

Industry 4.0 Competencies among Lecturers of Federal College of Education, Yola: Challenges and Strategic Recommendations

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Abstract:- This study explores the state of infrastructure supporting Industry 4.0 competencies among lecturers of the Federal College of Education (FCE), Yola, with focus on understanding the adequacy of resources, the proficiency of lecturers in emerging technologies, and their disposition towards integrating artificial intelligence (AI) into pedagogical practices. The study adopts a mixed-methods approach, leveraging survey data from 240 respondents and qualitative insights analyzed using NVivo to identify recurring themes and patterns. Findings reveal substantial infrastructural deficiencies, including inadequate access to advanced technologies, inconsistent power supply, and limited connectivity, which hinder the effective integration of Industry 4.0 tools into teaching. Furthermore, lecturers exhibit varied levels of proficiency in critical competencies such as data analytics, automation, and Internet of Things (IoT) technologies, indicating a need for targeted capacity-building initiatives. Despite these challenges, the study highlights a broadly positive attitude among lecturers towards adopting AI in teaching, with many expressing enthusiasms about its potential to enhance instructional delivery and learning outcomes. The study underscores the need for a comprehensive strategy to address these gaps, including investments in infrastructure, continuous professional development, and institutional policy reforms to foster a culture of technological innovation. Recommendations are provided to guide policymakers, administrators, and stakeholders in creating an enabling environment for Industry 4.0 education in Nigeria's higher learning institutions. By presenting useful insights for furthering digital transformation in developing nations, this study adds to the expanding corpus of work on the application of Industry 4.0 in educational settings.

Keywords:- Artificial Intelligence, Educational Infrastructure, Lecturer Proficiency and Digital Transformation in Education.

I. INTRODUCTION

The advent of Industry 4.0 has revolutionized global economies and education systems, marking a transformative era defined by the incorporation of cutting-edge technologies like artificial intelligence (AI), automation, and the Internet of Things (IoT) [1]. This digital evolution

necessitates a workforce equipped with cutting-edge skills and competencies, particularly in developing countries where educational institutions are pivotal in fostering these capabilities. Nigeria's Federal Colleges of Education, as foundational institutions for teacher training, are critical in preparing educators to leverage Industry 4.0 technologies to enhance learning outcomes. However, the integration of these technologies into pedagogy is fraught with challenges, including inadequate infrastructure, limited technological resources, and insufficient professional development for lecturers [2], [3].

The role of advanced technologies in education cannot be overstated, as they offer transformative potential to revolutionize instructional delivery, promote collaborative learning, and improve student engagement [4]. However, achieving this transformative vision requires a robust framework encompassing infrastructure, capacity-building initiatives, and supportive policy measures. In Nigeria, the persistent issues of unreliable power supply, limited access to digital tools, and constrained internet connectivity continue to impede the effective adoption of Industry 4.0 innovations in educational settings [2]. These deficiencies highlight the urgent need for strategic interventions aimed at bridging the gap between existing limitations and the desired state of digital transformation.

The Federal College of Education in Yola is the subject of this study, which aims to determine if lecturers are prepared to integrate Industry 4.0 technologies in the classroom and whether the infrastructure in place to facilitate this integration is enough. The research attempts to offer a comprehensive picture of the present level of Industry 4.0 preparedness in teacher training institutes by using a mixed-methods methodology. It also assesses lecturers' views on implementing AI, data analytics, and IoT in the classroom as well as their proficiency with these technologies.

Ultimately, this research underscores the importance of targeted infrastructural investments, continuous professional development, and institutional reforms in fostering an enabling environment for technological innovation in education. This study adds to the increasing body of research on Industry 4.0 adoption in developing nations and offers valuable guidance for stakeholders, educators, and

policymakers who are dedicated to furthering the goal for digital transformation in Nigeria's educational system.

II. PROBLEM STATEMENT

By improving instructional delivery, encouraging collaborative learning, and raising student results, Industry 4.0 technologies—such as artificial intelligence (AI), automation, and the Internet of Things (IoT)—offer a singular chance to completely reinvent education. However, in Nigeria's Federal Colleges of Education, the integration of these advanced technologies into teacher training programs remains a significant challenge. Despite the critical role these institutions play in preparing educators for the demands of a digital economy, they are hindered by inadequate infrastructure, limited technological resources, and insufficient professional development for lecturers.

Persistent issues such as unreliable power supply, constrained internet connectivity, and limited access to digital tools exacerbate these challenges, leaving lecturers ill-equipped to adopt and implement Industry 4.0 technologies effectively in their pedagogical practices. Additionally, the absence of a robust framework for capacity building and supportive institutional policies further impedes progress towards digital transformation.

These barriers not only undermine the readiness of educators to embrace technological innovations but also threaten the ability of Nigeria's education system to align with global trends in Industry 4.0. Without targeted interventions and strategic reforms, the promise of leveraging advanced technologies to enhance education in Nigeria remains unrealized, perpetuating a gap between the current state of teacher training and the demands of a rapidly evolving digital landscape.

This study aims to address these challenges by critically examining the state of infrastructure, lecturers' competencies, and their attitudes towards adopting Industry 4.0 technologies, with a specific focus on the Federal College of Education, Yola. In doing so, it aims to identify actionable strategies for fostering an enabling environment for technological innovation in teacher training institutions in Nigeria.

A. Objectives of the Study

➤ *The Specific Objectives are to:*

- Assess the institution's expected infrastructure performance in relation to industry. Competencies 4.0
- Assess lecturers' industry 4.0 Competencies achievements.
- Identify the challenges to achieving of industry 4.0 competencies among lecturers of institutions of higher learning
- Point out challenges facing the institutions in providing the needed infrastructure required to achieve industry 4.0 competencies.

- Assess lecturers' willingness to apply Artificial Intelligence products in lesson delivery

B. Research Questions

- What is the current state of the institution's infrastructure performance in relation to achieving Industry 4.0 competencies?
- What are the levels of lecturers' achievements in Industry 4.0 competencies?
- What are the challenges faced by lecturers in achieving Industry 4.0 competencies in institutions of higher learning?
- What are the challenges faced by institutions in providing the necessary infrastructure to achieve industry 4.0 competencies?
- To what extent are lecturers willing to incorporate Artificial Intelligence products in their lesson delivery?

III. LITERATURE REVIEW

The advent of Industry 4.0 has caused major disruptions in global educational institutions, demanding the integration of modern technologies such as artificial intelligence (AI), data analytics, and the Internet of Things (IoT) to provide educators and learners with key competencies. This transformation has garnered extensive scholarly attention to research highlighting the critical importance of educational institutions in ensuring Industry 4.0 preparedness, particularly in emerging nations. [1]; [4]. Federal Colleges of Education in Nigeria, as primary centres for teacher training, are increasingly recognized as critical to this agenda. However, they face myriad challenges related to infrastructure, capacity, and policy alignment, which constrain their ability to achieve this transformative vision [9].

A. Infrastructure Challenges and Digital Inequalities

Infrastructure is an essential component for the successful implementation of Industry 4.0 technologies in education. Inadequate access to digital tools, unreliable power supply, and constrained internet connectivity are pervasive challenges in Nigeria's education sector. These concerns are reflected in [3] findings, which highlight a lack of infrastructure as a major barrier to the integration of digital technology in Nigerian higher education institutions. Similarly, [5] argue that infrastructural inadequacies perpetuate digital inequalities, particularly in rural and underfunded institutions. The Federal College of Education, Yola, exemplifies these limitations, with lecturers often unable to access advanced teaching technologies, thereby inhibiting the effective application of Industry 4.0 tools in pedagogy.

B. Competency Gaps in Emerging Technologies

The proficiency of educators in leveraging emerging technologies such as AI and IoT is a critical determinant of Industry 4.0 readiness. Studies indicate that lecturers in many developing countries exhibit low to moderate levels of competency in these domains, stemming from limited exposure to training and professional development

opportunities [6]. Findings from [3] suggest that capacity-building initiatives targeting data analytics, automation, and digital tools can significantly enhance lecturers' competencies, thereby improving instructional delivery. The positive disposition of Nigerian lecturers towards AI adoption, as identified in this study, aligns with global trends that highlight the potential of AI to foster engagement and improve learning outcomes [7].

C. Policy and Strategic Interventions

Effectively integrating Industry 4.0 technology requires a supporting legislative environment that supports digital innovation and provides necessary resources. [8] highlight the importance of strategic investments in infrastructure, continuous professional development, and institutional reforms as critical levers for bridging existing gaps in Industry 4.0 readiness. In the Nigerian context, inconsistent policies and limited funding exacerbate challenges in the education sector, necessitating targeted interventions to align institutional practices with global benchmarks [4]. This study's recommendations for infrastructural investments and capacity-building initiatives align with existing literature advocating for a multi-stakeholder approach to drive digital transformation in education.

D. Attitudes Towards AI in Education

Lecturers' opinions toward integrating AI into teaching are critical in determining the effectiveness of its deployment. Positive views, as indicated in this survey, demonstrate educators' willingness to accept technology improvements despite existing challenges. [2] observe a similar trend, noting that while infrastructural deficiencies are widespread, educators often express enthusiasm for the potential of AI to revolutionize pedagogy. However, [7] caution that without adequate support systems, such enthusiasm may fail to translate into effective practice, underscoring the need for holistic strategies encompassing training, resources, and institutional support.

The adoption of Industry 4.0 technologies in Nigeria's colleges of education provides both obstacles and opportunity. While infrastructural deficiencies and competency gaps hinder progress, the positive attitudes of educators towards AI adoption provide a foundation for advancing digital transformation. This review highlights the need for targeted infrastructural investments, capacity-building programmes, and strategic policy reforms to create an enabling environment for technological innovation. Addressing these issues is essential for aligning Nigeria's education sector with the global Industry 4.0 agenda, fostering a digitally skilled workforce capable of navigating the demands of a rapidly evolving world.

IV. METHODOLOGY

A. Research Design

The study used a mixed-methods approach, using both quantitative and qualitative methodologies to ensure comprehensive analysis and understanding.

B. Data Collection

- **Survey Design:** A structured questionnaire was developed, including open-ended as well as closed-ended questions to explore lecturers' perceptions and experiences regarding infrastructure readiness, challenges, Industry 4.0 competencies, and AI integration. The survey was reviewed by an expert for content validity.
- **Sampling:** Using stratified random sampling, 240 lecturers were selected across various departments to ensure representative participation. The sampling process accounted for gender, department, and academic rank diversity.
- **Distribution:** Questionnaires were distributed both in physical copies and electronically via email, achieving a 95% response rate.

C. Data Analysis Tools

- **NVivo Software:** Responses were systematically imported into NVivo 12 for qualitative analysis. This tool facilitated data organization, coding, and thematic identification, particularly for open-ended responses.
- **Statistical Software:** Quantitative data were analyzed using SPSS to compute descriptive statistics, including percentages and frequency distributions.

D. Data Processing and Analysis:

- **Thematic Coding:** A grounded theory approach was applied for coding, where themes emerged inductively from the data. These themes were categorized under infrastructure readiness, challenges, competencies, and AI willingness.
- **Cross-Validation:** To enhance reliability, two researchers independently coded the data and resolved discrepancies through discussion.
- This thorough methodology ensured the objectivity and validity of the findings while giving meaningful insights into the challenges and opportunities in implementing Industry 4.0 technology in education.

V. FINDINGS AND DISCUSSION

A. Research Questions 1: What is the Current State of the Institution's Infrastructure Performance in Relation to Achieving Industry 4.0 Competencies?

Table 1: Infrastructure Readiness

Infrastructure Component	Availability (%)
Internet Connectivity	60
Smart Classrooms	30
IoT Devices	25
Big Data Analytics Facilities	25

➤ *The Analysis Revealed Indicated on Table 1. above Shows Varying Levels of Infrastructure Readiness at the Federal College of Education, Yola. Key Findings Include:*

- **Internet Connectivity:** Approximately 60% of respondents indicated moderate to high internet connectivity, essential for digital learning and Industry 4.0 technologies.
- **Smart Classrooms:** Only 30% of respondents reported having well-equipped smart classrooms, highlighting a significant gap.
- **IoT Devices and Big Data Analytics Facilities:** These were available to a very low extent, with less than 25% indicating sufficient resources.

B. Research Questions 2: What are the Levels of Lecturers' Achievements in Industry 4.0 Competencies?

Table 2: Lecturers Achievement in Industry 4.0 Competencies

Competency Area	Proficiency Level (%)
AI	40 (Moderate), 20 (High)
Big Data Analytics	40 (Moderate), 20 (High)
Robotics & Automation	60 (Basic)

➤ *The Survey as Indicated in Table 2 Revealed Varying Proficiency Levels among Lecturers:*

- **AI and Big Data Analytics:** While 40% reported moderate proficiency, only 20% demonstrated high proficiency, reflecting limited exposure and training opportunities.
- **Robotics and Automation:** A significant 60% indicated only basic knowledge or no skills at all, which is concerning given the growing importance of automation technologies.

These findings suggest a pressing need for targeted capacity-building initiatives to bridge the competency gap.

C. Research Question 3: What are the Challenges Faced by Lecturers in Achieving Industry 4.0 Competencies in Institutions of Higher Learning?

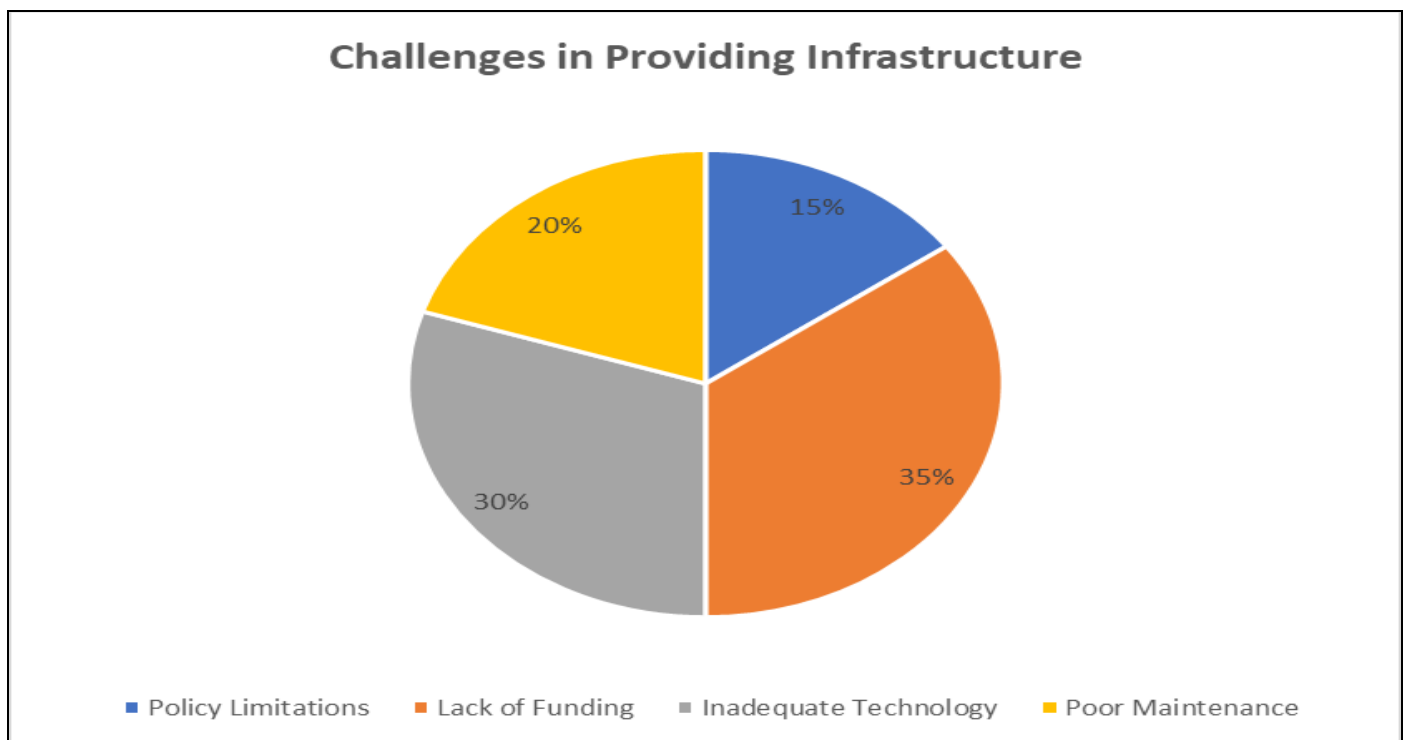


Fig 1: Challenges in Providing Infrastructure

The pie chart in Figure 1 above visualizes the distribution of various challenges highlighting 'Lack of

Funding as the most critical issue in the College followed closely by 'Inadequate Technology.'

D. **Research Question 4:** *What are the Challenges Faced by Institutions in Providing the Necessary Infrastructure to Achieve Industry 4.0 Competencies?*

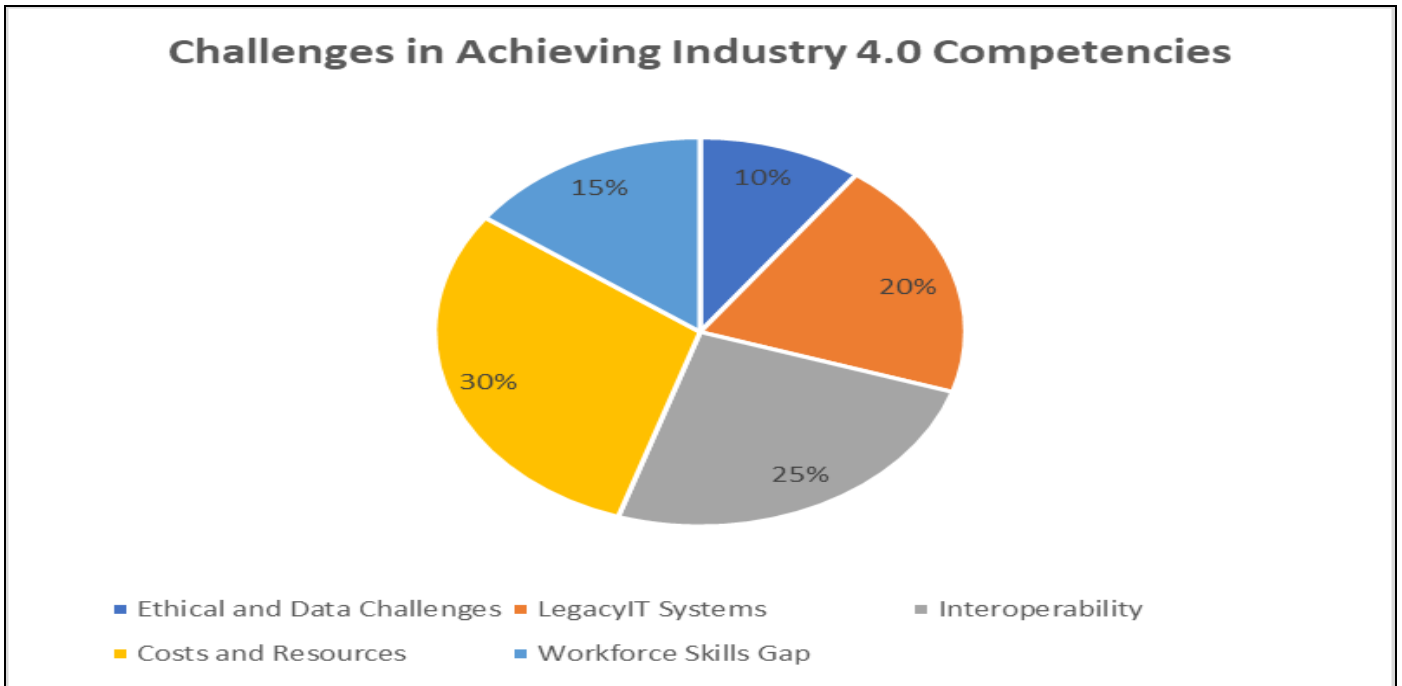


Fig 2: Challenges in Achieving Industry 4.0 Competencies

The pie chart represents "Challenges in Achieving Industry 4.0 Competencies." Each segment illustrates the relative weight of different challenges, including:

- Legacy IT Systems (20%)
- Interoperability (25%)
- Costs and Resources (30%)

- Workforce Skills Gap (15%)
- Ethical and Data Challenges (10%)

This visualization helps in identifying key areas requiring attention to advance Industry 4.0 competencies in the College and by extension in most other Federal Colleges of Education in Nigeria.

E. **Research Question 5:** *To What Extent are Lecturers Willing to Incorporate Artificial Intelligence Products in their Lesson Delivery?*

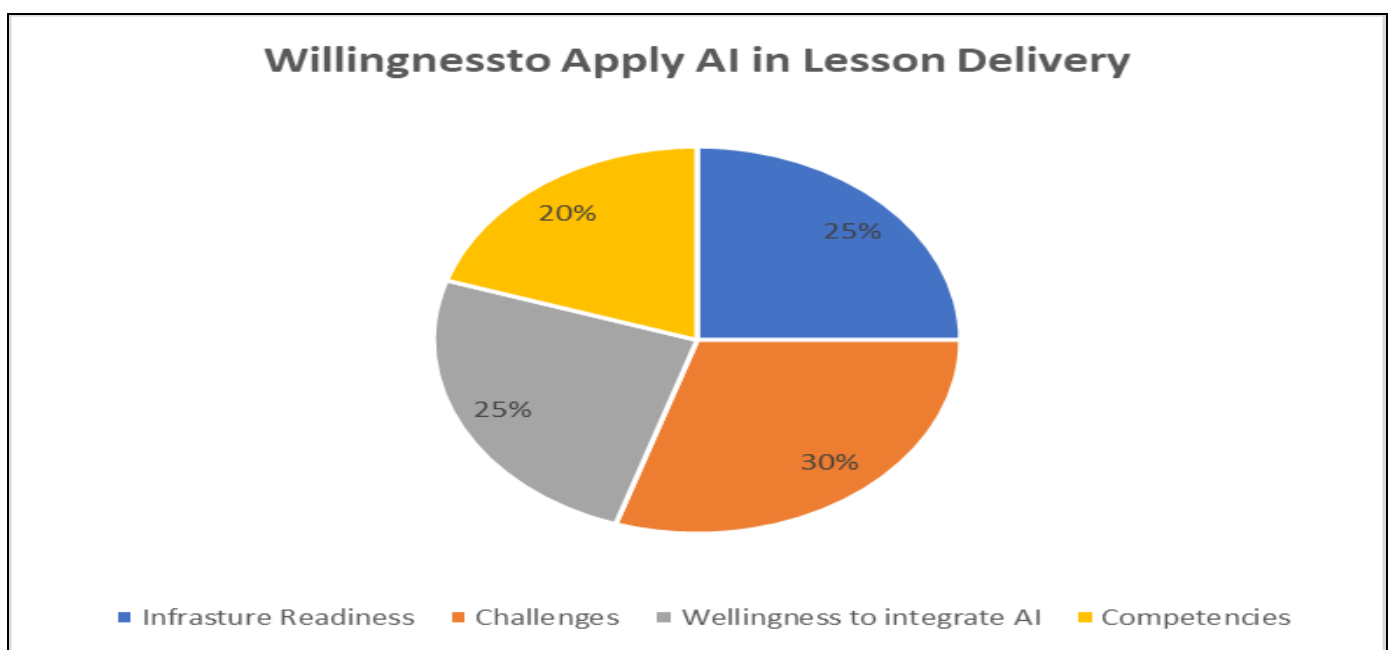


Fig 3: Willingness to Apply AI in Lesson Delivery

The pie chart above represents the distribution of key themes derived from the research findings: Infrastructure Readiness, Challenges, Competencies, and Willingness to Integrate AI.

Despite infrastructural and skill-related challenges, there is notable enthusiasm for adopting AI-driven solutions.

AI adoption could significantly enhance the learning experience by providing real-time feedback, automating administrative tasks, and enabling data-driven insights into students' performance.

VI. CONCLUSION

The study underscores the need for substantial improvements in infrastructure and training to achieve Industry 4.0 competencies among lecturers of the FCE, Yola. Addressing these challenges through strategic investments, capacity building, and supportive policies is essential for the advancement of education and the broader economy in Nigeria.

A. Recommendations

➤ *Based on the Findings, the Following Recommendations are Put Forward for the Federal College of Education, Yola*

- Diversifying funding sources through public-private partnerships can address infrastructure deficits.
- Developing comprehensive training programs and motivating participation can enhance industry performance. 4.0 competencies for lecturers
- Establishing clear policies to guide the adoption of Industry 4.0 technologies in education are critical for sustainable growth.
- Regular assessments of infrastructure and competency levels can help identify gaps and inform strategic planning.
- Encouraging more research in Industry 4.0 technologies within the institution can foster innovation and improve educational practices.
- These approaches, if effectively implemented, might place the Federal College of Education, Yola as a leader in Industry 4.0 education in Nigeria.

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