

THE IMPACT OF PROFESSIONAL DEVELOPMENT ON METALWORK TECHNOLOGY EDUCATION TEACHERS AND STUDENTS' OUTCOMES IN THE AGE OF AUTOMATION

¹DAWODU RASHEED ADEGBENRO, DEPARTMENT OF TECHNOLOGY EDUCATION, COLLEGE OF INFORMATION AND TECHNOLOGY EDUCATION, LAGOS STATE UNIVERSITY OF EDUCATION OTO/IJANIKIN, LAGOS STATE, NIGERIA.

²OGUNBOTE SHEFIU, DEPARTMENT OF TECHNOLOGY EDUCATION, COLLEGE OF INFORMATION AND TECHNOLOGY EDUCATION, LAGOS STATE UNIVERSITY OF EDUCATION OTO/IJANIKIN, LAGOS STATE, NIGERIA.

³ADEGUNLE, FELIX OMOTAYO, DEPARTMENT OF TECHNOLOGY EDUCATION, COLLEGE OF INFORMATION AND TECHNOLOGY EDUCATION, LAGOS STATE UNIVERSITY OF EDUCATION OTO/IJANIKIN, LAGOS STATE, NIGERIA

Abstract

The rise of automation, robotics, and digital technologies has revolutionized almost every field, and metalwork technology education is no exception. For metalwork teachers, the challenge is no longer simply about mastering tools of yesterday but about embracing tools of tomorrow. Professional development (PD) has therefore become the lifeline that helps metalwork teachers remain relevant, confident, and innovative in preparing metalwork technology students for a future defined by machines and intelligent systems. This article explores how PD transforms both teachers and learners, its role in bridging the skills gap, the barriers to its effectiveness, and the urgent need for renewed commitment from governments, TVET institutions, and industries in the age of automation. The advent of automation has transformed the metalwork technology education landscape, necessitating metalwork teachers to acquire new skills and competencies to remain effective. This article also explores the impact of professional development on metalwork technology education teachers and students' outcomes in the age of automation. It discusses the core competencies for metalwork technology teachers, challenges facing metalwork teachers, opportunities in the age of automation, and strategies for specific stakeholder roles in enhancing metalwork teacher competencies. The article concludes by recommending continuous professional development, collaboration and networking, and industry partnerships to improve teacher effectiveness and student outcomes.

Keywords: Metalwork, automation, landscape, collaboration, strategies

Introduction

Metalwork technology education has undergone remarkable transformations in recent years, largely driven by rapid technological advancements and automation (Kozma, 2003). The increasing use of computer numerical control (CNC) machines, 3D printing, and other automated systems has revolutionized how metalwork is taught and learned (Voogt & Roblin, 2012). These innovations have not only improved efficiency and precision but also broadened the range of projects students can undertake, opening doors to new possibilities in design and fabrication. Yet, these advancements also present serious challenges for metalwork technology teachers. To remain effective, metalwork teachers must acquire new skills, competencies and adapt their teaching methods to integrate emerging technologies (Lawson & Askill-Williams, 2007). This demands ongoing professional development and a willingness to keep pace with industry trends and demands.

This article therefore, explores the importance of strengthening teacher skills, competencies and professional development in metalwork technology education in the age of automation. It highlights the challenges teachers face, the benefits of PD, and strategies for building capacity. Metalwork technology education has long been the backbone of industrial growth, training students in the art and science of fabrication, machining, and mechanical processes. But the world awaiting today's students is far removed from the traditional workshops of the past. Tasks that once consumed hours of manual labour are now automated. Robots handle welding, precision cutting, and assembly with unmatched accuracy, while artificial intelligence (AI) optimizes production lines and even predicts machine failures before they occur (Schwab, 2019).

In this shifting landscape, one critical question emerges: How can metalwork teachers remain relevant, and how can students be prepared for jobs that may not even exist yet? The answer lies in continuous professional development. As UNESCO (2021) stresses, PD equips teachers with the skills, knowledge, and mindset needed to bridge the gap between outdated practices and modern industry demands ensuring that education continues to serve as a pathway to opportunity rather than a barrier to progress.

Unfortunately, many classrooms and workshops especially in developing countries such as Nigeria, Ghana, Sierra Leone among others still look much the same as they did decades ago. Outdated lathes, drilling machines, milling machines, welding machines among others gather dust or not in use, teachers depend on chalkboard sketches instead of digital simulations, and students learn theories with little hands-on experience using outdated industry tools. As Adebayo and Yusuf (2022) note, this gap between what TVET institutions teach and what

industries need leaves thousands of graduates stepping into the workforce unprepared for automation-driven environments. Without consistent and structured professional development, metalwork teachers risk passing on outdated skills to a generation that needs future-ready knowledge. The consequence? Students who work hard but struggle to find employment, and teachers who feel left behind by the rapid pace of technological change.

Why Teacher Competence Matters

Teachers are the vital bridge between rapid technological change and student success in technical vocational education training (TVET). Their competence determines whether students are prepared for the realities of today's evolving industries or left behind with outdated knowledge. When teachers lack up-to-date skills, learners often receive training that feels disconnected from the real demands of the workplace, creating a gap between education and employability (UNESCO-UNEVOC, 2020). This gap is especially dangerous in the age of automation, where employers increasingly demand graduates who are proficient in both hands-on craftsmanship and advanced digital tools.

On the other hand, when a teacher is highly competent combining mastery of traditional metalworking skills with fluency in modern technologies like Computer-Aided Design (CAD), Computer Numerical Control (CNC) machines, and 3D printing, they can offer learners a well-rounded, future-ready education. Such teachers help students develop not only technical expertise but also critical thinking, creativity, and problem-solving skills that are vital for thriving in an unpredictable workforce.

Globally, research shows that teacher competence directly correlates with student performance and long-term career success. Darling-Hammond et al. (2017) emphasize that effective teaching requires both deep content knowledge and the ability to apply it using innovative instructional methods. In the context of TVET, this means teachers must be continuous learners, capable of adapting to new industry standards and digital tools while still imparting the foundational skills of craftsmanship.

Ultimately, competent teachers ensure that metalwork technology education teachers remain relevant, practical, and transformative. They act as role models, mentors, and innovators who inspire confidence in their students and prepare them to navigate the challenges of a fast-changing world of work. Metalwork technology education teacher competence is not just about teaching a subject, it is about equipping students with the tools, skills, and mindset they need to succeed in industries shaped by both tradition and innovation.

The Impact of Professional Development

Professional development plays a vital role in shaping the effectiveness of metalwork technology education, directly influencing both teachers' professional growth and students' learning outcomes. In today's era of rapid technological advancement and automation, continuous learning has become indispensable for teachers who must adapt to new tools, methods, and industry expectations. Research has consistently shown that when teachers engage in structured professional development, it not only enhances their teaching abilities but also translates into better student performance. The major benefits include:

1. **Enhanced Teaching Skills:** Through workshops, seminars, and training programmes, metalwork technology education teachers gain access to modern instructional strategies and innovative pedagogical approaches. These new methods allow teachers to integrate emerging technologies, such as Computer Numerical Control (CNC) machines and 3D printing, into classroom practice. As Guskey (2002) highlights, effective professional development equips educators with practical tools that foster deeper student understanding and skill acquisition.
2. **Increased Confidence in Technology Integration:** Many teachers initially struggle with adopting automated and digital tools in teaching metalwork due to limited exposure or fear of complexity. Professional development programmes provide hands-on experience, which reduces anxiety and builds teachers' confidence in using advanced technologies. This aligns with Bandura's (1997) concept of self-efficacy, suggesting that when teachers feel competent in their abilities, they are more likely to deliver engaging lessons and encourage innovation in student projects.
3. **Improved Student Outcomes:** The ultimate goal of professional development is to enhance student achievement. Teachers who stay current with technological and pedagogical advancements can create richer learning environments that boost student motivation, participation, and performance. Studies by Yoon et al. (2007) confirm that sustained, high-quality professional development directly correlates with improved student outcomes. In the context of metalwork education, this could mean students mastering complex design processes, applying problem-solving skills effectively, and developing competencies that align with industry needs.

Core Competencies for Metalwork Technology Teachers in the Age of Automation

1. **Technical Competence:** Today's metalwork teachers must move beyond traditional workshop skills. They are expected to handle digital tools like CNC milling machines, 3D printers,

and laser cutters, while also understanding automation technologies such as PLCs, robotics, and sensors. The real value lies in their ability to combine hands-on craftsmanship with computer-assisted processes, giving students both heritage skills and modern expertise.

2. **Pedagogical Competence:** Knowing the technology is not enough—teachers must also know how to teach it. This means designing lessons that blend e-learning, simulations, and practical workshop tasks. Competency-based approaches, which tie classroom learning directly to industry tasks (Ogbuanya, 2018), help students see the relevance of their training. Project-based learning and performance-based assessments also ensure students can apply their knowledge in real situations.

3. **Digital Literacy:** Digital skills are now central to teaching. Teachers should be able to use simulation software to demonstrate machining processes, apply VR and AR for safety training or equipment visualization, and guide students in using online platforms for collaboration and project work.

4. **Industry-Responsive Skills:** The best teachers remain connected to industry. Through internships, industry attachments, curriculum co-design with employers, and active participation in professional networks, they ensure that what students learn is directly aligned with market needs. This not only keeps teachers relevant but also guarantees that students graduate with skills that employers value.

Models of Professional Development

Professional development is the engine that keeps metalwork teachers relevant in the automation era. Without it, skills quickly become outdated; with it, teachers can confidently prepare students for modern industry demands. Several models are shaping how teachers learn and grow today:

Industry-Based Training: When TVET colleges partner with industries, teachers gain access to short-term attachments in automated factories. These placements immerse them in real-world technologies and workflows, keeping their knowledge current and directly applicable in the classroom (NBTE, 2021).

Micro-Credentials and Certifications: Short, flexible courses in areas like CNC programming, CAD/CAM, and robotics—often delivered by platforms such as Coursera, Siemens, or Autodesk—allow teachers to upskill without leaving their full-time duties. These micro-credentials create affordable, accessible pathways for continuous learning (Oviawe, 2019).

Peer-Learning Communities: Teacher clusters and communities of practice give educators the space to share lesson ideas, experiences, and teaching strategies. This collaborative model has

been particularly successful in South Africa's TVET reforms and shows that learning together can be both cost-effective and sustainable (Bender, 2020).

Technology-Enhanced Professional Development: Virtual labs, low-cost simulators, and open-source CNC software make it possible for teachers to practice automation processes even in underfunded institutions. By experimenting in a virtual environment, teachers build confidence before working with expensive real-world machines.

Challenges Facing Professional Development

While professional development holds great promise for transforming metalwork technology education, several hurdles hinder its effectiveness, especially in the context of Technical and Vocational Education and Training (TVET).

1. **Inadequate Infrastructure:** Many TVET institutions still operate with outdated equipment, making it difficult for teachers to practice or teach automation-based skills. Workshops often lack modern CNC machines, CAD software, or 3D printing tools, leaving teachers to rely on traditional methods that no longer reflect industry realities. This infrastructure gap widens the disconnect between classroom learning and workplace expectations.
2. **Funding Constraints:** Access to quality professional development requires investment in training, workshops, and certification programs. Unfortunately, limited government funding, few scholarships, and scarce private sponsorships mean that many teachers cannot afford to upgrade their skills. In developing contexts like Nigeria, this challenge is particularly pronounced, where funding priorities often favor other pressing educational needs.
3. **Resistance to Change:** Some teachers, especially those deeply rooted in manual craftsmanship, fear that embracing automation may reduce the value of their traditional skills or even threaten their professional identity. This resistance to change can slow the adoption of new practices, even when they promise efficiency and relevance. Overcoming this requires mindset shifts and strong institutional support.
4. **Weak Industry Linkages:** Professional development thrives when schools and industries collaborate closely. However, in many TVET systems, partnerships with industries are either weak or absent. This means training risks becoming too theoretical, with teachers imparting knowledge that does not fully align with modern workplace needs. Without regular exposure to industry practices, both teachers and students are left behind.

Opportunities in the Age of Automation

Despite these challenges, the automation era opens exciting new possibilities for both teachers and learners in TVET:

Blended Pedagogy: By combining digital simulations, virtual reality models, and hands-on practice, teachers can make classrooms more engaging and prepare students to tackle real-life industry problems in safe, cost-effective ways.

Entrepreneurship Integration: With skills in CNC services, 3D printing, and custom fabrication, graduates can move beyond traditional employment pathways to start their own businesses, creating jobs and driving local innovation.

Global Competitiveness: Well-trained Nigerian TVET graduates with digital and automation skills will be able to compete for high-skill jobs not only locally but also in the international labor market, closing the skills gap highlighted by global workforce reports.

Sustainable Innovation: Automated processes often use materials more efficiently, reducing waste in workshops. According to the International Labour Organization (ILO, 2019), automation can make production greener, safer, and more sustainable aligning education with the global push for environmental responsibility.

In essence, professional development is not just about updating teachers; it is about transforming classrooms into hubs of innovation. When teachers embrace both traditional craftsmanship and digital technologies, they empower students with the confidence, skills, and creativity needed to thrive in an automation-driven future.

Specific Stakeholder Roles for Professional Development

Ensuring meaningful professional development in metalwork technology education, especially in the age of automation, requires the active involvement of multiple stakeholders. Each group policymakers, administrators, teachers, and industry play a unique but interconnected role in driving innovation, supporting capacity building, and aligning education with the realities of the workforce.

For Policymakers

Policymakers set the tone for national and regional priorities in TVET. Their actions determine whether teachers are equipped to thrive in an era of automation or left behind with outdated practices. To maximize impact, policymakers should:

1. **Provide Grants and Incentives:** Allocate targeted funding and grants to support teachers' participation in industrial attachments, particularly in automated industries. These placements expose teachers to cutting-edge technologies and workplace practices.

2. **Institutionalize Continuous Professional Development (CPD):** Make CPD mandatory and link it to metalwork technology education teacher promotions and career advancement. This ensures that teachers view professional development not as optional, but as an essential pathway to growth.

3. **Establish Automation Hub Centres:** Set up specialized hubs in TVET institutions dedicated to automation in metalwork technology training. These centres can serve as resource pools, offering training, research, and demonstration facilities that smaller institutions cannot afford individually.

For Administrators

Administrators of TVET act as the bridge between government policies and classroom realities. Their support creates an enabling environment for teachers to learn and innovate. Key roles include:

1. **Strengthening Industry Collaboration:** Build partnerships with local industries for equipment sharing, co-hosted training, and apprenticeships. This ensures students and teachers stay connected to real-world technologies.

2. **Supporting Peer-Learning Networks:** Encourage teachers to lead workshops, seminars, and knowledge-sharing sessions. Peer learning is cost-effective and cultivates a culture of collaboration.

3. **Integrating Micro-Credentials:** Introduce short, modular certifications and micro-credentials into teacher development pathways. This allows teachers to update specific skills without leaving their classrooms for long periods.

For Metalwork Technology Education Teachers

Metalwork teachers are the frontline agents of change. Their commitment to continuous growth directly impacts student outcomes. Their responsibilities include:

1. **Committing to Lifelong Learning:** Actively pursue online courses, professional workshops, and industry-recognized certifications. This self-driven approach ensures relevance in a fast-changing world.

2. **Blending Traditional and Modern Skills:** Teach students to appreciate the value of manual craftsmanship while mastering automation tools like CNC machines, CAD, and 3D printing. This balance prepares students for diverse career pathways.

3. **Collaborating for Innovation:** Work closely with colleagues to design curriculum modules that reflect current industry needs and promote problem-solving, creativity, and adaptability among students.

For Industry

Industry partners ensure that training reflects real workplace demands. Without them, TVET risks becoming detached from employment opportunities. Their responsibilities include:

1. **Supporting Institutions with Resources:** Provide equipment donations, software licenses, and access to modern tools that many schools cannot afford independently.
2. **Offering Internships for Teachers:** Host teachers in short-term placements where they can gain first-hand experience in automated industrial settings. This practical exposure is invaluable in updating classroom practices.
3. **Participating in Curriculum Advisory Boards:** Actively collaborate with education stakeholders to align TVET curricula with evolving workplace technologies and global labor market needs.

With these collaborative strategies, professional development becomes more than just a policy directive but it has become a transformative force. By working together, stakeholders can empower metalwork technology teachers with modern skills, equip students with industry-relevant competencies, and transform automation from a disruptive challenge into a catalyst for innovation, employability, and sustainable growth in TVET education.

Conclusion

The age of automation is redefining what it means to teach Metalwork Technology. Teachers can no longer rely solely on manual skills; they must also embrace digital, automated, and entrepreneurial competencies. In this context, professional development is not just a career requirement but a survival strategy in an ever-evolving industrial landscape. By continuously upgrading their technical, pedagogical, and digital skills, Metalwork Technology teachers in Nigeria can better prepare students to thrive in future workplaces shaped by automation. Professional development directly strengthens teaching effectiveness, builds teacher confidence, and enhances student outcomes. Workshops, structured training programs, peer collaboration, and strong industry partnerships are key strategies that ensure professional growth remains relevant and impactful. With supportive policies, visionary institutional leadership, and closer ties to industry, automation can shift from being a disruptive force to becoming a powerful driver of innovation, employability, and inclusive growth within the TVET system.

Recommendations

To maximize the impact of professional development on teachers and students in Metalwork Technology education, coordinated efforts are needed from teachers, administrators, policymakers, and industry stakeholders.

1. **Continuous Professional Development** Metalwork teachers should commit to ongoing learning through workshops, certifications, and online courses. Staying current with technological advances ensures that teachers remain relevant and students are trained with industry-standard practices. Blending traditional craftsmanship with automation-based teaching will also help students become versatile and future-ready.
2. **Collaboration and Networking:** Building strong professional networks with fellow educators and industry experts is essential. Through peer-learning communities, knowledge-sharing workshops, and collaborative projects, teachers can exchange best practices and stay updated on emerging industry trends.
3. **Industry Partnerships** TVET institutions and industries should strengthen partnerships that provide access to modern equipment, internships, and real-world industrial exposure. These collaborations bridge the gap between theory and practice, enrich classroom experiences, and better prepare students for automation-driven workplaces.

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PROFILE OF DR. DAWODU RASHEED ADEGBENRO

Dr. Dawodu Rasheed Adegbenro is an Associate Professor of Metalwork Technology in the Department of Technology Education, College of Information and Technology Education, Lagos State University of Education (LASUED), Oto/Ijanikin, Lagos State, Nigeria. A dedicated scholar and educator, Dr. Dawodu has built a distinguished career in Technical Vocational Education and Training (TVET), with a special focus on advancing metalwork technology education in Nigeria. His teaching and research interests cut across metalwork craftsmanship, curriculum innovation, automation in technical education, and professional development for teachers. Over the years, he has contributed to developing strategies that bridge the gap between traditional craftsmanship and modern automation-driven industry practices, ensuring that learners acquire both foundational and future-ready skills. As a researcher, Dr. Dawodu has published widely in peer-reviewed journals and presented papers at national and international conferences. His works highlight the importance of teacher competence, curriculum reform, and technology integration in improving student outcomes and preparing graduates for the challenges of a rapidly changing workforce. Beyond research, he is committed to mentoring young scholars and collaborating with industry stakeholders to strengthen the relevance of TVET programs. His contributions continue to play a significant role in shaping policies and practices that promote innovation, employability, and sustainability in Nigeria's technical education sector.