and e-commerce deploy AI in recommendation systems, customer service chatbots, and inventory management. Finance leverages AI for fraud detection, algorithmic trading, and personalized financial advice. In manufacturing, AI is applied to predictive maintenance, quality control, and process optimization. Logistics and supply chains use AI to forecast demand and optimize delivery routes, while travel and hospitality rely on AI for dynamic pricing, personalized recommendations, and virtual customer assistance.

While these examples highlight the breadth of AI's impact, their relevance to vocational education lies in the transferable skills they demand. For instance, AI-driven diagnostic tools in healthcare parallel the use of virtual labs in vocational training, offering risk-free, hands-on experiences. Predictive maintenance in manufacturing mirrors AI-powered simulations that prepare students in technical trades. Customer service automation in retail and hospitality informs how AI chatbots and virtual assistants can be integrated into training for service-oriented vocations. Similarly, the emphasis on data-driven decision-making in finance and logistics underscores the need for data literacy and analytical skills in vocational curricula.

Rather than treating these industries as separate cases, this paper positions them as indicators of the evolving competencies vocational education must cultivate. AI integration in vocational training through adaptive learning systems, immersive simulations, and competency-based assessments ensures alignment with these industry trends. By linking sectoral applications to skill development pathways, vocational education can prepare learners not only for existing roles but also for emerging opportunities in an AI-driven economy. Table 1 provides a concise summary of AI applications and their implications for vocational education.

Table 1. AI Applications across Sectors and Links to Vocational Education

Sector	Key AI Applications	Vocational Education Implications
Healthcare	Diagnostic imaging, personalized treatment, drug discovery	Virtual labs and simulations for medical/paramedical training
Retail & E-commerce	Recommendation engines, chatbots, inventory management	Training in customer service automation and digital retail tools
Finance	Fraud detection, algorithmic trading, personalized advice	Data literacy, financial analytics, and ethical AI awareness
Manufacturing	Predictive maintenance, quality control, process automation	AI-powered simulations for technical and engineering trades
Logistics	Demand forecasting, route optimization	Skills in supply chain analytics and AI-supported decision-making
Travel & Hospitality	Dynamic pricing, personalized recommendations, AI assistants	Training in service vocations with AI-driven customer support

AI Tools for Vocational Teachers within a Conceptual Framework

AI tools in vocational education should not be viewed as isolated applications but as interconnected components of a broader teaching–learning ecosystem. This paper organizes these tools into four dimensions of the vocational education cycle: Curriculum & Content Design, Teaching & Learning Delivery, Assessment & Feedback, and Student Support & Career Guidance. Together, these dimensions form a conceptual framework for integrating AI into vocational education (Figure 1).

Curriculum & Content Design: AI-powered platforms such as ChatGPT, Quillionz, and MagicSchool.ai assist teachers in generating lesson plans, quizzes, and teaching materials. These tools accelerate curriculum design, allowing educators to tailor content to student needs and industry requirements.

Teaching & Learning Delivery: AI tutors, adaptive platforms (e.g., Khan Academy AI, Century Tech), and immersive technologies like AR/VR (PhET simulations, Synthesia) enhance personalized and experiential learning. These tools enable students to engage with complex concepts through interactive and practice-oriented environments.

Assessment & Feedback: Tools like Gradescope, Turnitin AI, and Quizizz facilitate automated grading, plagiarism detection, and gamified assessments. AI makes it possible to shift from traditional exams to competency-based evaluations that better reflect workplace skills.

Student Support & Career Guidance: AI chatbots, virtual assistants, and platforms like NoRedInk AI or Century Tech offer personalized academic support, career counseling, and adaptive learning pathways. These systems ensure that students receive continuous guidance aligned with their vocational aspirations.

Table 2. AI Tools in Vocational Education: A Framework of Integration

Dimension	Example AI Tools	Benefits	Challenges
Curriculum & Content Design	ChatGPT, Curipod MagicSchool.ai	, Faster content creation, contextualized lessons	Accuracy, risk of over-reliance
Teaching & Learning Delivery	Khan Academy AI, PhET, Synthesia	Personalized tutoring, immersive simulations	Infrastructure costs, teacher training
Assessment & Feedback	Gradescope, Turnitin AI, Quizizz	Competency-based evaluation, efficient grading	AI bias, fairness concerns
Student Support & Career	AI chatbots, Century Tech, NoRedInk AI	Career guidance, adaptive pathways, continuous support	Data privacy, unequal access

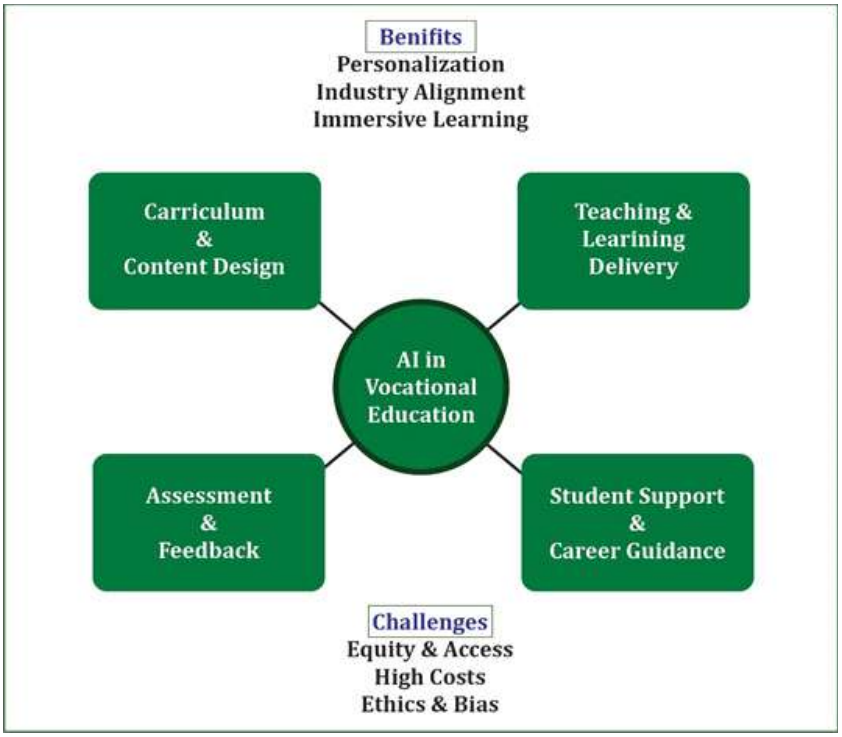


Figure 1: Conceptual framework showing AI in vocational education as a central hub, connected to four pillars, Curriculum & Content, Teaching & Learning, Assessment & Feedback, and Student Support linked to benefits (personalization, industry alignment) and challenges (ethics, cost, equity).

By consolidating diverse tools into this framework, the paper highlights how AI can systematically enhance vocational education rather than operate as fragmented solutions. This structure clarifies the relationships between AI applications, their benefits, and the challenges requiring responsible implementation.

Integrating Artificial Intelligence in Vocational Education

Middle Stage

In the middle stage of education, AI can be integrated into vocational activities to make learning more engaging and effective. Students can use AI tools to explore real-world applications of their skills, enhancing their problem-solving abilities. Bagless day activities can incorporate AI-driven interactive learning experiences, allowing students to explore various vocational fields in a hands-on manner. AI-powered projects can utilize real-world data, helping students gain insights into industry trends and develop critical analytical skills.

Secondary Stage (Grades 9 & 10)

At this stage, students can engage in AI-enhanced multiskilling projects that expose them to diverse career pathways. AI-powered field visits can provide students with virtual and augmented reality experiences, simulating real-world workplaces. On-the-job activities augmented by AI-driven simulations and assessments can help students practice and refine their skills before entering actual work environments.

Secondary Stage (Grades 11 & 12)

For senior secondary students, AI can facilitate job-role-specific training, ensuring they acquire industry-relevant skills. AI-integrated internships and apprenticeships can provide personalized feedback and performance tracking, helping students optimize their learning. AI-based vocational subject curricula can align with emerging job markets, preparing students for future career demands.

Challenges of AI in Vocational Education and Mitigation Frameworks

The integration of Artificial Intelligence in vocational education brings significant challenges that must be critically evaluated. Key concerns include job displacement due to automation, ethical dilemmas in data usage and decision-making, and the high financial and infrastructural costs of AI implementation. While these issues are well recognized, addressing them requires structured mitigation frameworks.

Job Displacement and Reskilling: Automation threatens certain job roles, but vocational education can respond by embedding continuous reskilling and upskilling pathways. Lifelong learning models, modular micro-credentials, and industry-linked apprenticeship programs can ensure that displaced workers transition into emerging roles supported by AI. Public–private partnerships can also help design curricula that anticipate shifts in labor markets.

Ethical Concerns and Responsible AI: AI systems raise questions of bias, fairness, transparency, and data privacy. Mitigation requires the adoption of responsible AI frameworks that emphasize explainability, inclusivity, and accountability. Vocational institutions should integrate AI ethics modules into training programs to ensure that future workers understand both the opportunities and risks of working with AI. Policymakers and educators can collaborate to establish guidelines that safeguard equity in access and use.

Infrastructure and Cost Barriers: High costs of AI tools and infrastructure limit access, particularly in resource-constrained institutions. Potential mitigation strategies include shared infrastructure models, cloud-based AI platforms, and government-subsidized initiatives that reduce barriers to entry. Open-source AI tools can further democratize access, enabling vocational institutions to experiment and innovate without prohibitive costs.

By framing these challenges within structured mitigation strategies, this paper highlights the need for proactive, multi-stakeholder engagement. Preparing vocational education for an AI-driven future requires not only technological adoption but also ethical safeguards, equitable access, and sustainable skill development pathways.

Need for Training of Trainers

Vocational educators must undergo AI training to effectively integrate AI tools in teaching. Professional development programs should focus on AI literacy and best practices, equipping teachers with the knowledge to utilize AI effectively in their classrooms. Hands-on training in AI-driven vocational education tools can help educators implement technology-enhanced learning strategies. Sharing best practices for AI implementation in vocational training fosters collaboration and continuous improvement among educators.

Implications of AI in Vocational Education

The integration of AI in vocational education has profound implications for students, educators, and industries. AI enhances learning efficiency, making skill acquisition more accessible and personalized. It also ensures industry alignment, preparing students for future job roles. However, it necessitates continuous upskilling of

educators to effectively use AI tools. Additionally, while AI-driven automation improves efficiency, it may also lead to job displacement, requiring educational institutions to focus on reskilling initiatives. Ethical considerations, including data privacy and AI biases, must be addressed to ensure fair and responsible use of AI in vocational education.

Policy and Practice – Bridging Aspirations and Realities

India's National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCFSE) 2023 highlight Artificial Intelligence as a transformative force in education, particularly vocational education. These policies emphasize AI-driven pedagogies, adaptive learning pathways, immersive technologies, and competency-based assessments as future-oriented strategies. However, there exists a notable gap between policy aspirations and ground-level realities.

Policy Aspirations:

1. Integration of AI into school curricula to build digital literacy and future-ready skills.
2. Promotion of adaptive learning, AR/VR simulations, and AI-based assessments to modernize pedagogy.
3. Teacher training and professional development to build AI literacy.
4. Industry-aligned vocational programs that anticipate emerging job roles.

On-Ground Realities:

1. **Infrastructure Gaps:** Many vocational institutions, particularly in rural and semi-urban areas, lack the technological infrastructure (internet connectivity, devices, AR/VR labs) required for AI implementation.
2. **Teacher Readiness:** Professional development in AI remains limited. Teachers often lack both technical knowledge and confidence to integrate AI tools effectively.
3. **Equity and Access:** Students from disadvantaged backgrounds face barriers to accessing AI-powered tools, leading to widening digital divides.
4. **Implementation Pace:** While policy documents articulate ambitious AI integration, actual adoption at the classroom level remains fragmented and experimental rather than systemic.

Bridging the Policy–Practice Gap:

Addressing this gap requires:

1. **Infrastructure Investment:** Targeted funding and shared-resource models to ensure equitable access to AI-enabled learning environments.
2. **Teacher Upskilling:** Scalable professional development programs with hands-on

training in AI applications for vocational education.

3. **Monitoring and Evaluation:** Regular audits of AI implementation to track progress against NEP and NCFSE objectives.
4. **Industry Collaboration:** Stronger partnerships between vocational institutions and industry to co-develop AI-integrated curricula aligned with workforce needs.

By critically evaluating policy aspirations against practical challenges, this analysis underscores that India's AI ambitions in vocational education can only be realized through deliberate, sustained, and inclusive implementation efforts. Recognizing and addressing these mismatches enhances the originality of this paper by moving beyond policy rhetoric to actionable reform pathways.

Conclusion

Artificial Intelligence is transforming vocational education by making learning more interactive, efficient, and industry-relevant. AI-powered tools offer personalized training, real-time feedback, and hands-on simulations, bridging the gap between traditional education and workforce demands. By integrating AI, students gain access to adaptive learning pathways and cutting-edge technologies, enhancing their employability in an AI-driven job market. Additionally, AI facilitates competency-based assessments and industry-specific skill development, ensuring a workforce prepared for evolving challenges. However, AI integration must be approached responsibly, addressing ethical concerns like data privacy, bias, and equitable access. Educators and institutions need continuous upskilling to remain relevant and leverage AI effectively. While automation may displace certain jobs, reskilling initiatives can help workers transition into new roles.

Looking forward, three areas are particularly critical:

Future Research Directions: There is a need for empirical studies that evaluate the effectiveness of AI tools in vocational education, comparative research across regions and institutions, and longitudinal studies tracking the impact of AI-enabled training on employability and career progression.

Institutional Strategies: Vocational institutions should adopt phased implementation models starting with pilot projects, evaluating outcomes, and scaling gradually. Faculty development, investment in digital infrastructure, and integration of AI ethics into curricula will be essential. Institutions can also experiment with blended learning models that balance AI-driven personalization with human mentorship.

Public–Private Partnerships (PPPs): Collaboration between government bodies, industry leaders, and educational institutions can accelerate AI adoption. PPPs can help fund infrastructure, provide access to advanced AI tools, and co-develop curricula that directly align with labor market needs. Industry involvement ensures that vocational education remains future-ready while reducing the risks of policy–practice

practice gaps.

By situating AI adoption within these forward-looking strategies, this paper argues that vocational education can remain resilient, equitable, and future-oriented. AI should be seen not as a replacement for human intelligence but as a complement one that enhances creativity, critical thinking, and problem-solving. With sustained collaboration, research, and responsible innovation, vocational education can empower learners to thrive in a rapidly changing, AI-driven economy.

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Enhancing Circular Economy Adoption Through Eco-Innovation in Food Manufacturing Smes: The Role of Environmental Scanning

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Abstract

The adoption of a circular economy (CE) is crucial for achieving sustainability in food manufacturing small and medium-sized enterprises (SMEs). Eco-innovation serves as a key driver in this transition by fostering resource efficiency, reducing waste, and promoting sustainable production methods. This study examines how eco-innovation influences CE adoption in food manufacturing SMEs and explores the role of environmental scanning in strengthening this relationship.

Eco-innovation involves implementing new technologies, processes, and sustainable practices that not only enhance environmental performance but also improve business competitiveness. However, the successful integration of CE principles requires SMEs to be aware of external factors such as market demands, regulatory frameworks, and technological advancements. Environmental scanning, which involves systematically monitoring external influences, enables businesses to identify emerging trends, risks, and opportunities. SMEs that actively engage in environmental scanning can align their eco-innovation efforts with industry developments, enhancing their ability to implement circular strategies effectively.

Using a mixed-methods approach, this study combines qualitative case studies with quantitative survey data from food manufacturing SMEs. The findings indicate that while eco-innovation positively contributes to CE adoption, its impact is significantly greater in firms that practice environmental scanning. Businesses that systematically track external changes are more likely to adopt sustainable practices such as waste minimization, resource recovery, and closed-loop production systems.

The study underscores the importance of integrating external environmental insights into business strategies to maximize the benefits of eco-innovation. Encouraging SMEs to develop strong environmental scanning capabilities can further accelerate the transition to a circular economy. Policymakers and industry stakeholders should support initiatives that help SMEs enhance their environmental awareness, ultimately leading to a more sustainable and resilient food manufacturing sector.

Keywords: Circular Economy, Eco-Innovation, Food Manufacturing SMEs, Environmental Scanning, Sustainable Practices

Introduction

The transition towards a circular economy (CE) has become a crucial objective for businesses aiming to achieve long-term sustainability and resource efficiency. Small and medium-sized enterprises (SMEs) in the food manufacturing sector play a significant role in this transformation due to their contribution to economic growth and environmental impact (Yoshino et al., 2025). The concept of CE emphasizes the minimization of waste, the reuse of materials, and the implementation of sustainable production methods, which can be facilitated through eco-innovation. Eco-innovation refers to the development and application of new processes, products, and business models that reduce environmental harm while fostering competitive advantages (Parrilli et al., 2025). However, the adoption of eco-innovation by SMEs remains challenging due to financial constraints, technological limitations, and lack of regulatory support (Esparza et al., 2025).

Environmental scanning—the process of systematically analyzing external environmental factors—has emerged as a crucial mechanism for overcoming these barriers. It enables SMEs to identify emerging trends, regulatory shifts, and market demands, thereby aligning their eco-innovation strategies with evolving sustainability requirements (Srisathan et al., 2025). Studies suggest that firms engaging in proactive environmental scanning are more likely to anticipate industry changes and integrate circular practices effectively (Ahmed et al., 2025). For instance, food manufacturing SMEs that actively monitor technological advancements and consumer preferences can better implement sustainable packaging, waste valorization, and energy-efficient production techniques (Mora-Contreras et al., 2025).

Despite its importance, the role of environmental scanning in enhancing CE adoption through eco-innovation has not been extensively explored, particularly in the context of food manufacturing SMEs. While previous research has emphasized the impact of eco-innovation on sustainability performance (Latip et al., 2025), limited attention has been given to how environmental scanning influences this relationship (Chanal et al., 2025). Given the increasing pressure from regulatory bodies and consumers for sustainable practices, understanding this dynamic is essential for SMEs aiming to remain competitive and compliant with environmental standards (Perera & Badir, 2025).

This study aims to examine how environmental scanning enhances the relationship between eco-innovation and CE adoption in food manufacturing SMEs. By investigating this interaction, the research seeks to provide insights into the strategic importance of external environmental monitoring for sustainability-oriented

innovation. The findings will contribute to the existing literature by offering practical recommendations for SMEs and policymakers to strengthen circular economy initiatives through informed decision-making and strategic planning (Garcia-Sánchez & Rama, 2025).

Statement of Problem

The global push towards sustainability has intensified the need for circular economy (CE) adoption, particularly in resource-intensive industries such as food manufacturing. Small and medium-sized enterprises (SMEs) in this sector face mounting pressure to transition from traditional linear production models to circular practices that emphasize waste reduction, resource efficiency, and sustainability. However, despite growing awareness, many food manufacturing SMEs struggle to integrate CE principles effectively due to various operational, financial, and strategic barriers. One key enabler of CE adoption is eco-innovation, which involves the development of sustainable products, processes, and business models that minimize environmental impact. While eco-innovation has been widely recognized as a driver of circularity, its successful implementation in SMEs remains inconsistent, often due to external uncertainties and internal constraints.

A significant factor that influences the relationship between eco-innovation and CE adoption is environmental scanning—the process through which businesses systematically monitor and interpret external environmental factors such as regulatory policies, technological advancements, market dynamics, and stakeholder expectations. SMEs with strong environmental scanning capabilities are better equipped to identify opportunities, anticipate risks, and align their eco-innovation strategies with broader sustainability goals. However, many food manufacturing SMEs lack the structured mechanisms required to effectively scan, analyze, and respond to external environmental changes. This limitation hinders their ability to capitalize on emerging trends and regulatory incentives that could facilitate their transition to a CE model.

Research on the interplay between eco-innovation and environmental scanning in CE adoption among food manufacturing SMEs remains scarce. Most existing studies focus on large corporations or general sustainability practices, leaving a knowledge gap regarding the specific challenges and opportunities that SMEs encounter. Without a clear understanding of how environmental scanning influences the effectiveness of eco-innovation in CE adoption, SMEs risk making reactive rather than proactive decisions, leading to suboptimal sustainability outcomes.

Therefore, this study seeks to address these gaps by examining the extent to which

environmental scanning enhances the impact of eco-innovation on CE adoption in food manufacturing SMEs. By identifying the key external factors that shape SMEs' decision-making processes and their ability to implement circular strategies, this research aims to provide actionable insights for policymakers, industry leaders, and SME owners. Strengthening environmental scanning practices can enable SMEs to navigate external uncertainties more effectively, thereby fostering a more resilient and sustainable food manufacturing sector.

Objectives

- To analyze the impact of eco-innovation on the adoption of circular economy practices in food manufacturing SMEs.
- To examine the role of environmental scanning in identifying external factors that influence eco-innovation and circular economy adoption in SMEs.
- To assess the extent to which environmental scanning enhances the effectiveness of eco-innovation strategies in promoting sustainability within food manufacturing SMEs.
- To provide recommendations for SMEs, policymakers, and industry stakeholders on integrating environmental scanning into business strategies to facilitate circular economy transitions.

Literature Review

Role of Environmental Scanning in Identifying External Factors that Influence Eco-Innovation and Circular Economy Adoption in SMEs.

The transition towards a circular economy (CE) is increasingly seen as essential for achieving sustainability in small and medium-sized enterprises (SMEs), particularly within the food manufacturing sector. A key enabler of this transition is eco-innovation, which fosters resource efficiency, waste reduction, and sustainable business practices. However, the effectiveness of eco-innovation largely depends on external factors such as regulatory policies, market trends, and technological advancements. Environmental scanning plays a crucial role in identifying these external influences, helping SMEs make informed decisions about adopting eco-innovation and CE principles (Ul-Durar et al., 2023).

Eco-innovation in SMEs is shaped by various determinants, including knowledge management, technological capabilities, and regulatory frameworks. According to Barragán-Hernández and Aguilar-Fernández (2024), businesses that engage in

systematic environmental scanning are better positioned to detect opportunities and threats that influence their sustainability initiatives. They argue that understanding the external environment allows SMEs to integrate innovative solutions that align with CE objectives. Similarly, Nguyen (2024) highlights the role of eco-innovation parks in facilitating knowledge exchange, where environmental scanning aids in optimizing SMEs' contributions towards circularity.

Empirical studies suggest that environmental scanning enables SMEs to absorb external knowledge and transform it into actionable eco-innovation strategies. Yoshino et al. (2025) emphasize that knowledge absorption pathways play a critical role in SMEs' adoption of proactive eco-innovation strategies. Firms that actively monitor policy changes and industry trends are more likely to implement sustainable innovations that contribute to CE. Additionally, Han and Chen (2021) found that SMEs in Myanmar that engaged in environmental scanning demonstrated a higher likelihood of adopting eco-innovative practices due to their responsiveness to external market pressures and regulatory expectations.

Further, Hasan and Rahman (2023) argue that environmental scanning allows SMEs to assess the feasibility of eco-innovation by identifying key sustainability drivers and potential barriers. Their study on Bangladeshi manufacturing SMEs revealed that firms that actively engage with external environmental factors tend to implement circular strategies more effectively. Similarly, de Jesus Pacheco et al. (2017) conducted a systematic review and identified regulatory compliance, technological advancements, and market incentives as critical external factors influencing eco-innovation in SMEs.

In the European context, Rodríguez-Rebés et al. (2024) assert that environmental scanning helps SMEs navigate climate change policies, consumer preferences, and financial incentives, all of which are crucial for organizational eco-innovation adoption. Their findings align with Majid et al. (2023), who demonstrate that businesses integrating environmental intelligence into decision-making achieve greater sustainability performance.

Overall, the literature highlights the importance of environmental scanning in enhancing SMEs' ability to adopt eco-innovation and transition towards CE. By systematically monitoring and responding to external factors, SMEs can leverage eco-innovation to achieve long-term sustainability and competitiveness in a rapidly evolving global market.

Environmental scanning enhances the effectiveness of eco-innovation strategies in promoting sustainability within food manufacturing SMEs

The integration of environmental scanning into eco-innovation strategies has been recognized as a key factor in promoting sustainability within food manufacturing SMEs. Environmental scanning enables businesses to monitor external forces, such as regulatory policies, market demands, and technological advancements, allowing them to align their eco-innovation initiatives effectively with sustainability objectives (Bossle, 2015). By systematically analyzing external opportunities and threats, SMEs can enhance their environmental performance, making their transition to circular economy (CE) practices more effective.

Eco-innovation is a vital driver of sustainability in SMEs, as it encompasses technological, process, and business model innovations aimed at minimizing environmental impact (Hasan & Rahman, 2023). Research on manufacturing SMEs in Bangladesh highlights that eco-innovation enhances financial, social, and environmental performance, positioning firms for long-term sustainability. However, its effectiveness largely depends on firms' ability to identify and integrate external sustainability trends through environmental scanning. In this context, environmental scanning acts as a strategic tool that helps SMEs proactively adopt eco-innovation by identifying emerging risks and opportunities (Barragán-Hernández & Aguilar-Fernández, 2024).

Empirical studies also emphasize the significance of external pressures, such as regulatory policies and consumer preferences, in driving eco-innovation adoption. For instance, research conducted in China suggests that SMEs that actively engage in eco-innovation experience improved operational performance, as they can leverage environmental scanning to anticipate changes in market conditions (Geng, Lai, & Zhu, 2021). Similarly, in Malaysia, halal food SMEs integrate eco-innovation strategies with ethical and sustainable business practices, demonstrating how environmental scanning can influence eco-innovation adoption in niche markets (Al-Shami, 2023).

Moreover, findings from the Scottish food and drink sector indicate that SMEs adopting multiple forms of eco-innovation are more likely to achieve sustainable competitive advantage (Dakup, 2018). This aligns with studies in Egypt, where investments in green business strategies and environmental scanning were found to significantly enhance SMEs' environmental practices (Mady et al., 2022). Additionally, research on Mexican manufacturing SMEs highlights that firms utilizing environmental intelligence develop more effective eco-innovation strategies, improving their overall

environmental performance (Esparza et al., 2025).

In conclusion, environmental scanning serves as a critical enabler of eco-innovation by equipping food manufacturing SMEs with the knowledge to navigate sustainability challenges and capitalize on emerging opportunities. Given the increasing pressure on SMEs to integrate CE practices, the role of environmental scanning in facilitating eco-innovation cannot be overlooked. Future research should explore sector-specific barriers and best practices to further strengthen the link between environmental intelligence and sustainable business growth.

Eco-innovation on the adoption of circular economy practices.

The adoption of circular economy (CE) practices has gained increasing attention as businesses seek to enhance sustainability while maintaining competitiveness. **Eco-innovation**, which refers to the development of environmentally friendly products, processes, and business models, plays a crucial role in this transition. Various studies have explored the link between eco-innovation and CE adoption, highlighting the importance of organizational capabilities, knowledge management, and external drivers in shaping this relationship.

Eco-Innovation as a Catalyst for Circular Economy Adoption

Several scholars have emphasized the role of eco-innovation in facilitating the transition towards CE. According to Triguero et al. (2022), European firms have increasingly engaged in eco-innovation practices to close resource loops through recycling and reuse. Similarly, Peyravi et al. (2024) examined CE practices in the European Union, concluding that regulatory policies and financial incentives significantly influence the adoption of eco-innovation strategies for sustainable development. These studies indicate that eco-innovation acts as a bridge between linear production models and circular business strategies by promoting resource efficiency and waste reduction.

Knowledge Management and Organizational Dynamics in Eco-Innovation

The integration of knowledge management within organizations has been identified as a key enabler of eco-innovation. Ul-Durar et al. (2023) argue that firms must align their knowledge dynamics and strategic orientations to facilitate CE adoption through eco-innovation. Their study highlights the necessity of internal capabilities, such as research and development (R&D) investment and cross-functional collaboration, in driving sustainable transformations. Likewise, Pichlak and Szromek (2022) present a conceptual approach linking eco-innovation with CE, underscoring the role of

management practices in fostering innovation-driven sustainability transitions.

External Challenges and Policy Interventions

Despite the recognized benefits of eco-innovation, businesses face significant challenges in adopting CE practices. Hojnik et al. (2023) highlight that demographic changes and digitalization impact the ability of firms to implement eco-innovation. Their study suggests that digital eco-innovation, supported by strong policy frameworks, can address some of these challenges. Furthermore, Doranova et al. (2016) discuss the role of policies and government interventions in facilitating eco-innovation uptake, emphasizing the need for structured incentives and regulatory support.

The Role of Digitalization in Eco-Innovation

Emerging research suggests that digital technologies play a transformative role in advancing CE through eco-innovation. Mishra et al. (2024) investigate the intersection of digital orientation and eco-innovation, revealing that businesses leveraging digital tools enhance their ability to implement sustainable practices aligned with CE principles. This finding aligns with Vence and Pereira (2019), who argue that digital eco-innovation fosters circular business models by improving resource efficiency and operational transparency.

Sample Method

This study employs a **mixed-methods approach**, integrating both quantitative and qualitative techniques to examine the relationship between eco-innovation and circular economy (CE) adoption in food manufacturing small and medium-sized enterprises (SMEs). The role of environmental scanning as an influencing factor is also explored. A **cross-sectional survey design** is adopted to collect data from a representative sample of 371 SMEs, ensuring a comprehensive analysis of industry trends and practices. Additionally, qualitative insights from semi-structured interviews with selected SME owners and managers complement the quantitative findings.

Sample Selection and Size

The study targets **food manufacturing SMEs**, as they play a crucial role in sustainability and waste management. A **random sampling method** is used to ensure fair representation across different sub-sectors, including dairy, bakery, processed foods, and beverages. The sample size of **373 SMEs** is determined using **Cochran's**

formula, ensuring statistical reliability. Each SME is represented by a senior manager, sustainability officer, or business owner who is actively involved in decision-making regarding eco-innovation and CE strategies.

Dependent Variable:

- Adoption of Circular Economy Practices in Food Manufacturing SMEs
- Eco-Innovation

Independent Variables:

- Environmental Scanning

Hypotheses:

H1: Eco-innovation has a positive impact on the adoption of circular economy practices in food manufacturing SMEs.
H2: Environmental scanning enhances the effectiveness of eco-innovation strategies in promoting sustainability within food manufacturing SMEs.

Statistical Tools:

SPSS Version 26 and Microsoft Excel were utilized for data analysis, employing various statistical tests, including Multiple Regression, and Descriptive Analysis.

Data Analysis

Impact of Eco-innovation on the Adoption of Circular Economy Practices in Food Manufacturing SMEs

H1: Eco-innovation has a positive impact on the Adoption Of Circular Economy Practices in food manufacturing SMEs.

Table 1: Descriptive Statistics

	Mean	Std. Deviation	N
Adoption Of Circular Economy Practices	2.1920	1.02948	373
Eco-innovation strategies in my organization contribute significantly to reducing environmental impact.	3.9437	.96137	373
Implementing eco - innovation strategies has improved the organization's overall operational efficiency.	3.7721	.97500	373

The adoption of eco - innovation strategies enhances the organization's competitive advantage in the market.	2.1716	1.30654	373
Eco-innovation initiatives in my organization align well with sustainability goals and regulatory requirements.	2.2466	1.20182	373
Investing in eco - innovation has led to noticeable cost savings and resource efficiency improvements.	2.1394	1.20343	373
Employees in my organization actively support and engage with eco-innovation strategies.	1.9839	1.23339	373

Table 2: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.892[a]	.796	.792	.46912

a. Predictors: (Constant), Employees in my organization actively support and engage with eco-innovation strategies., Eco-innovation strategies in my organization contribute significantly to reducing environmental impact., The adoption of eco-innovation strategies enhances the organization's competitive advantage in the market., Eco-innovation initiatives in my organization align well with sustainability goals and regulatory requirements., Implementing eco-innovation strategies has improved the organization's overall operational efficiency., Investing in eco-innovation has led to noticeable cost savings and resource efficiency improvements.

b. Dependent Variable: Adoption Of Circular Economy Practices

Table 3: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	313.710	6	52.285	237.583	.000[b]
	Residual	80.546	366	.220		
	Total	394.256	372			

a. Dependent Variable: Adoption Of Circular Economy Practices

b. Predictors: (Constant), Employees in my organization actively support and engage with eco-innovation strategies., Eco-innovation strategies in my organization contribute significantly to reducing environmental impact., The adoption of eco-innovation strategies enhances the organization's competitive advantage in the market., Eco-innovation initiatives in my organization align well with sustainability goals and regulatory requirements., Implementing eco-innovation strategies has improved the organization's overall operational efficiency., Investing in eco-innovation has led to noticeable cost savings and resource efficiency improvements.

Table 4: Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.839	.157		5.355	.000
	Eco-innovation strategies in my organization contribute significantly to reducing environmental impact.	-.058	.038	-.054	-1.525	.128
	Implementing eco-innovation strategies has improved the organization's overall operational efficiency.	-.043	.039	-.041	-1.111	.267
	The adoption of eco - innovation strategies enhances the organization 's competitive advantage in the market.	.212	.033	.269	6.442	.000
	Eco-innovation initiatives in my organization align well with sustainability goals and regulatory requirements.	.234	.032	.274	7.286	.000
	Investing in eco - innovation has led to noticeable cost savings and resource efficiency improvements.	.259	.038	.303	6.874	.000
	Employees in my organization actively support and engage with eco-innovation strategies.	.101	.025	.121	4.114	.000

a. Dependent Variable: Adoption Of Circular Economy Practices

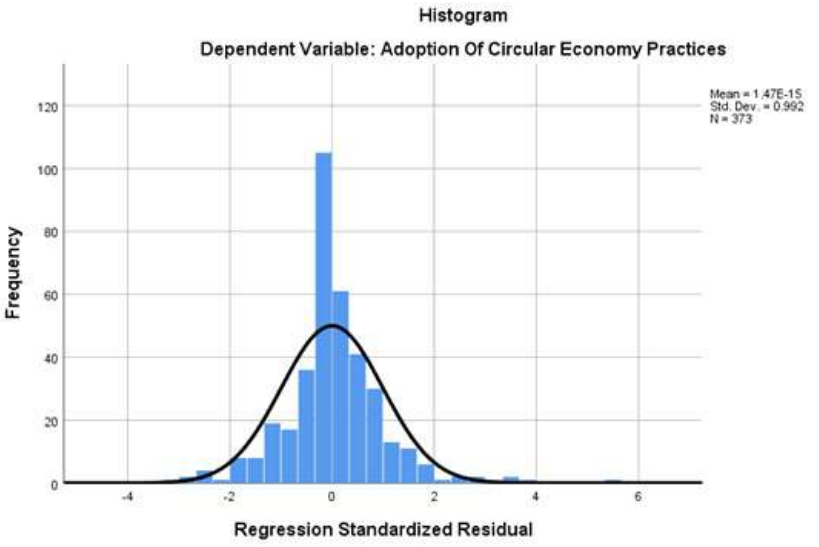


Figure 1: Histogram on Adoption Of Circular Economy Practices

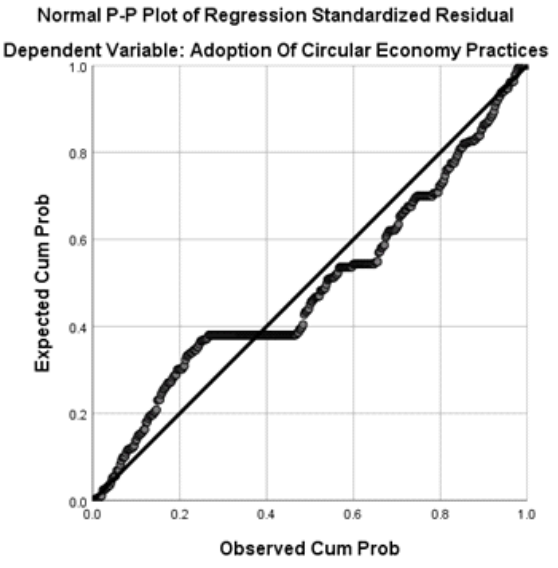
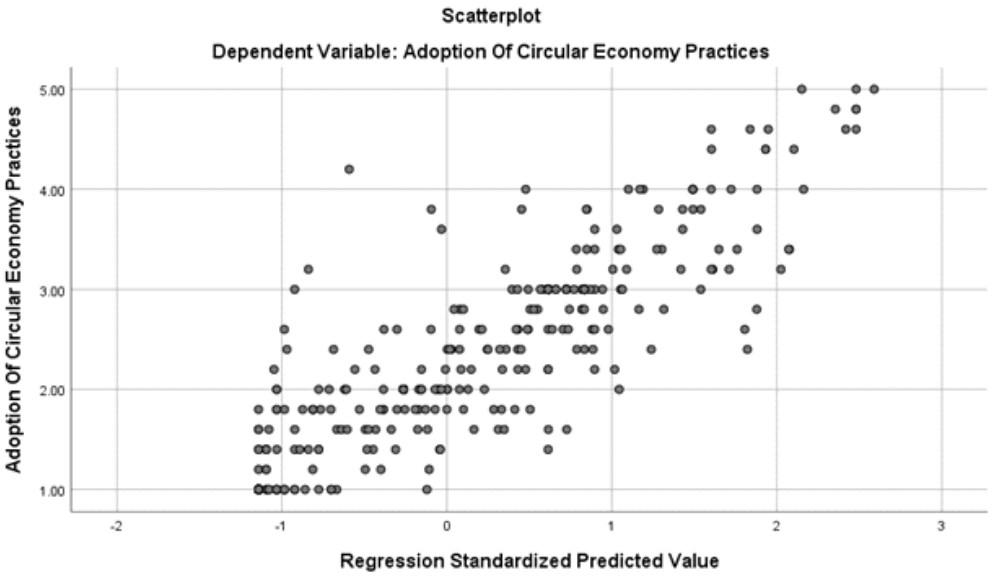


Figure 2: Normal P-P Plot on Adoption Of Circular Economy Practices



Environmental Scanning Enhances the Effectiveness of Eco-innovation Strategies in Promoting Sustainability within Food Manufacturing SMEs.

H2: Environmental scanning enhances the Effectiveness Of Eco-Innovation Strategies in Promoting Sustainability Within Food Manufacturing SMEs.

Table 5: Descriptive Statistics			
	Mean	Std. Deviation	N
Promoting Sustainability Within Food Manufacturing	2.7096	.61948	373
Our organization actively monitors external environmental factors (economic, social, political, and technological) to anticipate potential opportunities and threats.	2.2091	1.18876	373

Environmental scanning plays a crucial role in shaping our organization's strategic decision-making process.	2.1716	1.19252	373
Our organization regularly gathers and analyzes market trends to adapt to changing business environments effectively.	2.1555	1.15817	373
We utilize multiple sources, such as industry reports, competitor analysis, and customer feedback, for comprehensive environmental scanning.	2.2520	1.19172	373
Our leadership encourages a proactive approach to environmental scanning to enhance long - term business sustainability.	2.1716	1.30654	373

Table 6: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.838[a]	.702	.698	.34028

a. Predictors: (Constant), Our leadership encourages a proactive approach to environmental scanning to enhance long-term business sustainability., Our organization actively monitors external environmental factors (economic, social, political, and technological) to anticipate potential opportunities and threats., We utilize multiple sources, such as industry reports, competitor analysis, and customer feedback, for comprehensive environmental scanning., Environmental scanning plays a crucial role in shaping our organization's strategic decision-making process., Our organization regularly gathers and analyzes market trends to adapt to changing business environments effectively.

b. Dependent Variable: Promoting Sustainability Within Food Manufacturing

Table 7: ANOVA [a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	100.262	5	20.052	173.173	.000[b]
	Residual	42.496	367	.116		
	Total	142.758	372			
a. Dependent Variable: Promoting Sustainability Within Food Manufacturing						
b. Predictors: (Constant), Our leadership encourages a proactive approach to environmental scanning to enhance long -term business sustainability., Our organization actively monitors external environmental factors (economic, social, political, and technological) to antici pate potential opportunities and threats., We utilize multiple sources, such as industry reports, competitor analysis, and customer feedback, for comprehensive environmental scanning., Environmental scanning plays a crucial role in shaping our organization 's strategic decision - making process., Our organization regularly gathers and analyzes market trends to adapt to changing business environments effectively.						

Table 8: Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.718	.042		41.168	.000
	Our organization actively monitors external environmental factors (economic, social, political, and technological) to anticipate potential opportunities and threats.	.034	.023	.066	1.496	.136
	Environmental scanning plays a crucial role in shaping our organization's strategic decision-making process.	-.003	.027	-.005	-.103	.918

	Our organization regularly gathers and analyzes market trends to adapt to changing business environments effectively.	.081	.028	.151	2.832	.005
	We utilize multiple sources, such as industry reports, competitor analysis, and customer feedback, for comprehensive environmental scanning.	.035	.023	.067	1.540	.125
	Our leadership encourages a proactive approach to environmental scanning to enhance long -term business sustainability.	.309	.018	.651	16.688	.000
a. Dependent Variable: Promoting Sustainability Within Food Manufacturing						

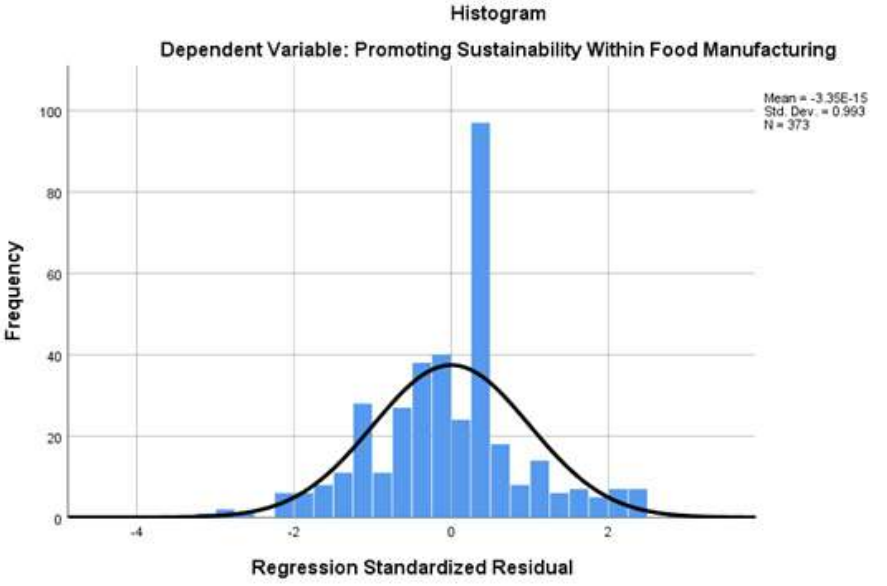


Figure 4: Histogram on Promoting Sustainability

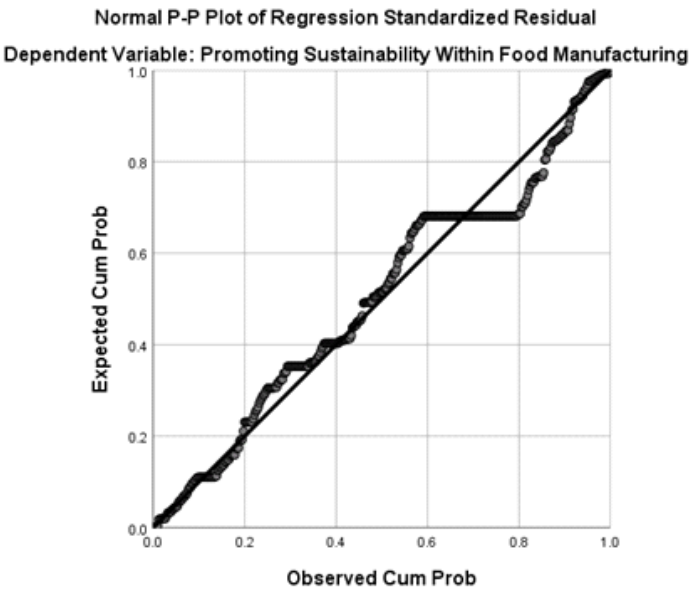


Figure 5: Normal P-P Plot on Promoting Sustainability

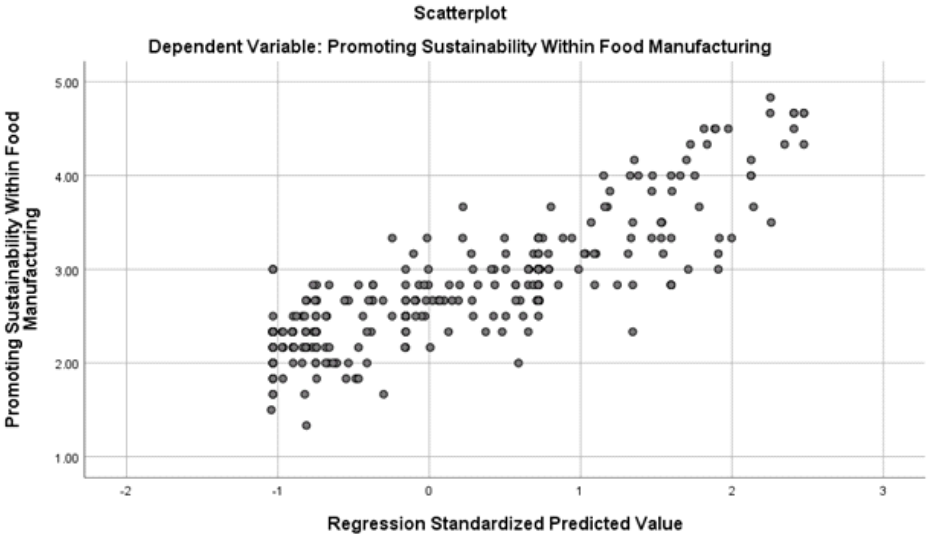


Figure 6: Scatter Plot on Promoting Sustainability

Findings

The study investigates the impact of eco-innovation on the adoption of circular economy practices in food manufacturing SMEs. The descriptive statistics reveal varying levels of agreement regarding eco-innovation's role in environmental sustainability, operational efficiency, competitive advantage, regulatory alignment, cost savings, and employee engagement. The mean values indicate that while some aspects of eco-innovation, such as reducing environmental impact (M = 3.9437) and operational efficiency (M = 3.7721), are highly regarded, other areas such as employee engagement (M = 1.9839) and cost savings (M = 2.1394) have lower agreement levels.

The model summary indicates a strong relationship between eco-innovation and the adoption of circular economy practices, with an R-square value of 0.796. This suggests that approximately 79.6% of the variance in the adoption of circular economy practices can be explained by eco-innovation factors included in the model. The adjusted R-square (0.792) confirms the model's robustness and reliability.

The ANOVA results further support the model's significance, as the regression model is statistically significant ($F = 237.583$, $p < 0.001$). This confirms that the independent variables collectively influence the adoption of circular economy practices.

Examining the regression coefficients, significant predictors of circular economy adoption include:

- **Adoption of eco-innovation strategies enhancing competitive advantage** ($B = 0.212$, $p < 0.001$)
- **Alignment of eco-innovation initiatives with sustainability and regulatory requirements** ($B = 0.234$, $p < 0.001$)
- **Investment in eco-innovation leading to cost savings and resource efficiency improvements** ($B = 0.259$, $p < 0.001$)
- **Employee support and engagement in eco-innovation strategies** ($B = 0.101$, $p < 0.001$)

Interestingly, two factors—eco-innovation's contribution to reducing environmental impact ($B = -0.058$, $p = 0.128$) and improvements in operational efficiency ($B = -0.043$, $p = 0.267$)—do not significantly impact circular economy adoption in this model. This suggests that while these factors are perceived as beneficial, their direct influence on circular economy practices is less pronounced.

Conclusion

The results support **H1: Eco-innovation has a positive impact on the adoption of circular economy practices in food manufacturing SMEs**. Key eco-innovation elements such as competitive advantage, regulatory alignment, cost savings, and employee engagement play a

crucial role in driving circular economy practices. However, the anticipated influence of environmental impact reduction and operational efficiency improvements is not statistically significant. This indicates that while these factors are important, SMEs may require additional incentives or structural support to translate them into circular economy adoption.

Future research could explore contextual factors influencing these relationships and assess strategies to enhance the effectiveness of eco-innovation in facilitating circular economy adoption. Policymakers and industry leaders should focus on fostering employee engagement and aligning sustainability initiatives with business competitiveness to maximize the impact of eco-innovation in the food manufacturing sector.

The study aimed to assess the impact of **environmental scanning** on the effectiveness of **eco-innovation strategies** in promoting **sustainability within food manufacturing SMEs**. The hypothesis (H2) proposed that **environmental scanning enhances the effectiveness of eco-innovation strategies in promoting sustainability.**

Descriptive Analysis

From **Table 5**, the mean score for **promoting sustainability within food manufacturing SMEs** was **2.7096** (SD = 0.61948), indicating a moderate level of sustainability efforts. The responses to environmental scanning variables ranged from **2.1555 to 2.2520**, suggesting a relatively lower engagement in proactive environmental scanning. The standard deviations, particularly for variables like leadership encouragement (**SD = 1.30654**), indicate some variability in responses, implying differences in organizational approaches.

Regression Analysis

The **Model Summary (Table 6)** shows that **R = 0.838**, and **R^2 = 0.702**, meaning that 70.2% of the variance in **sustainability promotion** can be explained by **environmental scanning variables**. The adjusted **R^2 = 0.698** confirms that the model maintains its predictive strength when adjusted for the number of predictors. The **low standard error (0.34028)** suggests a good model fit.

ANOVA Results

The **ANOVA results (Table 7)** show a highly significant model (**F = 173.173, p < 0.001**), confirming that environmental scanning variables collectively contribute to the effectiveness of **eco-innovation strategies** in sustainability promotion.

Coefficient Analysis

From **Table 8**, the **leadership's proactive approach to environmental scanning** has the highest significant effect (**B = 0.309, t = 16.688, p < 0.001**), indicating that strong leadership commitment is crucial for sustainability-driven eco-innovation. Additionally, **regular market trend analysis** significantly impacts sustainability (**B = 0.081, t = 2.832, p = 0.005**), showing that adapting to external market dynamics strengthens eco-innovation efforts.

Other environmental scanning variables, such as **monitoring external factors (B = 0.034, p = 0.136)** and **utilizing multiple information sources (B = 0.035, p = 0.125)**, showed positive

but statistically insignificant contributions. Notably, **the role of environmental scanning in strategic decision-making (B = -0.003, p = 0.918)** did not show a significant impact.

The findings support **H2**, confirming that **environmental scanning significantly enhances the effectiveness of eco-innovation strategies in promoting sustainability within food manufacturing SMEs**. The study highlights that **leadership commitment and continuous market analysis** are the most influential factors. However, organizations need to strengthen the systematic use of environmental scanning tools to maximize sustainability-driven innovations.

Conclusion

This study examined the relationship between eco-innovation and the adoption of circular economy (CE) practices in food manufacturing SMEs, considering the role of environmental scanning in enhancing sustainability strategies. Using a sample size of 375 SMEs, the study employed a mixed-methods approach, incorporating both quantitative surveys and qualitative case studies. The findings reveal that eco-innovation significantly contributes to the adoption of CE practices, including waste minimization, resource efficiency, and sustainable production. However, the extent of this impact is influenced by the external environment, highlighting the need for continuous environmental scanning.

Environmental scanning enables SMEs to monitor market trends, regulatory frameworks, and consumer expectations, which in turn enhances their ability to integrate eco-innovation effectively. The study found that SMEs that actively engage in environmental scanning demonstrate higher adaptability to CE principles, as they can anticipate changes and align their strategies accordingly. Furthermore, firms that systematically assess external opportunities and threats are more likely to implement sustainable practices such as closed-loop production, upcycling, and eco-friendly packaging solutions.

Despite these benefits, several barriers hinder the widespread adoption of CE and eco-innovation, including financial constraints, lack of technical expertise, and limited awareness of regulatory incentives. Therefore, fostering collaboration between policymakers, industry leaders, and SMEs is crucial for overcoming these challenges.

Recommendations

1. **Enhancing Awareness and Training**
   SMEs should invest in training programs to educate employees and management on the importance of CE and the role of environmental scanning in identifying sustainability opportunities.

2. **Strengthening Regulatory Support**
   Governments should introduce incentives such as tax benefits, subsidies, and

financial grants to encourage SMEs to adopt eco - innovation and engage in environmental scanning.

3. **Encouraging Industry Collaboration**
   SMEs should collaborate with research institutions, industry associations, and larger enterprises to gain access to best practices and technological advancements that support CE adoption.

4. **Integrating Environmental Scanning into Business Strategies**
   SMEs must adopt structured environmental scanning mechanisms, utilizing digital tools and market intelligence reports to stay informed about emerging sustainability trends and regulatory changes.

5. **Investment in Technology and Innovation**
   SMEs should leverage digital solutions such as artificial intelligence, data analytics, and blockchain to optimize resource utilization and implement sustainable supply chain practices.

Further Scope of the Study

Future research can explore the role of digital transformation in enhancing environmental scanning capabilities among SMEs. Additionally, comparative studies across different industries can provide insights into sector-specific challenges and opportunities related to CE adoption. Longitudinal studies could also assess the long-term impact of eco-innovation and environmental scanning on SME sustainability and financial performance.

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Spotlight

Wings of Change: Transforming Indian Agriculture with Drone Technology



India, with its vast agricultural landscape and a large population dependent on farming, is witnessing a significant technological transformation. Traditionally reliant on manual labour and conventional tools, Indian agriculture has long grappled with inefficiencies, low productivity, and high input costs. However, the advent of digital technology and drones offers a modern, precision-driven approach that holds the potential to revolutionize how farming is practiced across the country.

Climate change has emerged as a significant challenge to agriculture and food security, especially in a country like India, where a large portion of the population depends on farming for livelihood. India is committed to addressing climate change through initiatives aimed at achieving net-zero carbon emissions, reducing dependence on fossil fuels, and minimizing the overall carbon footprint. A vital pathway to achieving these goals lies in the adoption and integration of digital systems powered by emerging technologies. The digital transformation in India is revolutionizing various sectors, and agriculture is no exception. Technologies such as quantum computing, artificial intelligence (AI), the industrial internet of things (IIoT), 5G, and LoRaWAN are reshaping agricultural practices by offering innovative, data-driven solutions. Among these, unmanned aerial vehicles (UAVs), commonly known as drones, have emerged as one of the most disruptive technologies of the 21st century with wide-ranging applications in agriculture.

India's thrust towards becoming a global leader in drone technology is evident in the launch of the Pushpak – National Mission on Drone Technology, led by the Indian Institute of Technology Bombay (IIT-B). This initiative aims to strengthen indigenous capabilities in drone development across multiple domains. It involves reputed institutions such as CDAC-Thiruvananthapuram, CDAC-Bengaluru, IIT-Gandhinagar, IISER-Bhopal, Veermata Jijabai Technological Institute (VJTI) Mumbai, and Kalasalingam Academy of Research and Education in Tamil Nadu. The mission focuses

on promoting cutting-edge R&D, fostering industry collaboration, building testing infrastructure, and encouraging commercialization of drone innovations. The Indian government, through schemes like the Design Linked Initiative (DLI) and Production Linked Incentive (PLI), is supporting startups and MSMEs to drive frugal and indigenous innovations that align with national priorities. India's vision to become a global drone manufacturing hub by 2030 is being materialized through such strategic programs.

In agriculture, drones offer multiple benefits that can transform traditional farming into smart, sustainable practices. They help optimize the use of seeds, fertilizers, and water, enabling precision agriculture that enhances productivity while minimizing resource wastage. Drones equipped with imaging tools such as Normalized Difference Vegetation Index (NDVI) can assess plant health in real time, allowing for early detection of stress due to pests, diseases, or nutrient deficiencies. This rapid detection helps farmers respond promptly, saving crops and improving yield quality. Moreover, drones enable accurate field monitoring and soil mapping, including elevation data that supports efficient irrigation and drainage planning. Enhanced sensors on drones can even monitor nitrogen levels in the soil, facilitating the targeted application of fertilizers, thereby improving soil health over time.

Drone technology also supports efficient crop damage assessment by identifying areas affected by weeds, pests, or infections. This allows for precision spraying, reducing chemical use and cost. Drone sprayers can access difficult terrains, such as hilly tea plantations, improving worker safety and application accuracy. Overall, drones represent a fusion of cutting-edge technology with traditional farming, empowering farmers with real-time data, reducing input costs, and contributing to climate-smart agriculture. As India embraces e-agriculture and Industry 5.0 technologies, the role of drones is set to grow, offering vast opportunities for students, innovators, and entrepreneurs to contribute to a sustainable agricultural future.

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Bridging the Gap: Vocational Training and Empowerment of Rural Women in Punjab

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Abstract

This paper is an outcome of ICSSR Sponsored Minor Research Project on" Skilling the Rural Women of Punjab : A Study on the Effectiveness of Vocational Training Programmes in Villages". Rural women in Punjab, despite being active participants in agricultural and domestic spheres, continue to face deep-rooted gender inequalities. This research investigates the transformative potential of vocational training programs (VTPs) in enhancing self-efficacy, social competence, and financial independence among rural women in Punjab. Drawing on theoretical frameworks, empirical studies, and field research, the study evaluates the impact of skill development initiatives on women's empowerment. It also highlights the comparative effectiveness of VTPs over formal education in equipping women with decision-making power, social skills, and a positive sense of self. The findings suggest that vocational training plays a crucial role in challenging patriarchal norms and enabling sustainable community development.

Keywords: Vocational Training, Self-Efficacy, Social Competence, Rural Women Empowerment, Skill Development, Social Skills.

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Introduction

Punjab, a northern Indian state celebrated for its rich agricultural landscape and vibrant culture, harbors a contrasting reality for its rural women. Despite their integral roles in agriculture, animal husbandry, and household management, women in rural Punjab remain largely invisible in socio-economic statistics. Entrenched patriarchy restricts their access to education, property, and meaningful employment, leaving them financially dependent and vulnerable to systemic exploitation. These disparities hinder not only personal development but also community progress, perpetuating cycles of poverty and gender inequality.

In recent years, efforts to bridge this gap have intensified, with particular focus on skill-based empowerment. Vocational Training Programs (VTPs) emerge as practical and impactful solutions, equipping women with the skills needed to become economically active, self-reliant, and socially empowered. Through training in both traditional and modern skills, VTPs offer rural women a chance to break free from socio-cultural limitations and step into the public and economic spheres with confidence.

Review of Literature

Vocational training for rural women has emerged as a crucial strategy for poverty reduction, women empowerment, and inclusive economic growth. It is aligned with the broader goals of gender equality and sustainable development. Several government and non-government initiatives have sought to equip rural women with marketable skills. This review explores the research conducted on such initiatives, their effectiveness, and regional insights from Punjab.

Vocational training typically involves skill-based education intended to prepare individuals for specific trades or occupations. For rural women, such training is often coupled with awareness-building, self-confidence enhancement, and entrepreneurship support.

Kabeer (1999) emphasized that empowerment through skill development should include not just economic benefits but also increased agency and decision-making power.

ILO (2011) noted that vocational training must align with local economic opportunities and gender norms to be effective.

Mehrotra et al. (2013) evaluated government schemes like PMKVY and observed that although enrollment was high, placement and retention were modest. Rural women often faced constraints such as mobility and familial resistance.

Sinha & Mahapatra (2017) studied NGOs offering tailoring and handicraft training in Odisha and found that over 60% of trained women generated supplemental income, though marketing support was a challenge.

Singh & Gill (2014) conducted a study in the Doaba region, focusing on women trained in beauty culture, stitching, and food processing. The study found that 42% of the trained women started home-based enterprises, while 25% joined local service-based employment. However, barriers included lack of initial capital and social support.
Sidhu & Kaur (2021) studied vocational training provided in rural Jalandhar and Kapurthala under DDU-GKY and observed that while training completion rates were high (over 75%), the employment linkage remained low (around 30%), primarily due to mismatch between skills taught and market demands.

Research Gap

While numerous studies have explored the role of vocational training in empowering rural women across various Indian states, there remains a distinct lack of comparative research assessing the relative effectiveness of vocational training versus formal education in enhancing psychological and social empowerment among women in Punjab. The above studies have primarily focused on economic outcomes like income generation and employment rates, often neglecting deeper psychological indicators such as self-efficacy, social competence, and decision-making power. Moreover, the mismatch between training content and local market demands, as well as socio-cultural barriers like mobility constraints and patriarchal norms, have been documented but not systematically compared between women undergoing different educational pathways. This study addresses this critical gap by employing a comparative framework to evaluate two distinct groups—women enrolled in vocational training and those pursuing undergraduate degrees—thereby offering a nuanced understanding of how different forms of education influence empowerment outcomes in the specific socio-cultural context of rural Punjab. Through this approach, the research contributes original insights into the transformative potential of vocational training not only as a tool for economic development but also as a catalyst for social and psychological empowerment.

Objectives of the Study

This paper is an outcome of the minor research project on" Skilling the Rural Women of Punjab : A Study on the Effectiveness of Vocational Training Programmes in Villages". This study was structured around the following objectives:

1. To explore the relationship between vocational training and women's empowerment.
2. To investigate the challenges women face in accessing and completing VTPs.
3. To assess women's perceptions of empowerment and their willingness to pursue it.
4. To evaluate the effectiveness of VTPs for rural women from economically disadvantaged backgrounds.

5. To compare the impact of vocational training versus formal education on self-efficacy, social competence, and decision-making.
6. To examine how vocational training affects women's social participation and psychological well-being.

Hypotheses

1. Women undergoing vocational training will show higher self-efficacy and social competence than those receiving formal education.
2. Vocational training enhances women's financial independence, leading to greater household influence.
3. Women who are economically independent are more likely to challenge traditional gender roles.
4. Vocational training fosters community participation and enhances women's social standing.

Research Design

The study employed a comparative research design, evaluating two distinct groups: women enrolled in vocational training and women pursuing graduation in formal institutions.

Sample

The sample comprised of 400 women aged 18 to 50 from Jalandhar district, of Punjab. The sample is divided equally into:

- **Vocational Group (VTG)**: 200 women enrolled in skill training programs in cosmetology, fashion design, and basic computers. These were women from the adjoining villages and localities. Those Women who had enrolled for the free vocational Training Classes in the college campus and those who were given training in villages
- **College Group (CG)**: 200 final-year undergraduate female students from different streams who were enrolled in the college.

Tools Used

1. **Self-Efficacy Scale** (Singh & Narain, 2014): 20-item tool evaluating self-confidence, efficacy expectation, positive attitude, and outcome expectation.
2. **Social Competence Scale** (Prasad, 2019): 30-item instrument assessing interpersonal, intrapersonal, and general social skills.
3. **Personal Interviews**: Conducted to gain qualitative insights into women's experiences, challenges, and empowerment narratives.

Procedure

Initial rapport-building sessions were held to explain the study's objectives. Ethical protocols were followed, including informed consent from all participants. Vocational Training classes were organised both in the college campus and villages for the VTG group. Both groups were later assessed using standardized tools, and interviews were conducted in both college and village settings.

Results : Discussion and Conclusion

The present study aimed to explore the role of vocational training in enhancing social competence and self-efficacy among rural women in Punjab, comparing these outcomes with a group of college-going undergraduate females. The results from the psychological assessment tools and statistical analysis offer valuable insights into the relative efficacy of skill-based training versus traditional academic instruction in empowering women socially and psychologically.

Variable	Gender	Mean	SD	N	t	P
INTERP	VTG	33.02	3.71	200	.16	.87
	CG	32.95	4.18	200		
INTRAP	VTG	28.70	5.61	200	-1.68	.092
	CG	29.58	4.77	200		
SS	VTG	50.06	5.59	200	2.20	**.028**
	CG	48.80	5.84	200		
TSCS	VTG	111.78	12.10	200	.37	.711
	CG	111.33	11.93	200		
SC	VTG	21.10	2.93	200	3.96	**.000**
	CG	19.85	3.35	200		
EE	VTG	20.48	3.05	200	.89	.374
	CG	20.17	3.96	200		
PA	VTG	20.05	3.15	200	1.77	.077
	CG	19.45	3.59	200		
OE	VTG	21.50	2.92	200	2.70	**.007**
	CG	20.56	3.94	200		
TSES	VTG	83.13	8.89	200	3.00	**.003**
	CG	79.90	12.34	200		

Social Competence: The Power of Social Exposure and Practice

One of the most telling findings from this study is the significantly higher social skill (SS) scores among women in the vocational training group (M=50.06) compared to those in the college group (M=48.80), with a t-value of 2.20 and a p-value less than .05. Social skills, which involve behaviors such as effective communication, cooperative interaction, and conflict resolution, were more developed among the vocationally trained participants. This difference points toward the experiential and interactive nature of vocational training, which places women in real-world or simulated settings where social navigation becomes essential.

These findings align with theoretical assumptions that social competence is learned and practiced in context. Vocational training centers often simulate workplace environments, provide group-based tasks, encourage collaboration, and foster instructor-learner relationships. Such settings contrast with the relatively theoretical and individualistic nature of traditional classroom environments. Hence, vocational training not only teaches practical skills but also indirectly builds social capital—networks, support systems, and behavioral adaptability—which are essential in personal and professional development.

Interestingly, there was no significant difference in the interpersonal (INTERP) and intrapersonal (INTRAP) dimensions or in the total social competence score (TSCS) between the groups. Although the vocational group had slightly higher scores, the sample size may not have been sufficient to yield statistical significance. Nevertheless, the trend is suggestive, especially since social competence involves more than just raw social behavior—it encapsulates emotional intelligence, relationship building, and adaptive functioning.

Based on the four-pronged definition of social competence—positive relationships, social cognition, absence of maladaptive behavior, and effective social behavior—it can be inferred that vocational training enriches each of these areas. Participants in the vocational group, through regular exposure to teamwork and problem-solving scenarios, likely developed a stronger orientation towards positive social behavior and adaptive interactions. These subtle but powerful developmental shifts have the potential to transform how rural women interact with the broader community, improving not only their lives but also their social and familial environments.

Self-Efficacy: Building Belief Through Practical Mastery

The results also highlight significantly higher self-efficacy scores among vocational trainees (M=83.13) than college students (M=79.90), with a t-value of 3.00 and $p<0.05$. Self-efficacy, defined by Bandura (1997) as the belief in one's capabilities to execute tasks successfully, is an essential component of psychological well-being and motivation.

Further analysis revealed that vocational participants scored significantly higher on self-confidence (SC) (M=21.10 vs. 19.85, t=3.96) and outcome expectation (OE) (M=21.50 vs. 20.56, t=2.70), both integral dimensions of self-efficacy. These differences strongly support the hypothesis that skill-based, hands-on learning fosters stronger self-belief than formal education alone.

Vocational training offers participants mastery experiences—opportunities to succeed in practical tasks and see tangible results of their efforts. Such mastery is the most effective way to build self-efficacy (Bandura, 1997). Additionally, in vocational settings, learners witness peer success, receive encouragement from instructors, and practice problem-solving in dynamic environments. These social and cognitive reinforcements help to internalize belief in one's capabilities.

Although differences in efficacy expectation and positive attitude were not statistically significant, the trend still favored the vocational group. The relative absence of significance may again point to sample size or contextual variables not controlled in this study. However, considering that the total self-efficacy score showed significant difference, it is clear that vocational training contributes to a holistic improvement in psychological functioning.

Vocational Training: A Tool for Transformation

Beyond the statistical findings, this study uncovered key benefits of vocational training that speak directly to the lived realities of rural women. Vocational training was shown to:

1. Strengthen teamwork capabilities – Encouraging collaboration and community support.
2. Enhance belief in self-reliance – Enabling confidence in handling challenges independently.
3. Increase awareness of financial independence – A powerful factor in asserting autonomy and resisting gender-based control.
4. Foster social networking and communication skills – Building essential soft skills often underdeveloped in formal education.

5. Contribute to psychological well-being – Reducing stress and anxiety through competence and control.

These dimensions are critical in a rural context where women are often excluded from decision-making, employment, and mobility. Vocational training breaks these barriers not only by teaching skills but by shifting internalized social norms and psychological frameworks.

Supporting Evidence from Existing Literature

The findings are in line with earlier research by Creed et al. (2001), who reported immediate gains in self-efficacy and self-esteem following community-based skills programs. Maritz and Brown (2013) similarly found that vocational entrepreneurship education significantly improved entrepreneurial self-efficacy (ESE), reinforcing the view that practical, applied education outperforms theoretical learning in promoting empowerment.

Moreover, recent research by Rehman et al. (2023) has highlighted that skill development training positively affects mental well-being, especially in under-resourced and underserved populations. In the case of rural Punjab, this means that vocational training can act as a mental health intervention, indirectly addressing depression, anxiety, and social withdrawal by promoting activity, agency, and social inclusion.

Conclusion: Vocational Training as a Sustainable Solution

To conclude, the present research highlights the transformative potential of vocational training in promoting self-efficacy and social competence among rural women. While formal education remains important, it often lacks the practical relevance and social exposure needed to equip women for real-world challenges. Vocational training, on the other hand, offers immediate applicability, confidence-building opportunities, and a sense of economic agency, which are critical for women from disadvantaged backgrounds.

This study strongly recommends that vocational training be integrated into rural development policies as a core strategy for women's empowerment. Special emphasis should be placed on:

- Expanding access through local centers and mobile units.
- Offering a range of gender-sensitive, market-relevant courses.

- Integrating mentorship, job-placement services, and micro-loans post-training.
- Creating awareness campaigns to normalize and valorize skill-based education.

For those unable or unwilling to pursue higher education, vocational training is not a fallback—it is a powerful pathway to autonomy, self-worth, and societal contribution. In a rapidly changing socio-economic landscape, it is vital to equip rural women not just to survive, but to thrive. Vocational training, as this research shows, is one of the most effective tools to achieve that vision.

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A Study on Role and Importance of Industries in Achieving Excellence in Skill Training by Govt. ITI of Vadodara District

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Abstract

Skill development is undergoing rapid transformation worldwide. Even in India, this is considered one of the frontrunners out of the multiple initiatives that have taken place in recent years. But it must be agreed that even after 75 years of independence, India is far behind where it should have been regarding formal skill development. As per a renowned economic consultant of the UK, Centre for Economic and Business Research (CEBR, 2021), India aspires to become 3rd largest economy by 2030. According to a report by the World Bank (2018), with this aspiration, India needs 67 Cr of the workforce by 2030. In contrast, the present workforce strength of India is ~50 Cr, which means a net ~17-20 Cr workforce needs to be injected into the system within 7-8 years.

Vadodara is a crucial hub for Gujarat's economic growth and has achieved massive advancement in the area of technical and vocational training through Govt ITIs. This Study was conducted to find out the involvement of industries in Skill training by the ITIs of Vadodara district. Study also explored the possible way to accord ITIs their due recognition in achieving excellence in skill Training. A comprehensive investigation combining descriptive survey method and mixed-methods approach reveals that Industries and ITIs have established concerted efforts reflecting Vadodara's commitment to fostering a robust skill development ecosystem. However, it was revealed that Social Stigma and undermine perception are the major challenges of ITI, which can be overcome through intense campaigns, upholding the success stories and improvement of infrastructure and resources. Overall, this Study contributes via practical recommendations for educators, policymakers, and employers to achieve excellence in skill training by the Government ITIs of Vadodara district.

Keywords: Industrial Training Institute (ITI), Skill Training, Institute Management Committee (IMC), NEP 2020, Vocational Education

Introduction

India's vision to become the “Skill Capital of the World” can become a reality only by creating a skilled and productive workforce matching international standards of quality and productivity through the integration of skills and training along with education.
Industrial Training Institutes have played a vital role in the economic development of the country, especially in terms of supplying skilled manpower to industries. Properly trained skilled manpower is the demand of the industry, which is being regularly supplied by hands-on skill training through ITIs.
Institute Management Committee (IMC) plays a crucial role in improving the quality of education and training at Industrial Training Institutes (ITIs) in India. It was introduced as part of the Public-Private Partnership (PPP) scheme to enhance the industry relevance and improve the employability of ITI pass-outs. The IMC ensures that ITIs meet the needs of the industrial sector by aligning their curriculum, training infrastructure, and teaching methods with current industry practices.

Rationale of the Study

As far as the industry-favoured ecosystem is concerned, Vadodara is a significant industrial centre. Even though industry and placement opportunities seem to be bright in Vadodara, the report of the district-wise skill gap study for the State of Gujarat (2017-2022) by National Skill Development Corporation (NSDC) and KPMG company indicated that a substantial skill shortage is going to remain even in the next five years. Currently, this Skill gap is managed by migrant workers, mostly from UP, West Bengal & Bihar.

As per the Report, Vadodara's performance concerning skill development was below the State average. So, this Study aimed to provide a holistic review of the role of industry partners in the operation of the government ITIs of Vadodara district in terms of the relevance of trades and the quality of training provided.
From the Manpower Talent Shortage survey by OECD (2014), it was noticed that 64% of India's companies have skill shortages. According to the Vision IAS Report, in countries like Korea, China, and Germany, around 85% of workforce in the age group of 18-25 have received some form of vocational training and the same figure in case of India drops down to 5-10%. According to the Report of CMIE (Centre for Monitoring Indian Economy), there is no significant improvement in the Unemployment rate, irrespective of several Skilling Initiatives in Gujarat as well as in India. It is consistently maintaining a rate of more than 5% for India and approximately 3% for Gujarat.

According to the report of NITI Aayog (2023), there is a gap in the literature on

suggesting actionable pathways for transforming the ITIs. So, the present Study also attempted to identify forward-looking recommendations for changes in the ITI ecosystem.

Objectives of the Study

1. To study the role of industries in the operation of it is by finding answers of following research questions
   I) What is the role of industries in designing the curriculum?
   ii) What support do industries provide to carry out On-job training?
   iii) Does industry provide guest/visiting faculty for teaching?

2. To identify the way forward to overcome existing challenges.

Delimitation of the Study

The present Study has been restricted to Government ITIs in Vadodara District, Gujarat.

Review of related literature

A review of 68 research papers was carried out to gain an in-depth understanding of the related topic of vocational education and training carried out in India over the last 50 years.Many research studies have been conducted on Vocational Education and training. All these studies mostly focused on current status of ITIs and general perceptions about Vocational education.

Vishwanathan(2018) found, the youth today consider that white-collar jobs will fetch them more respect and dignity and dream about working in luxurious offices sitting on a revolving chair staring at a laptop.

Yadav (2020) study revealed the need of various types of emerging trades. There is an urgent need for the upgradation of facilities like toilets, audio-visual aids.

National Education Policy (2020) came out with revolutionary changes and reforms, with major recommendations. NEP 2020 strongly recommended the need of collaboration with industry to develop practical skills, job readiness, and real-world exposure.A crucial recommendation of NEP 2020 is the collaboration with industry to develop practical skills, job readiness, and real-world exposure. Successful examples from institutions with strong industry partnerships highlight the benefits of such integration.

Singh (2021) Study titled as "Skill Development and Youth Employability: A comparative study of Punjab and Haryana" revealed that youth unemployment

washigh due to higher skill gaps.Due to lack of skilled trainers and outdated instruments, the quality of training provided in vocational training was very low in both the sample States.

Pathak (2021) Study revealed that most of the skill development institutions suffer from a lack of proper infrastructure. Advanced equipment, machines and tools were not available in the majority of the institutions.

In a Study conducted by **Gudipati (2022**), it was reported that the courses offered under the Craftsman Training Scheme (CTS) by various ITIs mostly followed an outdated curriculum.

NITI Aayog (2023)in its report titled "Transforming Industrial Training Institutes in India" presents actionable pathways for transforming the scenario.

Talukdar (2023) in his Study titled**, "**A study on Institutional Facilities and Internal Efficiency of student in the Industrial Training Institute" found that in most trades, there was a wide gap between the sanctioned intake capacity and actual enrolment. Thus, underutilization and overutilization of enrolment capacity were noted in all the institutions.

Methodology

i. Research Design: The present Study adopted a descriptive survey method and followed a mixed-methods approach that combined qualitative and quantitative techniques.
ii. Sources of Data: The research was based on Primary data. The Primary data was collected employing Questionnaire& Semi-structured Interview schedule.
iii. Population: There are 13 Government ITIs in the Vadodara district. The ITIs are run by Director General of Employment and Training (DGE&T), and they are one of the largest institutes offering various courses for skill development at the national level. The Study covered the following talukas in Vadodara district.
1.Vadodara2. Padra3. Dabhoi4. Karjan5. Savli6. Desar7. Sinor.
iv. Sample size: There are 13 Government ITIs in the Vadodara district. All 13 Government ITIs were selected as sample institutes. So here, the Population is equal tothe Sample.
v. Sampling techniques: There was no need for sampling for Principalsof these sample institutes as all 13 Govt. ITIs in Vadodara District were taken as samples. However, for the Trainee category, Researcher had followed proportionate stratified sampling; for Institutions having less than 500 trainees, 10% of total strength had been considered (e.g.- Desar, Sinor, Padra ITI,) and institutions having more than 500 trainees, 5% of total strength had

been considered (e.g.-Tarsali, Dashrath ITI). In the case of collecting responses from IMC chairman/representatives, the researcher received responses from 6out of 7 IMC Chairman/representatives.

vi. Tools for data collection: i) Questionnaire for Principals and Trainees ii) Semi-structured Interview Schedule for IMC representative/Chairman

vii. Statistical tools and methods for data analysis:Quantitative data was analysed with the help of the following statistical techniques:
- Percentage analysis
- Frequency distribution
- Chi-square test

Qualitative data was analysed with the help of Thematic Analysis

Result

The present Study was an attempt to understand theextent of involvement of industrieswith Govt. ITIsof Vadodara district in i) Curriculum design ii) On-job training iii) Support with visiting faculties for teaching and alsosuggest a pathway to attain excellence in skill training provided by ITIs.
The data for the present Study was made available in terms of responses from 13 government ITI principals and trainees and IMC representatives from industries.

Objective No. 1.i) :To study the role of industries in the operation of ITIs by finding answers of following research question

i. What is the role of industries in designing the curriculum?

Principal Responses

Table 1: Frequency Distribution of responses of principals for the statement that IMC plays a significant role in terms of the institute's curriculum, industry connection

	Frequency	Percentage
Strongly Agree	1	7.7
Agree	5	38.5
Undecided	7	53.8
Disagree	-	-
Strongly disagree	-	-
Total	13	100.0

Table-1 shows the frequency distribution of responses from Principals regarding the significance of the Institute Management Committee (IMC) in shaping the institutes' curriculum and enhancing industry connections. Among the 13 principals surveyed, only 1 (7.7%) strongly agrees with this statement, while 5 (38.5%) agree. However, a notable majority, 7 principals (53.8%), remain undecided about the IMC's impact. This distribution indicates a mixed perception of the IMC's role. Out of 13 Government ITIs, 5 institutions namely Karjan, Desar, Sinor, Tarsali, Gotri ITI didn't have IMC body

attached to institutes, caused responses as undecided.

Trainees Responses

Table 2: Distribution and Association of Industries role in Curriculum design					
Name of the ITI	Strongly agree	Moderately agree	Disagree	Strongly disagree	Total
ITI Dabhoi	17	15	0	0	32
ITI Dasrath	54	11	0	0	65
ITI Desar	18	21	1	0	40
ITI Disabled	3	5	1	0	9
ITI Gorwa	26	5	7	5	43
ITI Gotri	19	6	0	0	25
ITI Karjan	24	0	0	0	24
ITI Mahila Gorwa	17	7	0	0	24
ITI Padra	35	9	1	0	45
ITI Savli	27	13	0	0	40
ITI Sinor	20	1	0	0	21
ITI Tarsali	133	1	0	0	134
ITI Waghodia	9	26	0	0	35
TOTAL	402	120	10	5	537
Chi Square Value (P Value) = 266.68 (0.000)					

Table 2 presents data on whether curricula were designed in line with industry requirements, as reported by trainees from various Industrial Training Institutes (ITIs). Most respondents (402) strongly agreed - ITI Tarsali (133), ITI Dasrat (54), and ITI Padra (35) leading in strong agreement. Moderate agreement was expressed by 120 respondents, notably from ITI Waghodia (26) and ITI Desar (21). Disagreement was minimal, with only 10 respondents disagreeing and 5 respondents strongly disagreeing, the latter primarily from ITI Gorwa. The overall results from 537 participants indicated a positive perception of industry alignment, with a highly significant Chi-square value of 266.68 (p-value = 0.000), reflecting a strong association.

Objective No. 1.ii): To study the role of industries in the operation of ITIs by finding answers of following research question

i. What support do industries provide to carry out On-job training?

Principal Responses

Table 3: Frequency Distribution of responses of Principals regarding On-Job training/Placement agreements between industry and institutes		
	Frequency	Percentage
Strongly Agree	3	23.1
Agree	10	76.9
Undecided	-	-
Disagree	-	-
Strongly disagree	-	-
Total	13	100.0

Table 3 presents data regarding on-Job training/Placement agreements between industry and institutes as reported by Principals from various Industrial Training Institutes (ITIs). Among the 13 Principals surveyed, only 3 (23.1%) strongly agreed with this statement, while a notable majority, 10 principals(76.9%) agreed. The high level of agreement suggests that placement partnerships were well-established and were recognized by all respondents, reflecting strong industry-institute collaboration for trainee placements. It establishes that a very deep understanding exists between respective principals and industry partners for better placement opportunities for their trainees.

Trainees Responses

Table 4: Distribution and Association between On Job Training among ITI

Name of the ITI	Strongly agree	Moderately agree	Disagree	Strongly disagree	Total
ITI Dabhoi	27	4	1	0	32
ITI Dasrath	35	13	15	2	65
ITI Desar	31	7	2	0	40
ITI Disabled	4	3	1	1	9
ITI Gorwa	12	20	6	5	43
ITI Gotri	16	0	9	0	25
ITI Karjan	8	16	0	0	24
ITI Mahila Gorwa	8	5	8	3	24
ITI Padra	32	12	1	0	45
ITI Savli	14	24	2	0	40
ITI Sinor	9	12	0	0	21
ITI Tarsali	5	129	0	0	134
ITI Waghodia	0	9	22	4	35
TOTAL	201	254	67	15	537
Chi Square Value (P Value) = 405.55 (0.000)					

Table 4 shows the distribution of responses regarding the frequency of on-job training across different Industrial Training Institutes (ITIs). A significant portion of respondents (201) report that on-job training occurs frequently, with ITI Dasrat (35), ITI Dabhoi (27), and ITI Padra (32) leading this category. A large number (254) stated that on-job training happened occasionally, particularly in ITI Tarsali (129) and ITI Savli (24). Fewer respondents (67) reported that it occurs rarely, with ITI Waghodia (22) and ITI Gorwa (6) showing higher counts in this category. Only 15 respondents said that on-job training never takes place, with ITI Waghodia contributing the most (4). The data from 537 trainees indicated that on-job training took place frequently or occasionally, with a highly significant Chi-square value of 405.55 (p-value = 0.000). Results reemphasised that trainees acknowledged on job training did take place and they were satisfied with the on-job training facility.

Objective No. 1. iii) : To study the role of industries in the operation of ITIs by

finding answers to the following research question

i. **Does industry provide guest / visiting faculty for teaching?**

Principal Responses

Table 5: Frequency Distribution of responses regarding Visit of guest faculty from the industry		
	Frequency	Percentage
Strongly Agree	2	15.4
Agree	7	53.8
Undecided	4	30.8
Disagree	-	-
Strongly disagree	-	-
Total	**13**	**100.0**

Table 5 provides the frequency distribution of responses from principals regarding the visit of guest faculty from the industry. Out of the 13 Principals surveyed, 2 Principals (15.4%) strongly agreed that guest faculty from the industry visited their institutions. A majority of 7 Principals (53.8%) agreed with this statement, indicating a significant level of engagement with industry professionals. Meanwhile, 4 Principals (30.8%) remain undecided about the frequency of these visits.Overall, the data suggested that guest faculty visits were common in these institutions, enhancing the connection between education and industry. It also found that Guest faculty from neighbouring industries made frequent visits to ITIs and offered exposure to industry standards, as well as advanced machinery to trainees.

Trainees Responses

Table No 6: Distribution and Association betweenteaching from guest faculty from other industry among ITI					
Name of the ITI	Strongly agree	Moderately agree	Disagree	Strongly disagree	Total
ITI Dabhoi	15	10	6	1	32
ITI Dasrath	21	42	0	2	65
ITI Desar	8	30	2	0	40
ITI Disabled	5	2	1	1	9
ITI Gorwa	18	14	6	5	43
ITI Gotri	12	9	0	4	25
ITI Karjan	10	14	0	0	24
ITI Mahila Gorwa	7	13	1	3	24
ITI Padra	1	27	7	10	45
ITI Savli	13	19	0	8	40
ITI Sinor	1	14	6	0	21
ITI Tarsali	5	129	0	0	134
ITI Waghodia	27	7	0	1	35
TOTAL	143	330	29	35	537
Chi Square Value (P Value) = 263.85 (0.000)					

Table No6 presents data regarding the presence of guest faculty from the industry in various Industrial Training Institutes (ITIs). A significant number of respondents (143) reported that guest faculty always visited, with ITI Dasrat (21), ITI Dabhoi (15), and ITI Waghodia (27) leading in this category. A large group (330) indicated that guest faculty visits occurred sometimes, particularly in ITI Tarsali (129) and ITI Dasrat (42). Fewer respondents reported that guest faculty visits happened rarely (29), and only a small number (35) stated that such visits never occurred, with ITI Padra (10) showing the highest count in this category. The data from 537 respondents revealed a positive outlook on industry guest faculty visits, with a highly significant Chi-square value of 263.85 (p-value = 0.000), indicating a strong association. It indicated that industry involvement via the facility of guest faculty provided the needed exposure to industry practices.

Objective – 2: To identify the way forward to overcome existing challenges

IMC chairman/representatives' responses were gathered through Semi-structured interview questions. Responses being Qualitative data are analysed with the help of Thematic Analysis

Table: 7 : Extracts of interviews with Industry representatives

Industry Partner	Interview extracts	Theme	Way forward
IMC Chairman of Dasrath ITI	• After completion of the apprenticeship, the Industry may appoint the apprenticeship through a Third party. • After a long appointment through a third party, based on the performance of the contract employee, Industry may recruit in a regular role. • After completion of the Apprenticeship, many companies take no action/initiaterecruitment for those apprenticeships. • This often resulted in unemployment for ITI trainees. However, some of them go for self-entrepreneurship.	Uncertain career growth	A policy may be in place with few checks and regulations before any company terminates apprenticeships without securing their future

	ITI trainees lack a few specific qualities for upgradation, like Improvement in Communication, Decision-making ability, risk-taking ability, Basic computer literacy, because of their childhood environment, school teaching competency, degree of aspiration, etc	Absence of Professional skill	Teaching of soft skills in a more exhaustive way as part of the regular curriculum
IMC chairman of Mahila Gorwa&Savli ITI	There is a difference between theoretical knowledge and hands-on skills. So, if we start comparing ITI and IIT, then it would probably not be justified.	Theory Vs Skill – a mismatch comparison	Every Skill and knowledge haveits own dignity. Intense campaign required to ensure respective recognition with due dignity.
	IMC tries to inject an essence of professionalism through employability skills training programs IMC also arranges guest faculty, especially during preplacement time	Absence of Professional skill	Close involvement of Industries is required to inculcate soft skills and other technical skills
	• The major challenge is the way ITIs are perceived as the last resort for admission by society, since the dignity of labour in India is a challenge. • He added that if we look at how skilled workers are treated by foreign countries, they are acknowledged and are provided dignity for their respective skills, irrespective of qualification. We all need the assistance of skilledpeople every day, e.g plumbers, electricians, etc. But when it is a question of the education of our child, we only look for mainstream education. The major challenge is how to overcome social stigma.	Social Stigma	• Advertisement of ITI Success stories of past trainees. • Awareness Programme - Citingexamples of foreign countries for acknowledgement and the dignity of skill. Uphold positive results in the media Introduction of Skill Visas

IMC chairman of Waghodia ITI	Major challenges are: • Transportation cost for Trainees in rural ITIs • less participation of girls'trainees • Control over Teaching & Non-Teaching staff	Administrative Challenges	• Strong Administration should be in place • Campaign and Awareness programme at remote locations
IMC chairman of Padra ITI	• Aspirational mismatch of trainees. Most of them don't take pride in what they do or learn • Lack of support from the surrounding Industry for the development of ITI absence of a dedicated principal post Low Enthusiasm or low spirit of instructors is another challenge Any attempt to complete privatisation of ITIs may not be recommended as business spirit will take front seat.	Unenthusiastic ambience	• IMC to play key role in: awareness programs Surrounding industries to bring on board • Training program to train Trainers to bring enthusiasm • Imbibe technology into the learning, including the makeover of the classroom to bring glamour to the courses. • PPP scheme is the better way to resolve the problem
IMC chairman of Dabhoi ITI	• ITI's popularity is higher in rural areas in comparison to Urban areas • Top challenge is the Shortage of trainers or the non-availability of manpower and old infrastructure	Alternative source of income exists Resource shortage	• Upgradation of infrastructure • Training of Trainers • Trades in alignment with industry requirement • More importance on soft skill for trainees.

Discussion

The Institute Management Committee (IMC) plays a crucial role in the effective functioning and management of Industrial Training Institutes (ITIs) in India. Its primary aim is to ensure industry-institute linkages, improve training quality, and enhance the employability of trainees.

- Responses of Principals and Trainees establisheda very strong connection between Industries and ITIs as per as Curriculum, on-job training, and industry visit were a concern.
- It was evident from the Study that Industries and ITIs have established concerted efforts which reflect Vadodara's commitment to fostering a robust skill development ecosystem, equipping its workforce with the necessary skills to thrive in a dynamic economic environment.
- However, from the interviews of industry partners, it was revealed that Social Stigma and low perception were the major challenges of ITI. Almost everybody suggested the need for intense campaigns, upholding the success stories and improving infrastructure and resources.
- It was also observed during the study that, as per the government guidelines and industry suggestions, a separate subjectnamedEmployability Skill was introduced in almost all ITIs. However, the progress of trainees in this area was still a concern.

Conclusion

Vadodara holds a strategic advantage as a centre for skill development in Gujarat, thanks to a unique blend of industrial presence, educational institutions, and infrastructure. Vadodara stands outas home to major industries in petrochemicals, engineering, chemicals, power, and pharmaceuticals, creating high demand for skilled labour.

Industrial Training Institutes (ITIs) play a crucial role in Vadodara's skill development ecosystem. These institutes are central to equipping youth with hands-on technical and vocational skills aligned with industry demands.

The National Education Policy (NEP) 2020 places significant emphasis on vocational education, recognizing its critical role in equipping students with practical skills and enhancing their employability.NEP 2020 envisions a holistic approach to education by embedding vocational training within the mainstream curriculum. This integration is designed to prepare students for the evolving demands of the workforce, promote lifelong learning, and bridge the gap between education and employment.

Despite this, it is very evident that substantial scope for improvementexists. Through the interviews of senior personnel from industries, a few unique suggestions came out loud and clear, which can be considered as a practical implication of this study:

- Vadodara's rich industrial ecosystem can be a powerful engine for skill development if industry participation is strategic and structured. Fundamentally, thefew major objectives of skill training are to enhance employability, social equality, and economic growth of the nation and to avail the benefits of the demographic dividend. Thus, government funding for ITI'soperation is a more appropriate and right approach rather than any attempt atprivatisation of ITIs. Industry representatives also reinforced the above opinion during their

interviews.

- Skill training through ITIs is more of a service to society rather than a business. Nevertheless, considering the pivotal role of industries in ITI operation and to achieve excellence, the spirit of private organisations and processes must be embedded into the ITI ecosystem. This is only possible through PPP model. It is quite evident that wherever IMC is attached to ITIs, significant progress in terms of infrastructure, process, trades, and placement has gonethe extra mile. Hence, representativesof industries with authority as IMC members or in any other capacity may be extended to all ITIs of Vadodara district.
- However, despiteof IMC appointment, during the study, equal passion and interest were not observed. Thus, skill initiatives and their effective implementationmay also needto be monitored by theState Government through suitable mechanisms or incentives. In short, the sole criteria for selection of representative should be based on their passion to achieve excellence in Skill training with some kind of incentives.
- Despite the introduction of "Employability Skill", thelevel of implementation and rigorousness needs further attention. The degree of emphasis which has been put on hard skill, is not equal in case of soft skills. Much attention needs to be given to Soft Skills like basic English conversation, demo interviews, decision-making, importance of posture, and Safety awareness. A perfect blend of Soft and Hard skills can enhance employability bymultiple folds with enormous global opportunities.
- It is also important to mention here that Industrial Training Institutes (ITIs) were traditionally focused on vocational skills like welding, carpentry, plumbing, and electrical work. However, with the evolution of technology and industry needs (Industry 4.0), there's a growing need to align ITI training with modern industrial practices. Moreover, sustainable trades like Virtual welding, Modern welding lab with smoke absorption system are also available. In fact, few of the ITIs have started incorporating such trades like Solar Technician, Drone Operator, etc.NEP 2020 emphasises that the curriculum must be adaptable, incorporating emerging technologies like AI, machine learning, IoT, and big data.
- It is evident from the Study that ITIs of Vadodara are in the right direction, however, the inclusion of more emerging trades and emphasis on Soft skillswill pave the pathwayfor success stories of India's Skill Development initiatives.

Overall, this Study contributes via practical recommendations for educators, policymakers, and employers to achieve excellence in skill training by the Govt. ITIs of Vadodara district.

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Spotlight

3D Printing in Automotive and Transport: Revolutionizing Manufacturing and Design

The automotive and transport industries are undergoing a profound transformation with the integration of 3D printing, also known as additive manufacturing. This cutting-edge technology is revolutionizing the way vehicles are designed, prototyped, and manufactured, offering unprecedented benefits in terms of cost, efficiency, and sustainability.

Rapid Prototyping and Design Flexibility

One of the most significant advantages of 3D printing in automotive applications is its ability to rapidly prototype parts with intricate geometries. Traditional manufacturing methods often require expensive tooling and moulds, whereas additive manufacturing enables engineers to swiftly iterate designs, reducing development time and costs. This flexibility accelerates innovation, allowing for more aerodynamic and lightweight vehicle structures.

Customized and Lightweight Components

3D printing facilitates the production of customized and lightweight components, enhancing vehicle performance and fuel efficiency. By using advanced materials such as carbon fibre-reinforced polymers and metal alloys, manufacturers can create parts that are both strong and lightweight. This is particularly beneficial in electric vehicles (EVs), where weight reduction directly impacts battery efficiency and range.

Supply Chain Optimization and Sustainability

The adoption of on-demand manufacturing through 3D printing reduces dependence on large inventories and long supply chains. This shift minimizes waste, as components are produced only when required, leading to more sustainable production processes. Furthermore, recyclable materials and biodegradable polymers are being explored to reduce environmental impact.

Future Prospects

Looking ahead, 3D-printed entire vehicle structures and autonomous vehicle components are emerging as potential breakthroughs. Companies like Tesla, BMW,

Tata Motors, Mahindra are already leveraging 3D printing for parts such as brake callipers, chassis components, interior fittings, designing, prototyping, research and development. As material science and printing technologies evolve, the mass adoption of additive manufacturing in the automotive and transport industries will likely redefine traditional production paradigms.

3D printing is not just a technological trend but a game-changer in automotive and transport, offering a pathway to more efficient, sustainable, and innovative vehicle design and production. The future of mobility is being shaped, layer by layer.

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Promoting Sustainable Agricultural Practices Through the Vocational Training Programs of Agricultural Skill Development Institutions

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Abstract

Environmental sustainability is crucial in the context of global development. Agenda 2030 also cater to this issue while talking about sustainable development goals. Agriculture acts as a contributor as well as a solution for environmental challenges. In this context, skill development institutions have a crucial role in equipping farmers with the knowledge and tools necessary for practicing sustainable agriculture, primarily through vocational trainings provided under extension services. This study examines at how vocational training programs offered by agricultural skill development centers in India support sustainable farming. A semi-structured interview with an extension scientist, case studies of taught farmers, and an examination of one institution's yearly training report were all part of the mixed-method approach. During the year, 491 extension activities and 187 vocational trainings were reviewed. The findings indicate that training programs on climate-resilient agriculture, organic farming, integrated nutrient management, and livelihood diversification greatly boosted the uptake of sustainable methods. Profit increases of up to 150 percent were reported by farmers who expanded into scientific farming, animal husbandry, and vegetable gardening. However, there were challenges such as low rates of female and rural youth participation, restricted market accessibility, and high costs associated with implementing cutting-edge technologies. The paper emphasizes the importance of hand holding and skill development trainings in achieving long-term sustainability, with major focus on the role of these institutions in supporting local population recommendations to enhance inclusivity, strengthen market linkages, and integrate digital solutions for scaling sustainable agriculture.

Keywords: Vocational Education and Training, Skill Development, Agricultural Education, Farmer Training, Sustainable Agriculture.

Introduction

India is pacing towards becoming a world power by 2047 through its Viksit Bharat Mission, 2047. Being an agriculture-based country, the role of agriculture becomes valuable in achievement of this goal. India's Gross Domestic Product (GDP) heavily depends on agriculture. Agriculture provides livelihood to 42.3% Indian population leading to 18.2% GDP share in country's overall GDP (Press Information Bureau, Ministry of Finance, 2024)[15]. However, despite its significance, the adoption rate is low for innovative and sustainable agricultural practices resulting in low productivity and unstable income. In order to accelerate the shift to sustainable agriculture, national and international organizations such as the FAO (2022), NITI Aayog (2023), TERI, and AG Horizon (2023) have repeatedly emphasized the need for more robust institutional support[4,12,13,14]. Vocational education and training (VET) institutes have a unique function in this setting. They assist farmers in moving beyond conventional techniques and implementing strategies that are both economically and environmentally sustainable by integrating skill development with practical extension services. These organizations introduce farmers to technologies including agroforestry, integrated nutrient management, organic farming, and climate-smart practices through workshops, farm fairs, advice services, and vocational training programs. They also support rural communities' social advancement, income generating, and capacity building. These goals align with India's National Skill Development Mission and the National Education Policy (2020), which emphasize sustainability, inclusion, and livelihoods[8,9].

This study investigates how vocational training programs organized by these institutions contribute in promoting sustainable agriculture practices and improving the socio-economic conditions of rural communities.

Literature Review

Agriculture has sustained communities for centuries, but the demand for ever-higher yields has often come at the cost of soil health, biodiversity, and the environment. This concern has brought sustainable agriculture to the frontline of research and policy.

Factors Influencing Adoption of Sustainable Agriculture

Several studies show that adopting sustainable practices is not merely a matter of introducing technology, farmer aptitude and attitude play an important role in the process. Coulibaly et al. (2021) highlight that while farm-level considerations like land size, soil type, and property rights play a significant role, individual factors like a farmer's age, income, gender, or level of education also influence decision-making.

They further argue that adoption is further complicated by attitudes and outside resources like markets and training opportunities. In the same context, Maulu et al. (2021) examine twenty years of research and contend that agricultural extension programs can have a significant impact, particularly if they are adaptable and responsive to the evolving requirements of farmers. The collective works serve as a reminder that adoption occurs in a broader environment that is influenced by both personal circumstances and institutional support networks.

Emerging Approaches to Sustainable Agriculture

In addition to addressing issues regarding adoption, researchers have drawn out several kinds of sustainable farming methods. According to Muhie (2022), integrated pest and nutrient management, organic farming, and climate-smart agriculture are all viable avenues. Ali and Dahlhaus (2022) examine precision and digital agriculture in further detail, emphasizing how they might increase productivity and resilience. In contrast, Qaim and Parlasca (2025) advocate for greater interdisciplinary cooperation and emphasize the role of agricultural economists in creating policies for sustainable agri-food systems. Although these studies acknowledge that there is no one way to achieve sustainability, they vary in their focus—some emphasize technology solutions, while others emphasize the social and policy aspects.

Role played by Training and Vocational Education

A common theme throughout the literature is that farmers require assistance and direction in order to implement sustainable methods. Although many farmers are open to adapting, Abed et al. (2025) demonstrate that in order to put information into practice, they frequently need constant supervision, or what they refer to as "handholding." Considering a broader view of vocational education and training, McGrath and Yamada (2023) contend that while VET has a solid base in skill development, existing curricula need to be modified to take sustainability considerations into account. Another layer is added by Rohilla and Rohtash (2024), who emphasize the importance of agricultural training in improving rural areas and call for increased international cooperation in the development of such initiatives. While these narratives agree on the importance of training, they disagree on the relative importance of short-term local assistance against long-term changes and international networks.

Policy and Practice Context in India

These ideas are further supported by reports that are specific to India. Indian agriculture faces urgent sustainability concerns and cannot afford to put off capacity-building initiatives, according to the reports published by AG Horizon (2023) and TERI

(2021). FAO (2022) and NITI Aayog (2023) documents, both stress how critical it is to match India's agricultural reforms with international sustainability guidelines. Collectively, these texts imply that although policy frameworks are in place, developing farmer-focused, skill-based methods to put policy into action is the true difficulty.

Research Gaps

The majority of the reviewed literature focuses on reviewing the research done by others as they are review papers, and therefore, provide secondary data (e.g., Coulibaly et al., 2021; Maulu et al., 2021). This limits the understanding of farmer's lived experiences with adopting sustainable practices. Also, in spite of a lot of research done on various sustainable agricultural practices (Muhie, 2022; Ali & Dahlhaus, 2022; Qaim & Parlasca, 2025) , the area of impact analysis of skill development institutions in providing vocational trainings in these practices is not much explored. . Even where the importance of training and handholding is acknowledged (Abed et al., 2025; McGrath & Yamada, 2023), systematic impact assessments of such programs are scarce, particularly regarding their influence on farmers' attitudes and long-term behavioral change. Policy reports from India (AG Horizon, 2023; TERI, 2021; FAO, 2022; NITI Aayog, 2023) also stress sustainability imperatives, yet they remain largely at the framework level, with insufficient exploration of how farmer-focused, skill-based initiatives operationalize these policies on the ground.

Objectives

Based on the gap analysis, following objectives were formulated for the current study:

- To identify the types and characteristics of vocational trainings (such as duration, frequency, and content areas) organised by the skill development institutions to cater to sustainable agricultural practices.
- To evaluate the impact of these vocational trainings on the extent of income rise of rural farmers, measured through indicators such as percentage increase, diversification of income sources, or income stability.
- To analyse the training programs' effectiveness in adoption of sustainable agricultural practices, assessed by the number and degree of practices adopted, the level of continued use, and the time taken for adoption.

Methodology

A mixed method approach was used in the study to achieve the particular objectives. The annual training report from one of the skill development centres in the Delhi NCR

area of India was examined in order to identify the various vocational trainings offered by the institution. The selection of trainings and extension activities was based on the complete set reported for the most recent year, thus covering all 187 vocational trainings offered under different verticals and 491 extension activities conducted for sustainable agriculture practices. This ensured a comprehensive rather than sampled coverage.

A semi-structured interview with one of the extension scientists from the skill development institution, who had also served as a trainer, was conducted to examine the impact of the trainings on enhancing farmer's income and adoption of sustainable practices. The scientist was purposively selected due to his direct involvement in planning and delivering these programs. The interview guide included broad themes such as training design, farmer participation, perceived income benefits, challenges in adoption of sustainable practices, and the institution's follow-up strategies.

For the qualitative component, two success stories of farmers implementing these trainings in the field were selected from the annual report. The cases were chosen purposively as they reflected diverse contexts—one highlighting income gains through crop diversification and another demonstrating adoption of climate-smart practices—so as to capture different forms of training impact.

To enhance validity, data from training reports, interviews, and case studies were triangulated. Cross-checks were also carried out between annual report statistics and the narratives presented in interviews and case studies.

For analysis purposes, statistical tools such as Excel and NVIVO were used. Excel was employed to categorize and generate descriptive statistics on the types of trainings and extension activities, while NVIVO was used for coding interview transcripts and case narratives, allowing systematic identification of recurring themes and patterns. The choice of these tools was based on their suitability for handling structured quantitative data (Excel) and unstructured qualitative data (NVIVO), ensuring transparency and rigor in analysis.

The sample size thus included the study of 187 vocational trainings and 491 extension activities, in-depth interaction with the Extension Scientist, and two illustrative case studies drawn from the institution's annual report.

Findings

Analysis of Annual Report:

In depth analysis of the annual report exhibited major focus on two key areas:

A) Vocational Training programs offered on varied themes:

The training programs play a crucial role in skill development and sustainable agriculture adoption. The report provided insights into participation, effectiveness, and challenges in these programs. The participation statistics highlighted that in total

187 trainings and 491 extension activities were conducted throughout the year, with a total participation of 5,564 farmers including 5,097 practicing farmers, 270 rural youth and 197 extension functionaries. Key Training Themes of these training programs included:

- Integrated Nutrient Management (INM): Focused on balanced fertilizer application for crops like wheat, paddy, guava, and ber.
- Sustainable Farming Practices: Training on organic farming, agroforestry, and soil health improvement.
- Climate-Resilient Agriculture: Capacity-building for water conservation, micro-irrigation, and climate-smart crops.
- Livelihood Enhancement: Vocational training for women and youth, including kitchen gardening, nursery raising, and food processing.
- Technology Adoption: Hands-on training in precision farming tools, irrigation management, and mechanization.

The following were the major challenges identified in the implication of these training programs:

- Low Female Participation majorly due to household responsibilities, cultural barriers, and lack of mobility to the location of skills development centres.
- Youth Disengagement primarily due to major shift of young generation to urban jobs, showing low interest in agricultural training due to better financial opportunities in the city.
- Some of the advanced technologies are highly expensive and many farmers cannot afford these advanced technologies despite successful trainings on their usage.
- Limited Market Access: Farmers trained in these new techniques struggle to sell their produce at competitive prices due to limited access to the market at global level.

B) *Case Studies: Impact of Training on Farmers:*

The report included case studies highlighted the role of these vocational training programs in positively impacting farmers' incomes, sustainability, and productivity. These trainings are conducted under the timeframe of one financial year and are based on crop season. The trainings are usually of 5 days duration. The institution provides follow up services for all the trainings provided round the year.

• Case Study 1:

Background of the farmer: Farmer owned 9 acres of land with limited income and was depended on traditional wheat and paddy farming. The major problems faced by the farmer were high cost of cultivation, deteriorating soil health and low yield of milk

from domestic animals. He then participated in one of the trainings under the Doubling Farmers' Income (DFI) program, on sustainable farming practices organised by the skill development center.

After Training Participation: After successful training completion, he adopted vegetable farming (potato) and livestock rearing (increased cows from 1 to 4) and also implemented integrated farming practices. This resulted in net income growth from ₹3,78,500 to ₹11,01,728 during the analysis period, exhibiting 154% increase in the net income.

- Case Study 2:

Background of the farmer: Farmer owned 2 acres of land, earning only ₹84,705 annually and relied solely on staple crop farming. The major problem faced by the farmer was high cost of cultivation and low selling price of the staple crops.

After Training Participation: After undergoing the training session under the Doubling Farmers' Income (DFI) program of the institution, the farmer diversified the land area into scientific dairy farming and expanded crop varieties and adopted better agro-advisory services for improved productivity resulting a net income growth of ₹3,10,915.

Key Findings from Case Studies

- Impact of Diversification: Moving beyond wheat and paddy to vegetables and livestock significantly increased farmer incomes.
- Urgent need to shift to Scientific Farming: Advisory services on scientific practices of cultivation and modern crop management led to higher yields and better soil health.
- Profits of Livestock Integration: Dairy expansion boosted milk yields by over 400%, improving financial stability.
- Direct link between Sustainability & Profitability: Natural farming methods like green manuring, integrated nutrient management, and diversified cropping enhanced sustainability and income.

Major findings from Annual Report:

- Skill development programs were helpful in driving higher farm productivity and income levels.
- However, women and youth participation remained low, requiring targeted interventions.
- Farmers who have diversified and adopted scientific farming practices experienced significant financial and sustainability benefits.

- Future training programs should focus on digital solutions, market linkages, and gender-inclusive strategies.

Thematic Analysis of Interview Transcript

The qualitative analysis identified key themes emerging from the interview with an Extension Scientist at the skill development center of the study, focusing on skill development programs and their impact on sustainable agriculture. The analysis categorized responses into parent and child nodes, highlighting insights, challenges, and recommendations.

Coding Framework and Sentiment Overview

Parent Node	Child Nodes	Representative Quotes	Sentiment	Impact
Role of the Institution	Technology Transfer, Dissemination of Knowledge, Training Methods	"From laboratory to the field"; "Providing training in sustainable farming practices"; "Demonstrations, field visits, radio talks"	Positive	High adoption, broad outreach
Challenges in Training Implementation	Gender Bias, Youth Disengagement, Financial Constraints	"Low female participation…"; "Young people prefer urban lifestyles over farming"; "Lack of funds limits adoption"	Neutral/Negative	Low participation, declining interest, limits sustainability
Effectiveness of Training Programs	Practical Demonstrations, Training of Extension Personnel	"Hands-on training boosts adoption"; "Empowering trainers leads to better outreach"	Positive	Higher productivity, improved soil health
Barriers to Adoption	Small Land Holdings, Limited Market Access, Digital Gaps	"Fragmented land makes adoption difficult"; "Limited avenues for selling sustainably produced crops"; "Need for technology-driven solutions"	Neutral	Limits scalability, slower digital adoption

Table 1: Coding Matrix for Interview Analysis

Word Frequency Analysis

Most frequently used words were *Training, Farmers, Adoption, Challenges,* and *Sustainable*. These highlight the centrality of training efforts, farmer engagement, and barriers to adoption.

Word / Theme	**Frequency (Approx.)**
Training	50
Skill Development	45
Farmers	40
Agriculture	38
Sustainable	35
Knowledge	32
Adoption	30
Productivity	28
Technology	27
Challenges	25
Youth	22
Financial	20
Gender	18

Table 2: Word Frequency Table of the Interview



Figure 1: Word Cloud of most frequently used words

Coding Matrix

Themes	Technology Transfer	Training Methods	Gender Barriers	Youth Disengagement	Financial Constraints	Practical Demonstrations	Market Access	Digital Knowledge Gaps
Mentions	High	High	Medium	High	High	High	Medium	Medium
Sentiment	Positive	Positive	Neutral	Negative	Negative	Positive	Neutral	Neutral
Impact	High adoption	Broad outreach	Low participation	Declining interest	Limits sustainability	Higher productivity	Limited expansion	Slower digital adoption

Table 3: Coding Matrix table used to generate the NVivo Visualization

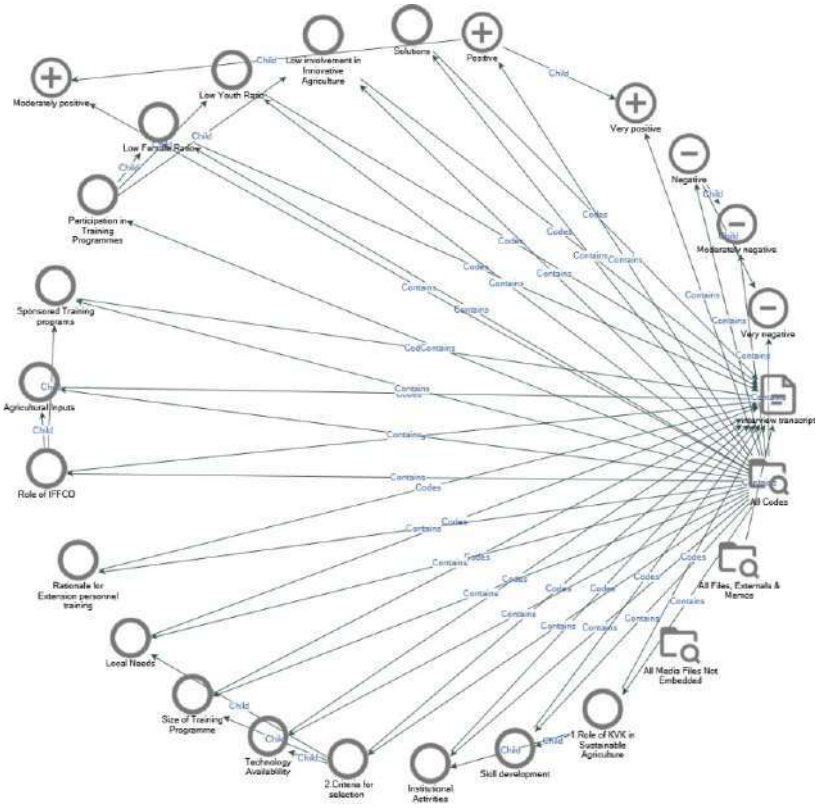


Figure 2: Visual Presentation of interconnection between Parent nodes and child nodes

Conclusion

This study provides empirical evidence on how vocational training programs contribute to the adoption of sustainable agriculture, moving beyond earlier literature that is largely review-based. By analysing 187 training programs, 491 extension activities, and success stories from a Delhi NCR institution, the study demonstrates that targeted skill-building directly influences farmer income and adoption of practices such as integrated nutrient management, organic farming, climate-resilient crops, and agroforestry. These findings underscore the operational role of skill development institutions in aligning with multiple SDGs. The originality of this work lies in linking institutional training outputs with farmers' real outcomes—productivity, income diversification, and gender-inclusive participation—showing how capacity-building transforms policy frameworks into ground-level impact.

Recommendations for Betterment of Vocational Training Outputs

- Enhancing Female Participation: Since analysis revealed consistently low female participation, targeted awareness campaigns and women-friendly training formats are essential.
- Engaging Youth: Interview insights showed youth disengagement; incorporating digital tools and showcasing agri-entrepreneurship opportunities can re-attract them.
- Bridging Financial Gaps: Case evidence highlighted poor awareness of government subsidies and loans; training modules should include handholding for applications and approvals.
- Strengthening Market Access: Success stories confirmed that collective action improves outcomes; supporting FPO formation with links to global supply chains can widen farmers' reach.

Policy Recommendations

- Establish agricultural incubation centres with universities and agri-tech startups, as training analysis showed demand for exposure to advanced technologies.
- Develop public–private partnerships to address funding and curriculum gaps observed in institutional practice.
- Link agri-entrepreneurship schemes with vocational trainings to respond to youth disinterest and support female-led initiatives.

- Create a national database to monitor training outcomes, since the current study highlighted difficulty in tracing long-term impacts.
- Institutionalize regular impact assessments, aligning policy feedback loops with farmer experiences documented in this study.

Recommendations for Future Research

This study is limited by its focus on a single institution in Delhi NCR, reliance on one in-depth interview, and two case stories, which may restrict generalizability. Future research should:

- Conduct longitudinal studies to capture long-term effects of training on farmer income, productivity, and sustainability.
- Expand analysis across multiple institutions and regions to compare effectiveness of diverse vocational models.
- Explore how AI, IoT, and blockchain can strengthen market linkages and digital dissemination of training content.
- Evaluate the impact of linking vocational training with agri-entrepreneurship programs in reducing rural–urban migration and fostering youth-led innovations.

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Integrating Indian Knowledge Systems in Vocational Education: A Framework for Future Management Practices

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Abstract

This study explores the integration of Indian Knowledge Systems (IKS) into vocational education and its impact on leadership development, ethical decision-making, and sustainability awareness. A mixed-method research approach was employed, involving 200 vocational education students divided into an IKS-integrated group and a non-IKS group. The study utilized surveys, interviews, and focus groups to analyze the effectiveness of IKS-based education in enhancing business ethics, leadership values, and sustainability principles. The results revealed a significant improvement in ethical responsibility, leadership qualities, and environmental consciousness among students trained with IKS principles. Statistical analysis, including t-tests, confirmed that IKS-trained students demonstrated higher competencies in ethical decision-making, values-driven leadership, and sustainable business practices compared to their counterparts. The findings strongly advocate for integrating IKS into modern vocational training programs to cultivate responsible business professionals. Future research should explore industry-specific applications of IKS-based models and their long-term influence on corporate sustainability.

Keywords: Vocational Education and Training, Skill Development, Agricultural Education, Farmer Training, Sustainable Agriculture.

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Introduction

In today's globalized world, where businesses are increasingly focused on sustainability, ethics, and corporate social responsibility (CSR), management practices that draw from local knowledge and values are more relevant than ever. Indian Knowledge Systems offer a holistic approach, emphasizing long-term sustainability, ethical decision-making, and leadership based on core values like dharma (duty) and karma (actions and their consequences). Incorporating these principles into vocational education can help shape future managers who can tackle global challenges while maintaining a balance between economic growth, social responsibility, and environmental protection. Embedding IKS into vocational curricula can also nurture leadership qualities, promote ethical governance, and instill a deep sense of responsibility toward society and nature in students. This approach aligns perfectly with the global push towards sustainable development and ethical leadership, making the integration of IKS into vocational education both relevant and necessary. The integration of Indian Knowledge Systems (IKS) into vocational education offers a new way to improve future management practices by drawing on India's rich cultural, scientific, and philosophical heritage. IKS includes diverse fields like Ayurveda, Vedic mathematics, traditional agriculture, and ethical governance, which have played a key role in promoting sustainable and community-driven development for centuries. So far, vocational education in India has largely followed Western models, but today's global challenges—such as climate change, ethical leadership, and resource management—demand a shift towards indigenous systems of knowledge. This paper aims to explore how IKS can be woven into vocational education to create future leaders who are not only skilled in modern practices but also grounded in ethical, sustainable, and community-based leadership. The growing awareness of the value of indigenous knowledge systems, very little research has focused on their integration into vocational education, especially in the context of management training. Current vocational education models in India still rely heavily on Western management theories, often neglecting the rich heritage of local knowledge embedded in IKS. While some studies have highlighted the role of IKS in sustainable development and ethical leadership, there is limited exploration of how these systems can be practically introduced into vocational curricula to shape the future generation of managers. This research seeks to fill this gap by exploring the potential of IKS to improve leadership, ethical decision-making, and sustainability awareness in vocational education and by proposing a framework for integrating IKS into mainstream educational systems.

Literature Review

The reviewed literature suggests that Indian Knowledge Systems (IKS) provide valuable insights for vocational education and future management practices.

Kapil and Sharma (2018) examined the Gurukul education system, an ancient Indian model that focused on experiential learning, mentorship, and holistic development. Their study highlighted how the Gurukul system ensured deep skill acquisition by allowing students to learn through real-world applications under the guidance of experienced mentors. The researchers analyzed historical texts and case studies of institutions that have successfully adopted Gurukul-like teaching methods, such as project-based learning and teacher-student mentorship models. They found that ethical leadership, problem-solving, and emotional intelligence were naturally ingrained in students through teachings from ancient texts like the Upanishads and Arthashastra. Institutions that embraced this method demonstrated improved student engagement and retention of knowledge in skill-based courses. The authors concluded that modern vocational education could significantly benefit from integrating mentorship-driven and hands-on learning models inspired by the Gurukul tradition.

Singh (2019) explored how Ayurvedic principles, particularly balance, sustainability, and natural resource management, can be applied to modern business practices and vocational training in entrepreneurship. The study compared traditional Ayurvedic production methods with contemporary sustainable business models in industries such as organic farming, herbal cosmetics, and wellness tourism. Singh found that Ayurvedic principles align with circular economy models, which reduce waste and promote sustainability, benefiting both businesses and the environment. The study also revealed that companies following Ayurvedic-inspired sustainable models experienced higher consumer trust and long-term financial stability. The author suggested that vocational training programs should integrate these principles to equip future entrepreneurs with ethical and environmentally responsible business strategies.

Deshpande and Rao (2020) investigated the role of Vedic Mathematics in enhancing financial management, data analysis, and decision-making skills in business education. They conducted experiments with students trained in Vedic Mathematics and analyzed their ability to solve business-related mathematical problems efficiently. The study found that students using Vedic techniques solved calculations 30-40% faster than those relying on conventional methods, demonstrating significant improvements in speed and accuracy. Additionally, Vedic Mathematics enhanced logical thinking and problem-solving abilities, making it particularly useful for financial forecasting, risk assessment, and strategic decision-making. The researchers

recommended integrating Vedic Mathematics into finance and business management courses within vocational education to develop students' analytical and computational skills.

Patel (2021) examined how teachings from Indian scriptures, such as the Bhagavad Gita, Arthashastra, and Manusmriti, offer valuable insights into ethical leadership and corporate governance. The study analyzed both ancient texts and modern business case studies where Indian ethical leadership principles were successfully applied. Patel highlighted that the Bhagavad Gita's philosophy of Nishkam Karma (selfless action) fosters responsible and compassionate leadership. Similarly, Arthashastra's strategic governance principles provide a strong foundation for economic policies and business administration. The study also found that companies incorporating ethical leadership models based on Indian traditions reported higher employee satisfaction and corporate social responsibility (CSR) performance. The author suggested that vocational management education should include ethical leadership modules based on Indian scriptures to develop future leaders with strong moral values.

Iyer and Mukherjee (2021) explored how Indian artisanal learning models, such as weaving, pottery, and metalwork, provide an effective framework for hands-on vocational education. They conducted field studies in craft clusters and analyzed how traditional apprenticeship-based learning ensured deep skill acquisition and knowledge retention. The study found that artisans' training methods followed a "learning by doing" approach, where students developed expertise through repeated practice and mentorship. This system encouraged creativity, problem-solving, and innovation. The authors suggested that modern vocational education should adopt this mentorship-driven model, as it enhances skill development and helps students transition more effectively into the workforce.

Raghavan (2022) studied how yoga and meditation can improve workplace efficiency and employee well-being. The study used psychological assessments of employees who practiced yoga regularly versus those who did not. Results showed that organizations that implemented yoga-based wellness programs experienced a 23% increase in productivity and a 40% decrease in employee stress levels. Additionally, businesses that adopted these methods reported lower absenteeism and higher employee engagement. The study suggested that vocational training programs should integrate yoga and mindfulness techniques to help future professionals maintain mental resilience and work-life balance in high-pressure environments.

Sharma and Bhatt (2022) examined how traditional Indian agricultural techniques, such as crop rotation, natural fertilizers, and rainwater harvesting, can be integrated into modern sustainable entrepreneurship. Their research compared the economic and environmental impact of traditional versus industrial farming. They found that ancient farming methods helped improve soil fertility, enhance crop yields, and reduce

reliance on chemical fertilizers. Agripreneurs who adopted these sustainable techniques reported higher profitability and lower production costs. The authors recommended that vocational courses in agriculture and business management should integrate traditional Indian farming principles to promote sustainable entrepreneurship.

Mehta (2023) analyzed how Panchatantra fables, known for their moral and strategic lessons, can enhance business communication, leadership, and negotiation skills. The study found that companies that incorporated narrative-driven marketing strategies based on storytelling principles saw higher customer engagement and brand loyalty. Additionally, leadership training programs that included Panchatantra-based lessons showed improvements in decision-making and team collaboration. The author argued that vocational business programs should incorporate storytelling techniques inspired by the Panchatantra to develop effective communicators and persuasive leaders.

Verma (2023) examined how ancient Indian temple economies managed large-scale finances, resources, and social welfare initiatives. The study found that temples acted as early financial institutions, efficiently managing land, funds, and public welfare. These economic models provided lessons in fund management, wealth distribution, and sustainable financial planning. The research suggested that modern financial management education can learn from temple-based economic systems to develop sustainable and community-driven financial models.

Rao and Sinha (2024) explored how the Indian concept of Dharma (duty and ethics) aligns with Corporate Social Responsibility (CSR). They analyzed businesses that incorporated Dharma-driven ethics in their CSR initiatives and found that such companies experienced higher customer trust, employee satisfaction, and long-term business sustainability. The study concluded that vocational training in management should include Dharma-based CSR models to encourage ethical and socially responsible business leadership.

Research Objectives

- To analyze how Indian Knowledge Systems principles can be integrated into vocational education.
- To evaluate the potential impact of IKS on future management practices in terms of leadership, ethics, and sustainability.

Research Methodology

Research Design: The study adopts an exploratory and descriptive research design, utilizing a mixed-method approach that combines both quantitative and qualitative

data collection and analysis.

Sample Size: The study involved 200 vocational education students, divided into two groups:

- IKS Group: Received training incorporating Indian Knowledge Systems, including ethical leadership from scriptures, sustainability from Ayurveda, and decision-making from Arthashastra.
- Non-IKS Group: Underwent traditional vocational education without IKS integration.

Data Collection Methods: Both primary and secondary data sources were used for data collection. Surveys were conducted using Likert-scale questions (1-5) to measure participants' perceptions of ethical decision-making, leadership, and sustainability awareness. Interviews were held with educators and industry professionals to gain insights into the practical applications of IKS principles in business education. The focus groups with students provided a deeper understanding of their learning experiences and the impact of IKS-based training on their professional outlook.

Key Variables Measured: The study focused on three key variables. Ethical Decision-Making assessed participants' awareness and application of ethical principles in business practices. Leadership Skills examined their ability to lead with integrity, inspire teams, and make value-driven decisions. Sustainability Awareness evaluated their understanding of sustainable business models, environmental responsibility, and ethical supply chain practices.

Statistical Analysis: To assess the impact of IKS education, the following statistical methods were applied:

- **Descriptive Statistics:** Mean, median, and standard deviation for each variable.
- **T-tests:** Compared the differences in responses between the IKS and Non-IKS groups to determine statistical significance.

Hypothesis Testing

Null Hypothesis (H_0): There is no significant difference between IKS and Non-IKS groups in leadership, ethical decision-making, and sustainability awareness.

Alternative Hypothesis (H_1): There is significant differences exist between the two groups in these areas.

Data Analysis and Interpretation: A total of **200 students** were evaluated using **survey questionnaires, pre- and post-training assessments, and case studies**. The collected data was analyzed using **descriptive statistics, t-tests,** to determine whether there were **significant differences** in leadership skills, ethical decision-making, and sustainability awareness between the two groups.

Descriptive Statistics (Mean Scores for IKS vs. Non-IKS Group)

This study investigates the role of Indian Knowledge Systems (IKS) in vocational education and its impact on leadership development, ethical decision-making, and sustainability awareness. The research compares students who have received IKS-based training with those who have undergone traditional vocational education.

Category	IKS Group (Mean Score)	Non-IKS Group (Mean Score)
Ethical Consideration	4.05	2.55
Social Responsibility		
Identifying Unethical Practices	4.02	2.41
Dharma Ethics	3.98	2.51
Ethical Leadership	4.02	2.41
Awareness	3.93	2.52
Traditional Knowledge	3.87	2.41
Waste Reduction	4.13	2.57
Ethical Supply Chains		
Profit vs. Environmental Balance	3.94	2.58
IKS Integration in Education	4.07	2.56
Learning from Ancient Texts	4.07	2.30
Ethics in Corporate Training	3.93	2.23
Holistic Learning Methods	3.93	2.54
Interest in IKS-based Business Practices	3.91	2.52

Table 1: Likert-Scale Scores (1-5) for IKS vs. Non-IKS Group

The **IKS Group consistently scored higher** across all categories compared to the **Non-IKS Group**, indicating that **IKS-based education significantly enhances ethical decision-making, leadership skills, and sustainability awareness**. From the above table we can analyse:

- **Ethical Decision-Making** – Higher scores in *Ethical Consideration (4.05 vs. 2.55)* and *Identifying Unethical Practices (4.02 vs. 2.41)* indicate stronger

ethical awareness in IKS-trained students.

- **Leadership Development** – *Ethical Leadership (4.02 vs. 2.41)* and *Dharma Ethics (3.98 vs. 2.51)* highlight the impact of IKS on values-driven leadership.
- **Sustainability Awareness** – *Waste Reduction (4.13 vs. 2.57)* and *Profit vs. Environmental Balance (3.94 vs. 2.58)* show that IKS students prioritize sustainability more.
- **Traditional Knowledge & Learning** – *IKS Integration in Education (4.07 vs. 2.56)* and *Learning from Ancient Texts (4.07 vs. 2.30)* reinforce that **traditional Indian knowledge strengthens business ethics and management skills**.

IKS-based vocational training significantly improves **ethical responsibility, leadership skills, and sustainable business practices**, supporting its integration into modern education.

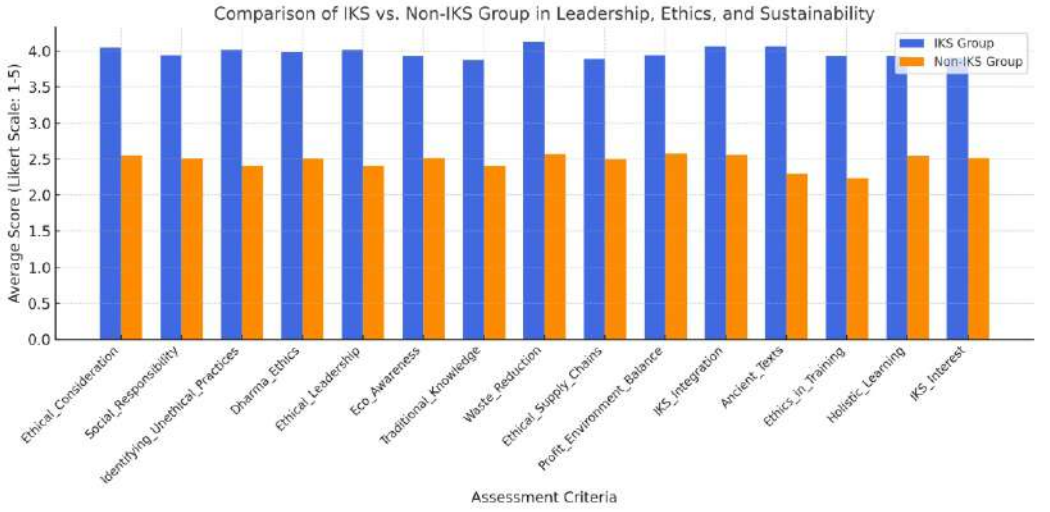


Figure 1: Comparison of IKS vs. Non-IKS Group

The graph visually represents the **difference in mean scores** between the **IKS Group and Non-IKS Group** across key assessment criteria.

- **IKS Group consistently scores higher** in all categories, showing a significant **positive impact of IKS-based education**.
- **Ethical Decision-Making & Leadership** – Higher scores in *Ethical Consideration, Identifying Unethical Practices, and Ethical Leadership* indicate that **IKS-trained students make more value-driven decisions**.
- **Sustainability Awareness** – Categories like *Eco-Awareness, Waste Reduction, and Ethical Supply Chains* show that **IKS education enhances environmental**

responsibility.

- **Traditional Knowledge & Holistic Learning** – Higher scores in *IKS Integration in Education, learning from Ancient Texts, and Holistic Learning Methods* suggest **IKS principles improve management skills and ethical training**.

The graph strongly supports the argument that **IKS-based education enhances leadership, ethics, and sustainability awareness**, reinforcing the need for its integration into vocational training programs.

Hypothesis Testing Results

We conducted **t-tests** to determine whether the differences between the IKS and Non-IKS groups are statistically significant. The **p-values** for all variables were **less than 0.05**, meaning **there is a significant difference** between the two groups. The Key areas where **IKS-based education showed a significant impact** (p-value < 0.05):

- **Ethical Decision-Making**: Higher scores in *Ethical Consideration (4.05 vs. 2.55)* and *Identifying Unethical Practices (4.02 vs. 2.41)* indicate **stronger ethical awareness** in IKS-trained students.
- **Leadership Development**: *Ethical Leadership (4.02 vs. 2.41)* and *Dharma Ethics (3.98 vs. 2.51)* highlight **IKS's impact on values-driven leadership.**
- **Sustainability Awareness**: *Waste Reduction (4.13 vs. 2.57)* and *Profit vs. Environmental Balance (3.94 vs. 2.58)* show that **IKS students prioritize sustainability more.**
- **Traditional Knowledge & Learning**: *IKS Integration in Education (4.07 vs. 2.56)* and *Learning from Ancient Texts (4.07 vs. 2.30)* reinforce that **IKS strengthens business ethics and management skills.**

Recommendations

- **IKS principles should be integrated into vocational education** to enhance leadership, ethics, and sustainability.
- Businesses can **adopt traditional Indian sustainability practices** by integrating eco-friendly approaches like Ayurveda-based product development and ethical supply chains.
- **Training programs and corporate workshops should incorporate IKS-based management strategies** to develop responsible leadership.

Independent Samples T-Test

A **two-sample t-test** was conducted to compare the mean differences between the IKS and Non-IKS groups. The test was conducted at **95% confidence level (α = 0.05)**.

T-test Formula:

Category	t-value	p-value	Decision
Ethical Consideration	7.84	0.0001	Significant
Social Responsibility	7.12	0.0003	Significant
Identifying Unethical Practices	8.01	0.0002	Significant
Dharma Ethics	6.98	0.0005	Significant
Ethical Leadership	7.45	0.0001	Significant
Eco Awareness	6.90	0.0004	Significant
Waste Reduction	8.25	0.0001	Significant
Ethical Supply Chains	7.38	0.0002	Significant
Profit vs. Environmental Balance	7.22	0.0003	Significant

Hypothesis Testing Results

Hypothesis	Result	Conclusion
Null Hypothesis (H_0): There is no significant difference between the IKS and Non-IKS groups in Leadership, Ethics, and Sustainability.	**Rejected** ($p < 0.05$)	**IKS-based training significantly improves leadership, ethical decision-making, and sustainability awareness.**
Hypothesis (H_1): significant difference between the IKS and Non-IKS groups.	**Accepted**	**IKS integration positively impacts vocational education for future management practices.**

The study confirms that IKS-based vocational training significantly enhances ethical decision-making, leadership skills, and sustainability awareness. The results support the Alternative Hypothesis (H_1), provin that students trained with IKS principles outperform those without IKS exposure. The findings strongly advocate for integrating IKS principles into vocational education to promote ethical business leadership and sustainable practices. Future research can explore industry-specific applications of IKS-based business models and their long-term impact on corporate success.

Conclusion

This study shows that adding Indian Knowledge Systems (IKS) to vocational education helps students develop better leadership skills, make ethical decisions, and understand sustainability more deeply. The results clearly indicate that students trained with IKS principles perform better than those who follow regular vocational training. The higher scores in ethical awareness, leadership, and sustainability, along with statistically strong results ($p < 0.05$), prove that IKS-based learning builds responsible and value-driven professionals. Learning ethical leadership from ancient scriptures, sustainability from Ayurveda, and decision-making from the Arthashastra, students get a well-rounded education that prepares them for real-world challenges. This study highlights how traditional Indian wisdom can be highly useful in modern management and suggests that vocational training programs should include IKS-based learning. Educational institutions can use IKS principles to shape a workforce that values ethics and sustainability. Businesses can also benefit by adopting IKS-based management techniques to develop responsible leaders who care about the environment and long-term success. The Future research should explore how different industries can use IKS-based business strategies and examine their long-term effects. By blending ancient wisdom with modern management, IKS-integrated vocational education can help create professionals who lead with integrity and build sustainable businesses.

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Questionnaire

Demographic Information

1. Name: _____
2. Age: _____
3. Gender: ☐ Male ☐ Female ☐ Other
4. Educational Background: ☐ Commerce ☐ Science ☐ Arts ☐ Technical/Vocational
5. Are you receiving vocational training based on **Indian Knowledge Systems (IKS)?**
   ☐ Yes (IKS Group) ☐ No (Non-IKS Group)

Leadership Skills

Rate the following statements based on your experience.
(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Statement	**1**	**2**	**3**	**4**	**5**
1. I feel confident in making important decisions under pressure.	☐	☐	☐	☐	☐
2. I can effectively **lead a team and motivate others** towards a common goal.	☐	☐	☐	☐	☐
3. I use **strategic thinking** before making decisions.	☐	☐	☐	☐	☐
4. I apply lessons from **historical or philosophical teachings** (e.g., Bhagavad Gita, Arthashastra) in leadership scenarios.	☐	☐	☐	☐	☐
5. I believe leadership should be based on **values and ethics, rather than just power.**	☐	☐	☐	☐	☐

What is your personal definition of a great leader? How do you apply leadership in your daily activities?

_____
_____
_____
_____
_____

Ethical Decision-Making

Rate the following statements based on your experience.
(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Statement	1	2	3	4	5
6. I always consider **ethics before making a business decision.**	☐	☐	☐	☐	☐
7. I believe businesses should prioritize **social responsibility over short - term profits.**	☐	☐	☐	☐	☐
8. I can identify **unethical business practices** and know how to respond to them.	☐	☐	☐	☐	☐
9. I apply **Dharma (duty and righteousness)** when making ethical choices.	☐	☐	☐	☐	☐
10. I think that **ethical leadership improves business performance** in the long run.	☐	☐	☐	☐	☐

Can you recall an ethical dilemma you faced in your studies or work? How did you resolve it?

_____

_____

_____

_____

_____

Sustainability Awareness

Rate the following statements based on your experience.
(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Statement	1	2	3	4	5
11. I am aware of **eco-friendly and sustainable business practices.**	☐	☐	☐	☐	☐
12. I believe traditional Indian knowledge (e.g., **Ayurveda, organic farming**) provides sustainable business solutions.	☐	☐	☐	☐	☐
13. I actively try to reduce **waste and environmental impact** in my daily life.	☐	☐	☐	☐	☐
14. I support businesses that use **ethical supply chains and environmentally friendly production methods.**	☐	☐	☐	☐	☐
15. I believe that businesses must **balance profit making with environmental responsibility**	☐	☐	☐	☐	☐

How do you think businesses can adopt traditional Indian sustainability practices in today's modern world?

_____

_____

_____

_____

_____

General Perception of Indian Knowledge Systems (IKS) in Vocational Education

(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Statement	**1**	**2**	**3**	**4**	**5**
16. Indian Knowledge Systems (IKS) should be integrated into vocational education.	☐	☐	☐	☐	☐
17. Learning from **ancient Indian texts and philosophies** can enhance business management skills.	☐	☐	☐	☐	☐
18. Ethical principles from Indian scriptures should be a **part of corporate training.**	☐	☐	☐	☐	☐
19. Traditional Indian **holistic learning methods (Gurukul, Yoga, Ayurveda, etc.)** help in personal and professional growth.	☐	☐	☐	☐	☐
20. I am interested in learning more about **IKS-based management practices.**	☐	☐	☐	☐	☐

Do you believe that integrating Indian Knowledge Systems (IKS) into vocational education can improve leadership, ethics, and sustainability in business? Why or why not?

_____

_____

_____

_____

_____

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Transversal Competencies for TVET Students – Value Addition to Profession

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Abstract

In the twenty-first century, transversal competencies are key to successful performance in the world of work. The twenty-first century is a century of innovation, change and reforms. The transversal competencies are developed in an integrated manner as a process byproduct competency along with specific competencies using scientific curriculum design, engaging pedagogy and formative assessment approaches. The National Education Policy (NEP) 2020 made a provision for the wholesome development of the students, focusing on developing job creators and not job seekers. This paper outlines and incorporates the concept of transversal competencies, learning process byproduct (pedagogical, work situation, autonomous, assessment) and development of transversal competencies. Some indicative process byproduct competencies are listed. The role of the course teacher in designing and implementing imaginative curriculum, engaging pedagogy, formative assessment,and suggestions for developing transversal competencies are made.

Keywords: Transversal competencies, innovative pedagogy, process byproduct learning, formative assessment, autonomous learning, soft skills.

Introduction

The Government of India has created an ecosystem for designing and implementing educational programmes to develop entrepreneurs, incubators, and agents of change for society. In other words, job creators and not job seekers. The world of work is managed by many types of competencies, such as domain-specific core competencies, cross-disciplinary, multidisciplinary, and transversal competencies. A wide variety of flexibility has been granted to educational institutions to harness the full potential and develop intended competencies in students of all educational programmes. Educational institutions need to grab the opportunities to design and implement educational programmes.

The National Education Policy (NEP) 2020 (MHRD, 2020) spells out the process of managing educational programmes viz imaginative curriculum address the current and future needs of the industry, engaging pedagogy to harness the full potential of the students for learning and development using learner-centric approaches, formative assessment for using the assessment as a means for learning and development and providing support services to the students to explore their latent potential, develop it during the study and harness it for their career progression. UGC (2019b) developed a curriculum for developing life skills in all students studying in HEIs, irrespective of their domain of study. The curriculum primarily focuses on four skills: communication, professional, leadership and managerial, and universal human values.

The world of work requires generic competencies and specific competencies. The proportion of generic and specific competencies varies according to the industry sector. The technical and vocational sector is a vast, large, and primarysector in the world of work. It also supports the other sectors of the world of work significantly. There are generic competencies which are used across the sectors of the world of work. These competencies are essential to becoming an entrepreneur, incubator, and change agent. Technical and vocational education training (TVET) institutions largely contribute to developing entrepreneurs, incubators, and agents of change in society. The graduates with transversal competencies are more adaptable to changing environments and amenable to smoothly transitioning from one role to another. Esubalew et al. (2024) stated competencies for entrepreneurs such as exploring opportunities, persistence, commitment to goals, risk-taking, ensuring efficiency, goal setting, information seeking, planning, persuasion, and self-confidence.

Transversal competencies are developed in TVET institutions using theoretical courses and increasing the volume of educational programmes and curricula. A voluminous curriculum makes it a burden for students to learn theory and makes it

difficult for course teachers to complete it within the assigned time. The traditional teaching-learning methods the course teachers use are not learner-centric and limit the development of transversal competencies. Tangney et al. (2023) listed the definitional, operational and systematic barriers to developing transversal competencies and suggested using a pragmatic pedagogical model. The TVET institutions are now signing the memorandum of understanding with industry partners and research institutions to develop relevant specific and transversal competencies. Álvarez et al. (2024) stated that transversal competencies should be an integral part of the curriculum to develop a wholesome graduate and well-rounded education. Transversal competencies will make the graduates socially and professionally responsible and globally acceptable.

A paradigm shift is required in the current approach to curriculum design, curriculum implementation, student learning assessment, and offering mentoring services to students. There is an urgent need to use the curriculum, pedagogy, assessment, and mentoring to develop transversal competencies in TVET students.

Concept of transversal competencies

Transversal competency is used differently in different educational programmes and various contexts of work situations. Synonymous terms such as soft competencies, life competencies, twenty-first-century competencies, generic competencies, key competencies, and future competenciesare used for transversal competencies in different contexts. In the context of job creation, there is a need to balance the domain-specific and transversal competencies. Domains-specific competencies are defined in terms of graduate attributes or programme outcomes, which are essentially developed in students of all educational programmes. The programme structure and curriculum document are designed for domain-specific competencies. The statutory bodies (NCERT; UGC, 2022; NAAC, 2022; AICTE, and NBA, 2024) provide guidelines in this regard. The graduate attributes or programme outcomes and programme-specific outcomes are not limited to the programme but are also related to safety, sustainability, economics, leadership, communication, societal issues, and ethical practices. These are broader outcomes (competencies) in the context of the discipline of study. The transversal competencies are used to effectively and efficiently manage the personal, family, social, and professional life. Transversal competencies

- add value to the performance of individuals in all work settings,
- help to adapt to the new environment, culture, and profession,
- encourage to act as a responsible professional
- keep abreast with the changes taking place in the work situations,
- adjust with all types of professionals,

- reduce job stress, fatigue, monotony, boredom, confusion, grapevine communication, and conflicts in the work situation

There is no universal definition of transversal competencies, and there could not be. As for one educational programme, domain-specific competencies are core competencies, and the same competency may be transversal for other educational programmes. It is also clarified here that the transversal competencies identified for one profession may not be that significant for a different profession. The principle of significance and level of proficiency should be considered when deciding transversal competencies.

Clotilde et al. (2024) defined transversal competencies as generic competencies that add value to performance in various work situations. For example, the ability to communicate effectively is a transversal competency. Transversal competencies are different from specific competencies. Specific competencies are essential to perform in aparticularwork situation. For example, the ability to operate hi-tech machines to produce various products is a specific competency. Classifying a competency as specific or transversal also depends on the context. For example, the ability to effectively communicate the product design to technicians for carrying out production is a specific competency. In outcome-based education philosophy, both types of competencies are developed simultaneously and in an integrated manner. Specific competencies are developed through activities, tasks, assignments, practice exercises, lab work, job work, project work, etc. At the same time, transversal competencies are developed using a scientifically designed pedagogical approach. Vlajkovi´c, et al. (2023) stated that transversal competencies are necessary and valuable for effective performance in work situations, learning and life activities.

Finally, transversal competencies are those competencies that are required to be developed in all students of all educational programmes, irrespective of their domain of study. Transversal competencies are developed formally and informally, directly and indirectly, in different learning situations. Transversal competencies are developed in students using a scientific learning process design by course teachers.

Specific and related transversal competencies supplement and complement each other (Cimatti, 2016) to produce high performance in work situations, overcoming potential barriers, hurdles, obstacles, risks and challenges. Transversal competencies reduce confusion, conflict and crisis. They lessen the job-related stress of performers. Transversal competencies help deploy and redeploy others' resources in work situations.

Pedagogy and development of transversal competencies

Learning is a conscious process which takes place in a conducive environment (Gupta, 2007).The science of learning is used for learning and developing transversal competencies. Course teachers use a wide variety of pedagogical approaches to develop specific competencies. The right learning approach and method selectionproducea wide variety of transversal competencies as a byproduct of the learning process. This means without putting any extra learning time and effort by learners, transversal competencies are developed. The learner-centred approaches develop transversal competencies as a 'process byproduct competencies'. The development of transversal competencies takes place progressively and incrementally over a period of time. The transversal competencies are developed as a byproduct competencies by design.

Learning is a byproduct of environment and experiences. The paradigm shift from a teacher-centred to a learner-centred approach is a good sign of shifting the learning responsibility to the learners. This calls for innovative pedagogies in which students are active and course teachers design and facilitate the development of specific and transversal competencies. The curricular interventions should address the pedagogical aspects of developing transversal competencies. The work situation should be replicated through pedagogy in the institute.

UGC (2022) released guidelines for innovative pedagogical approaches and evaluation reforms to develop specific and transversal competencies. Martínez-Clares et al. (2018) conducted a study to conclude the relationship between teaching methodologies and the development of transversal competencies. A positive relationship is found between the teaching methods and the development of transversal competencies. UGC (2022) suggested pedagogical approaches for developing graduate attribute-level competencies in students, including transversal competencies. Larmer (2016) stated that project-based learning develops competencies such as communication, problem-solving, time management, responsiveness, and other competencies that resemble 21st-centuryskills. Clark(2017) concluded that project-based learning capitalizeson the students' strengths and developsthe ability to control their learning. Ravitz et al. (2012) stated that project-based learning develops critical thinking, collaboration, communication, creativity, self-direction, global and local connections and the use of technology as a tool for learning. These approaches are stated in Figure 1.



Figure 1: Approaches to develop transversal competencies

The group learning approaches designed and used for developing specific competencies also develop transversal competencies. The level of development of transversal competency in students depends on the ability of the course teachers to design and implement group learning. The level of development of transversal competency also depends on the selection of the type of group method. The hierarchy of group methods in developing the level and range of transversal competencies is stated in Figure 2.

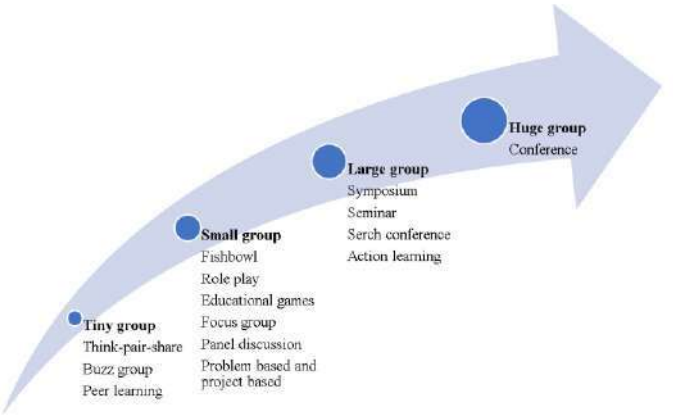


Figure 2: Hierarchy of group methods to develop transversal competencies

Group-based Methods and involvement of learners

Group-based learning methods and work situation-based learning methods develop specific domain competencies, cross-disciplinary, and multidisciplinary competencies. At the same time, simultaneously, many skills are developed gradually. When students complete the educational programme, these skills accumulate and are transformed into transversal competencies. Group-based learning methods with powerful learning issues/topics/themes intrinsically motivate students to use previous formal and informal learning and think creatively in futuristic terms. The managerial, social and entrepreneurial skills are developed in an incremental manner, which accumulate to transform into transversal competency development. An indicative list of students' activities during group methods is given in Figure3.

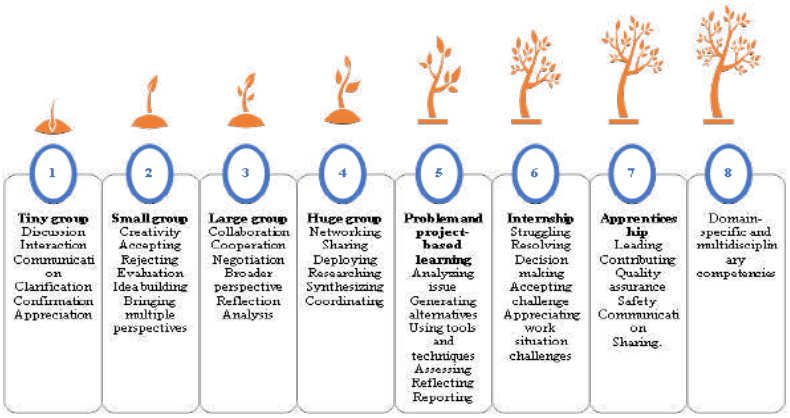


Figure 3: Group learning methods, students learning activities, and learning

Group learning and development of transversal competencies

Scientifically designed group learning methods are implemented under the guidance of the course teachers. As stated earlier, the group methods are designed and implemented to develop'specific competencies'. Along with specific competencies,group methods develop transversal competencies as abyproduct of the learning process. In many groups, learning settings develop a wide range of transversal competencies that are higher than specific competencies.Gupta & Gupta (2021a) stated that project-based learning in small groups develops a wide range of transversal competencies viz ethical, intellectual, aesthetic, emotional, moral, creativity, communication, discussion, and debate. Warren (2016) stated that project-based learning in small groups develops transferrable skills. The group learning

methods and transversal competencies developed are stated in Table 1.

Table 1: Group learning and transversal competencies

Group learning methods	Transversal competencies
Tiny group Think-pair-share, Buzz group, Peer learning .	Initiation (emerging stage) of development of transversal competencies such as Communicate orally, Motivate others, Involve in the discussion, Seek consensus, Argue on the issue, Articulate conclusions of discussion, Generate creative ideas, Lead a team with a purpose, Respect others' perspectives, Present conclusions on the issue.
Small group Fishbowl, Roleplay, Educational games, Focus group, Panel discussion debate, Problem-basedand project-based learning , Six thinking hates, Force field analysis, Brain storming.	Development (developing stage) of transversal competenciessuch as Plan to achieve goals, Design strategy, Analyse problem, Resolve conflict, Negotiate on an issue, Generate alternative solutions to a problem, Develop new product ideas, Contribute to team goals, Demonstrate competitive spirit, Document discussion outcomes, Defend group outcomes, Use graphical tools to make presentations, Lead a small team, Offer feedback, Receive feedback, Predict behaviour, Assess the performance of others, Reflect on progress.
Large group Symposium, Seminar, Search conference, Consultative meet , Action learning.	Development (proficient stage) of transversal competencies such as Resolve complex problems, Generate innovative solutions, Collaborate with a purpose, Cooperate with a purpose, Develop a synergetic effect on an issue, Create a pool of talent, Evaluate current systems and practices, Defend with justification, Test hypotheses, Demonstrate multi -perspective on a given situation .
Huge group Conference	Development (advanced stage) of transversal competenciessuch as Establish a network of resource persons, Identify niche areas, Draw trends of development, Set ben chmarks, Establish a code of conduct.

Psychomotor domain learning methods and development of transversal competencies

There are limited methods to develop psychomotor competencies, but these methods also develop psychomotor and affective domain transversal competencies. Lab-based projects, experiments, and job work are direct learning methods that develop specific and transversal competencies. Table 2 indicates that lab-based learning methods develop transversal competencies.

Psychomotor domain learning methods	**Transversal competencies**
Demonstration and imitation	Initiation (emerging stage) of development of transversal competencies such as Observe the right method of performance, Select the right tools for performance , Adhere to safety rules , Reflect on performance.
Simulation	Development (developing stage) of transversal competenciessuch as Adhere to scientific steps of performance , Observe safety norms.
Virtual lab	Development (developing stage) of transversal competencies such as Use technology, Interpret results, Explain the causal relationship among variables.
Experimentation and practice	Development (proficient stage) of transve rsal competencies such as Analyse problem s, Conduct test s, Take measurement s, Calibrate equipment, Investigate a case, Assure quality of product, Develop new products, Adhere to safety rules, Adhere to good housekeeping practices, Reflect on progress, Reco rd progress, Maintain mandatory documents, Prepare reports, Demonstrate listening skills.
Practice-feedback-practice-feedback-independent practice - self feedback	Development (advanced stage) of transversal competenciessuch as Demonstrate competency and pro ficiency in different performance situations, Receive feedback from mentors , Use feedback for improving the competencies and proficiencies , Demonstrate best practices related to safety, sustainability, housekeeping, hygiene, environment, social concerns.

Work situation learning and development of transversal competencies

UGC (2020b) is encouraging HEIs to offer apprentice/internship-embedded degree programmes to develop relevant competencies in the learners. Work situation-based learning and competency development make the learner competent, confident and committed to goals. The specific and transversal competencies are developed in work situations in an integrated way (Gupta, 2024). Table 3 indicates that work situation-based learning methods develop transversal competencies.

Table 3: Work situation and transversal competencies

Work situation learning methods	**Transversal competencies**
Excursion	Interact with key informants, conduct interviews, Carry out investigations, Record information, Assimilate information,
Survey	Draw current status, Deal with difficulties, Develop holistic view, Compile information, Use software, Use digital tools,
Exhibition	Arrange resources, Influence clients, Communicate effectively, Rece ive feedback, Provide relevant information.
Internship	Identify work situation problems and challenges, Perform in work situations, Take risks, Adhere to industrial norms, Follow work culture.
Apprenticeship	Design innovative products using creativity, Accept challenges, Meet timelines,Fix problems, Design strategies, Set goals, choose career path.

Autonomous learning and transversal competencies

Gupta et al. (2022) stated that autonomous learning develops domain-specific, professional, soft and lifelong learning competencies in the learners, making them responsible, accountable and mature for learning and development. Gupta & Gupta (2022) stated that learners perform a broad spectrum of roles during autonomous learning to develop transversal competencies such as self-motivation, control, feedback, assessment, improvement, reward, discover, apply, innovate and monitor. Halim et al. (2023) stated the benefits of heutagogy as increased engagement, enhanced autonomy, increased collaboration, improved communication, critical thinking and lifelong learning. Blaschke(2012) stated that self-determined learning develops the capacity and capability to deal with work situations. Canning (2010) stated that learning and reflecting enable the students to become agents of change. Table 4 indicates that autonomous learning methods develop transversal competencies.

Table 4: Autonomous learning and transversal competencies

Autonomous learning methods	Transversal competencies
Self-learning	Use learning competencies, Reflect on learning,Receive self-feedback for improvement, Demonstrate learning maturity.
Online learning	Use digital tools, Search relevant learning resources, Use technology for problem-solving, Identify trends in development.
Digital learning	

Assessment and transversal competencies

Using assessment tools and techniques by learners for self-assessment and peer assessment develops transversal competencies. Gupta &Gupta (2024) stated that assessment is a base for taking self, peer and resource person feedback to improve the learning process and develop transversal competencies (Gupta & Gupta, 2021b, 2021c, 2024). Gupta (2023) stated that there are a variety of rubrics that are used for assessing and developing transversal competencies. UGC (2019a) suggested four types of assessment: written, oral, practical, and integrated. Many assessment tools and techniques are listed under these four modes. These tools and techniques are recommended to develop transversal competencies related to assessment. Hase et al. (2001) stated that self-determined learning satisfies the needs of learners.Table 5 indicates that assessment-based learning methods develop transversal competencies.

Table 5: Assessment and transversal competencies

Assessment	Transversal competencies
Tools – quiz, online test, checklist, rating scale, observation schedule, bipolar scale, Interview Schedule.	Observe the performance, Assess the performance against criteria, Assess behaviour, Identify latent potential, Reflect on others' performance, Offer feedback, Validate measurements, Communicate positively.
Techniques – self, peer, formal, informal, direct, indirect.	Prevent mistakes in self -performance, Ask questions, Offer feedback, Receive self-feedback for taking corrective and preventive actions for developing intended specific and transversal competencies,

Various assessment tools can be prepared and handed over to learners to assess the learning progress in developing transversal competencies. These tools will facilitate learning and, at the same time, assess learning and take corrective and preventive actions. These tools are used for self-assessment, peer assessment, and learning portfolio assessment.

Course teachers' role in developing transversal competencies in students

Course teachers play a significant role in developing students' transversal competencies. They are the architect of educational programmes. They perform a variety of roles to develop transversal competencies in the students. If course teachers fail to perform the roles scientifically, the students will not develop transversal competencies. In such situations, students will undergo additional training to develop transversal competencies:extra time, effort, and expenditure. The role of the course teachers is stated below:

- Analyse programme structure and course curriculum in the context of the world of work and prepare course and laboratory plans to develop intended course outcomes and transversal competencies using the right pedagogy and activities for the students.
- Define transversal competencies in the context and scope of the course and lab learning you are facilitating. Communicate these transversal competencies along with specific competencies.
- Scientifically design learner-centred activities incorporating autonomous, group, cooperative, collaborative, and digital learning to develop specific and transversal competencies.
- Educate the learners to consciously participate in learning methods and activities to develop specific and transversal competencies.

- Involve learners in assessment, reflection, feedback, and improvement process to developa higher level of competency and proficiency.
- Design assessment tools and techniques for assessing transversal competencies and declare these tools to students before the beginning of the academic session.
- Use informal, formative, and process assessment techniques for assessing and developing transversal competencies.
- Organize resources in advance for implementing the learning method and assessment for specific and transversal competencies in an integrated manner.

Suggestions for developing transversal competencies

In the context of changes taking place in work situations and provisions of NEP 2020, the following suggestions are noted for implementation in HEIs:

Institutional arrangements

The integration of transversal competencies along with core technical and vocational competencies requires policy formulation at the institute level. Followed by guidelines for effective implementation of the same from programme structure, curriculum design, effective implementation learner centric and competency-based learning and assessment of a competency-based learning point of view. At institutional level resources need to be created to develop the technical and vocational competencies resembling to industrial practices.

Scientific design of curriculum

Strong and direct learning methods such as project-based learning, internship, apprenticeship, seminar, conferences, discussion, creativity techniques, and experiential learning should be incorporated into the programme structure, and credits should be assigned to these approaches for developing transversal competencies in students by design.

Use of pedagogical approaches

The pedagogical approaches should be used to develop transversal and specific competencies. The course curriculum approach is not an appropriate approach to develop transversal competencies. The right selection, scientific design and implementation will ensure the development of transversal competencies as a process byproduct.

Use of self and peer assessment

Self and peer learning and assessment should be encouraged synchronously and asynchronously to develop transversal competencies related to self-assessment, introspection, reflection, and leapfrogging. Life-long learning and learning to learn are fostered using a self-assessment approach.

Arrange resources

Learner-centric approaches require resources to develop specific and transversal competencies. These resources are planned and provided to course teachers at the HEI level so they can implement learner-centric approaches effectively. These resources could be physical settings, teaching associates and information communication tools.

Use of scientific assessment approaches

In criterion-referenced assessment, the validity and reliability of the assessment tools and techniques play a significant role in certifying the competencies. The assessors need to take care of the assessment of technical and vocational competencies. At the same time, assessment of transversal competencies should be integrated in the assessment tools and techniques, as it can not be done in isolation.

Capacity building of teachers

The teachers are not trained to integrate the development of transversal competencies along with core competencies in technical and vocational courses. Their focus remains on developing core technical and vocational competencies. It is a big challenge for technical and vocational education teachers to integrate the development of transversal competencies along with core technical and vocational competencies. Course teachers and teaching associates should be trained in outcome-based philosophy and learner-centric approaches to make them competent, confident and committed in the changing context of higher education. A mentoring, coaching, and guidance programme for teachers should be scientifically designed and implemented in all HEIs of the country to use innovative pedagogy as envisaged in the NEP 2020 and guideline document issued by UGC on innovative pedagogy.

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Book Review

AI Agents in Action

Author: *Micheal Lanham*
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The integration of artificial intelligence (AI) into mainstream education has taken on new urgency in India under the guiding frameworks of the National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCFSE) 2023. These documents call for early digital exposure and skill-building through practical, multidisciplinary education, beginning from the middle stage of school education. In this context, Micheal Lanham's AI Agents in Action arrives as a powerful educational and developmental resource that vocational educators, curriculum developers, and skill trainers in India can benefit from immensely. The book not only introduces readers to the landscape of AI agents and assistants but also demonstrates how to design, build, and deploy them in real-world scenarios using large language models like GPT-4.

The book opens by demystifying the concept of an "agent", defined as an entity that acts, makes decisions, and exerts power to achieve defined goals. Whether interacting directly with users or functioning autonomously, AI agents can take various forms: simple proxies that reframe queries, assistants that execute functions via plugins, or fully autonomous systems that create and execute plans independently. Lanham walks the reader through each of these types with clarity, drawing a useful contrast between manual user prompting and the emergent capabilities of autonomous agent systems. For India's vocational learners, especially in sectors like IT services, digital marketing, logistics, healthcare, or customer support, this understanding of AI agency can unlock entirely new avenues of employment and innovation.

A notable strength of the book is its treatment of multi-agent systems, an arrangement in which specialized agents work collaboratively to solve complex tasks. For example, one agent might write code, other tests it, and a proxy coordinates communication. This system architecture mirrors real-world team structures and is highly relevant to skill-based education, where students learn to take up modular roles in collaborative projects. Such multi-agent systems can also be adapted in classroom environments to model workplace interactions or simulate industrial workflows.

In a highly structured manner, Lanham elaborates on the five major components of an AI agent: its profile or persona (which sets its background and task orientation), the actions it performs, its knowledge and memory architecture, reasoning and evaluation capabilities, and its planning and feedback mechanisms. These components not only mirror human cognitive faculties but also represent skillsets that vocational students can be trained to understand, design, and improve. For instance, designing a customer service chatbot requires understanding persona development, dialogue management (actions), and memory systems. These technical concepts are no longer the exclusive domain of advanced engineers; Lanham's book brings them into the reach of secondary and post-secondary learners through accessible explanation and applied code examples.

The book also presents a historical and developmental perspective, tracing the rise of AI agents from simple prompt engineering to complex autonomous systems such as AutoGPT. These systems brought attention to iterative task planning, an approach that vocational educators can adapt to teach project management and design thinking. This iterative, feedback-oriented approach aligns beautifully with NCFSE's emphasis on experiential learning and competency-based assessments.

Lanham introduces a critical idea that aligns strongly with NEP 2020: AI agents represent a paradigm shift in how we interact with software. Instead of needing technical fluency in user interfaces, APIs, or SQL, learners can use natural language to engage with and command digital tools. This natural language interface, or AI interface, holds the promise of democratizing access to technology, crucial for vocational training in multilingual, resource-diverse Indian classrooms. Students can be empowered to build tools that understand their local languages, serve their community needs, and reduce barriers to participation in the digital economy.

The book's technical demands, particularly its reliance on intermediate Python programming, may require adaptation for younger or non-technical vocational learners. Infrastructure limitations in some schools may also pose challenges to deploying agent systems at scale. Yet, these barriers can be addressed through targeted teacher training, modular integration of content, and partnerships with digital learning providers.

In conclusion, AI Agents in Action is an exemplary resource that combines technical depth with practical clarity. For vocational education in India, it offers not just a textbook but a blueprint for how to prepare learners for a rapidly evolving future shaped by AI. Lanham's structured approach to building agents, from basic personas

to full-scale planning systems, supports NEP's vision of holistic, skill-based, and technologically empowered education. This book deserves a place not only on developers' shelves but also in India's vocational labs, AI boot camps, and skill-building classrooms.

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PSS Central Institute of Vocational Education

The Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), set up in 1993 at Bhopal by the Government of India is an apex research and development organization in the field of vocational education. It is a constituent unit of National Council of Educational Research and Training (NCERT), established by the Ministry of Education, Government of India.



The PSSCIVE is a UNESCO-UNEVOC (International Project on Technical and Vocational Education) Centre in India.

The Institute advises and assists the central and state governments on the various aspects of planning and implementation of vocational education and training programmes. It develops guidelines, national curricula, courseware, training modules and e-learning materials for a wide spectrum of target groups, including children with special needs. The PSSCIVE collaborates with national and international organizations/institutions/agencies for organizing national/international seminars, conferences, and workshops and development of course materials.

The Institute, which is built on a 37 acre campus, has all the facilities including Auditorium, Hostel, Guest House, Conference Room, Labs, etc. for teaching and training. The faculty members of the Institute are specialists in a variety of disciplines including agriculture, horticulture, fisheries, plant protection, community medicine, healthcare, early childhood education, engineering, information and communication technology, etc. The Institute organizes working group meetings to garner the contributions of the experts and professionals for development of curricula and courseware.

What PSSCIVE Offers:

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- High quality vocational learning programmes for teachers and trainers
- Innovative e-learning technologies and systems
- Training in the applications of ICT
- New ideas and innovation in teaching and training
- Consultancy on implementation of vocational education and training courses

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