International Journal of Innovative Education Research 14(3):336-349, July-Sept, 2026

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DOI:10.5281/zenodo.21999576

Perceived Barriers To Infrastructural Development For Successful Commercialization Of STEAM Research Among Public University Lecturers In Rivers State

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ABSTRACT
This study explored the perceived barriers to infrastructural development for successful Commercialization of Science, Technology, Engineering, Arts and Mathematics (STEAM) research among public University lecturers in Rivers State. The study adopted a qualitative research design and purposively sampled 12 senior academics from a population of 2849 lecturers. The participants comprised of senior lecturers and professors, from three public Universities in Rivers State. A total of 4 participants were selected from each University. Data were collected through face-to-face interviews using a semi-structured interview guide. The interviews were audio-recorded with participants' consent and later transcribed verbatim. Data were analyzed using Braun and Clarke's thematic analysis approach. The findings produced two major themes. First, participants perceived the current state of infrastructural development for STEAM research Commercialization as inadequate, uneven and poorly coordinated. This was reflected in weak physical research infrastructure, limited digital and technological infrastructure, inadequate funding, weak institutional Commercialization structures and poor maintenance culture. Second, participants identified multiple infrastructural and institutional barriers limiting Commercialization, including unstable electricity, weak university-industry linkage, poor intellectual property support, bureaucratic procedures and limited incubation support. The study concluded that successful STEAM research Commercialization requires a coordinated ecosystem involving laboratories, digital systems, funding, patent support, industry collaboration, incubation structures and supportive institutional policies. The study recommends stronger university-industry-government collaboration, dedicated Commercialization grants and revised academic reward systems.
Keywords: Perceived Barriers, Infrastructural development, Commercialization, STEAM research, Public University Lecturers.

INTRODUCTION

Universities are expected to function not only as centers of teaching and publication but also as engines of innovation, enterprise creation and national development. In the contemporary knowledge economy, Science, Technology, Engineering, Arts and Mathematics (STEAM) research is valuable when it moves beyond journal articles into usable products, services, creative technologies, industrial processes and

policy solutions. However, in many Nigerian public universities, the movement from research output to market value remains weak because the infrastructure required to support experimentation, prototyping, intellectual property protection, incubation and industry linkage is either inadequate or poorly coordinated. Recent studies show that Nigerian Universities produce research with social and economic potential, yet weak laboratories, poor electricity supply, limited digital facilities, inadequate funding, weak industry partnership and low institutional support continue to constrain commercialization (Okwelogu et al., 2023; Chikwe et al., 2024; Olasupo et al., 2024). This makes the problem more than a funding issue; it is a structural barrier to transforming knowledge into development outcomes (WIPO, 2025; TETFund, 2024; World Bank, 2024).

Infrastructural development is a foundational requirement for any University that seeks to transform research into social and economic value. Infrastructural development is described as the provision, improvement and effective utilization of physical, digital, financial and institutional facilities that support research generation, experimentation, testing, prototyping and knowledge transfer. This includes laboratories, workshops, studios, fabrication centers, internet facilities, power supply, research grants, innovation hubs, technology transfer offices, intellectual property support systems and University-industry linkage structures. The World Bank (2024) explains infrastructure as the basic systems and services that enable productive activity, while Organization for Economic Co-operation and Development (OECD) (2023) links research infrastructure to facilities, resources and services that support scientific communities in conducting high-quality research and innovation. Similarly, TETFund (2024) emphasizes that functional infrastructure in tertiary institutions is central to research productivity, staff development and national competitiveness. In Rivers State public Universities, infrastructural development should not be understood only as the construction of buildings, but as the total ecosystem that enables lecturers to move from ideas to tested outputs. Where this ecosystem is weak, research remains largely theoretical, fragmented and disconnected from industry needs. This makes infrastructural development the first logical condition for the successful Commercialization of STEAM research.

Commercialization of STEAM research logically follows from infrastructural development because research can only become economically useful when there are systems that support its conversion into products, services, patents, licenses, start-ups, spin-offs, industrial processes and creative solutions. Commercialization of STEAM research refers to the process through which knowledge generated from Science, Technology, Engineering, Arts and Mathematics is transformed into marketable, socially useful or industry-adopted outcomes. World International Property Organization WIPO (2024) defines commercialization as the process of converting intellectual property and knowledge assets into economic value, while Perkmann et al. (2021) describes University research commercialization as the transfer of academic knowledge into industry, markets and society through licensing, collaboration, consultancy and enterprise creation. Guerrero et al. (2024) also argue that entrepreneurial Universities are expected to convert research outputs into innovations that stimulate regional and national development. In the context of STEAM, this Commercialization process is broader than science and technology alone because the arts introduce creativity, design thinking, communication, user experience and cultural innovation into product and service development. However, for lecturers in Rivers State public Universities, Commercialization may remain difficult where research outputs are not supported by incubation centers, funding pipelines, legal/IP structures, prototype facilities and industry partnerships. Thus, even when lecturers produce valuable STEAM research, the absence of enabling infrastructure may prevent such research from reaching the market or solving practical societal problems.

Perceived barriers become important because lecturers are the direct producers of university research and are therefore in a strong position to identify the infrastructural conditions that either support or obstruct Commercialization. In this study, perceived barriers refer to lecturers' subjective but experience-based judgments about the factors they believe hinder infrastructural development for successful STEAM research Commercialization. Ajzen (1991) explains that perception influences intention and behaviour because individuals act based on how they interpret enabling or constraining conditions. Rogers (2003) similarly shows that the adoption and diffusion of innovation depend on how potential adopters perceive

complexity, compatibility, relative advantage and available support. Tornatzky and Fleischer (1990), through the Technology-Organization-Environment framework, further suggest that innovation is shaped by technological readiness, organizational support and external environmental conditions. Applied to this study, lecturers may perceive barriers in terms of poor laboratories, unreliable electricity, weak internet access, inadequate research funding, lack of patent support, limited University-industry collaboration, bureaucratic grant systems and promotion structures that reward publication more than innovation. These perceived barriers are significant because they reveal the lived institutional realities behind low Commercialization outcomes. Therefore, examining perceived barriers among public University lecturers in Rivers State provides a practical way of understanding why STEAM research often fails to move from academic output to commercial, industrial and developmental impact.

The current Nigerian situation reveals a wide gap between this ideal and practice. Nigeria's innovation system remains constrained by low research investment, weak infrastructure and fragile linkages among universities, industries and government agencies. WIPO's Global Innovation Index continues to rank Nigeria low in innovation input indicators, particularly infrastructure, institutions, and human capital and research, even though the country shows potential in creative and knowledge outputs (WIPO, 2024; WIPO, 2025). Studies on Nigerian Universities have similarly reported poor laboratory facilities, inadequate power supply, limited research funding, bureaucratic grant access and weak industrial collaboration as recurring barriers to research development and commercialization (Okwelogu et al., 2023; Momoh et al., 2022; Igbokwe-Ibeto & Anyanwu, 2022). For public University lecturers in Rivers State, these challenges are particularly important because the state hosts Universities in an oil-rich, industrial and entrepreneurial environment where STEAM research should naturally connect with energy, environment, engineering, digital technology, creative industries and community development needs (Aneke & Ibiam, 2022; Chikwe et al., 2024; Leo, 2022).

The implications of these infrastructural barriers are significant. When lecturers lack functional laboratories, reliable internet, research assistants, prototype funding or Commercialization offices, research remains largely academic rather than developmental. This weakens University relevance, reduces patenting and start-up formation, discourages industry confidence and limits the contribution of public Universities to employment generation and regional economic diversification. It also affects lecturer motivation because promotion systems often reward publication more than innovation, while industry actors may view University research as theoretical or disconnected from market needs (Dutse et al., 2021; Okoronkwo et al., 2022; Olasupo et al., 2024). The result is a cycle in which poor infrastructure produces weak commercial output, weak output reduces industry trust, and low industry trust further reduces investment in university-based innovation (Ejilah et al., 2025; FMIST, 2026; TETFund, 2024).

Theoretically, this study was framed through the Triple Helix model and the Technology-Organisation-Environment perspective. The Triple Helix model argues that innovation grows through interaction among Universities, industries and government, not through isolated academic effort (Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2003; Leydesdorff, 2012). From this view, infrastructural barriers are not only internal University problems; they also reflect weak collaboration, policy inconsistency and limited industry absorption capacity. The Technology-Organization-Environment framework further explains that research commercialization depends on technological readiness, organizational support and environmental conditions such as regulation, market demand and funding climate (Tornatzky & Fleischer, 1990; Rogers, 2003; Oliveira & Martins, 2011). These frameworks are useful because lecturers' perceptions can reveal how technological infrastructure, institutional culture and external partnerships jointly influence STEAM Commercialization (Perkmann et al., 2021; Guerrero et al., 2024; OECD, 2023).

Existing literature has examined University-industry collaboration, research funding and commercialization in Nigeria, but much of it is broad, discipline-specific or regionally concentrated outside Rivers State. For example, studies have focused on South-East Nigeria, Enugu State, FIIRO Lagos, and Northern Nigerian technical education programme and general Nigerian public universities (Igbokwe-Ibeto & Anyanwu, 2022; Aneke & Ibiam, 2022; Okoronkwo et al., 2022; Asukwo, 2024).

Others have discussed TETFund intervention, national innovation systems and general research-development barriers without isolating lecturers' perceived infrastructural barriers within STEAM fields in Rivers State public universities (Leo, 2022; Okwelogu et al., 2023; Anachuna et al., 2024). This creates a contextual and empirical gap. Therefore, this study focuses on perceived barriers to infrastructural development for successful Commercialization of STEAM research among public University Lecturers in Rivers State. The rationale is that lecturers are direct producers of university research and are therefore well positioned to identify the infrastructural weaknesses preventing STEAM knowledge from becoming commercially useful, socially relevant and economically transformative.

Purpose of the Study

The purpose of this study is to explore the perceived barriers to infrastructural development for the successful commercialization of STEAM research among public university lecturers in Rivers State. Specifically, the study sought to:

1. Explore public University Lecturers' perceptions of the state of infrastructural development supporting STEAM research Commercialization in Rivers State.
2. Examine the infrastructural barriers perceived by public University Lecturers as limiting the successful Commercialization of STEAM research in Rivers State.

Research Questions

The following research questions guided the study:

1. How do public University Lecturers perceive the current state of infrastructural development supporting STEAM research Commercialization in Rivers State?
2. What infrastructural barriers do public University Lecturers perceive as limiting the successful Commercialization of STEAM research in Rivers State?

METHODOLOGY

This study adopted a qualitative research design because this is deemed most suitable for exploring the meanings, experiences and perceptions of public University lecturers regarding infrastructural barriers to the Commercialization of STEAM research. The population of the study was 2849 lecturers across the three public Universities in the state, namely: Rivers State University, University of Port Harcourt and Ignatius Ajuru University of Education. Purposive sampling technique was used to select 6 senior lecturers and 6 professors from the three Universities because of their relevance, knowledge and experience. That is 4 lecturers from each University. Data were collected through face-to-face interviews using a semi-structured interview guide and was analyzed using Braun & Clark's thematic analysis.

Qualitative design is appropriate when a study seeks to understand how participants interpret a social or institutional problem within its real-life context rather than measuring variables statistically (Creswell & Poth, 2018; Denzin & Lincoln, 2018). Since the study focused on perceived barriers, the design allowed participants to describe, in their own words, how infrastructure, institutional support, research facilities and University-industry linkages influence the Commercialization of STEAM research. This approach is also consistent with exploratory studies where limited context-specific evidence exists and where the researcher seeks depth, detail and meaning rather than numerical generalization (Saunders, Lewis & Thornhill, 2019).

Population of the Study

The population comprised senior lecturers and professors in public Universities in Rivers State who were involved in STEAM-related teaching, research, supervision or innovation activities. This population was considered appropriate because senior lecturers and professors are senior academics with extensive experience in University research systems, institutional infrastructure, grant processes, academic productivity and the challenges of translating research into practical or commercial value. In qualitative research, population relevance is not determined only by size, but by the closeness of participants to the phenomenon being investigated (Patton, 2015). Therefore, professors in the three public universities in Rivers State were considered information-rich participants because they could provide informed

reflections on research infrastructure, Commercialization opportunities and systemic barriers within public University settings.

Sample and Sampling Technique

The study purposively sampled twelve participants (6 senior lecturers and 6 professors) from the three public Universities in Rivers State, with four professors selected from each University. Purposive sampling was adopted because the study required participants who had direct knowledge of STEAM research and could provide rich, experience-based insights into infrastructural barriers. Purposive sampling is suitable in qualitative studies because it enables the deliberate selection of participants who are most capable of answering the research questions (Patton, 2015; Campbell et al., 2020). The sample size of twelve was considered appropriate because qualitative inquiry prioritizes depth and relevance of data over statistical representation. Guest, Namey and Chen (2020) argue that relatively small qualitative samples can generate meaningful insights when participants are knowledgeable and interviews are focused. Thus, selecting four professors from each University ensured institutional spread while maintaining the depth required for interview-based inquiry.

Data Collection Procedure

Data were collected through face-to-face interviews using a semi-structured interview guide. The interview guide enabled consistency across participants while allowing flexibility for probing, clarification and follow-up questions. Semi-structured interviews are appropriate where the researcher has defined research questions but still wants participants to explain their experiences in detail (Kvale & Brinkmann, 2015; Rubin & Rubin, 2012). Before each interview, participants were briefed on the purpose of the study, their rights as participants and the voluntary nature of participation. With their consent, the interviews were audio-recorded to ensure that participants' responses were captured accurately. Recording the interviews reduced the risk of data loss and allowed the researcher to focus on listening, probing and observing participants' explanations during the interview process. The recorded interviews were later transcribed verbatim, which means that participants' spoken responses were reproduced word-for-word. Verbatim transcription is important in qualitative research because it preserves participants' meanings, expressions and emphasis for accurate interpretation (Halcomb & Davidson, 2006).

Data Analysis Procedure

Data analysis was conducted using Braun and Clarke's (2021) thematic analysis method. Thematic analysis was suitable because the study aimed to identify patterns of meaning across lecturers' accounts of infrastructural barriers. The process began with familiarization, where the researcher read the transcripts repeatedly to gain an overall understanding of participants' responses. Initial codes were then generated from relevant statements relating to infrastructure, Commercialization, institutional support, funding, laboratories, power supply, incubation, intellectual property and industry collaboration. These codes were examined and grouped into possible themes. The themes were then reviewed, refined and named to ensure that they reflected the data and answered the research questions. Braun and Clarke (2021) emphasize that thematic analysis is not a mechanical counting process but an interpretive method through which the researcher actively identifies meaningful patterns in the data. Byrne (2022) also notes that Braun and Clarke's approach is useful for organizing qualitative data while retaining participants' lived meanings. To strengthen credibility, the analysis focused on recurring ideas across participants while also paying attention to unique views that offered deeper explanation of the problem.

Ethical Clearance

Ethical approval was secured from the Rivers State University Research Ethics Committee before data collection commenced. This was necessary because ethical review protects participants from harm and ensures that the study meets accepted standards of responsible research practice (Israel, 2015; BERA, 2018). All participants gave informed consent before the interviews were conducted. They were informed that participation was voluntary, that they could withdraw at any stage, and that their responses would be used only for academic purposes. To ensure anonymity and confidentiality, participants were coded as P1 to P12 rather than being identified by name or institution. The recorded interview files were stored securely and deleted from saved storage 73 hours after transcription. This helped to reduce the risk of

unauthorized access to participants' voices and personal information. These measures were important because qualitative interviews often involve personal and institutional reflections that must be handled with care, trust and confidentiality (Wiles, 2013; Tracy, 2020).

RESULTS

Deductive Thematic Data Presentation and Analysis

The data were analyzed deductively using the two research questions as the organizing framework. The analysis produced two major themes. The first major theme focused on lecturers' perceptions of the current state of infrastructural development supporting STEAM research Commercialization, while the second major theme focused on the infrastructural barriers limiting effective Commercialization. Participants were coded as P1 to P1 to ensure anonymity.

Research Question One: How do public University Lecturers perceive the current state of infrastructural development supporting STEAM research Commercialization in Rivers State?

Major Theme One: Current Infrastructural Development is Inadequate, Uneven and Poorly Coordinated

Participants generally perceived the current state of infrastructural development for STEAM research Commercialization as inadequate, uneven and poorly coordinated. Although some public Universities in Rivers State have basic research facilities, participants explained that these facilities are not sufficiently developed, maintained or organized to support the movement of research from academic output to commercial value.

Minor Theme One: Weak Physical Research Infrastructure

Participants explained that physical research infrastructure remains weak because laboratories, workshops, studios and prototype development spaces are either inadequate, outdated or poorly equipped. One participant noted, *"We have laboratories, but most of them are not equipped for serious innovation; they are mainly useful for teaching basic practicals"* (P1). Another participant explained, *"For STEAM research to become commercial, we need workshops where prototypes can be developed and tested, but that is still very limited"* (P7). A further participant added, *"Some equipment we use cannot support modern research because they are outdated and difficult to maintain"* (P3). These responses produced codes such as poorly equipped laboratories, obsolete equipment, inadequate workshops, lack of prototype spaces and insufficient creative production facilities. This finding shows that STEAM research commercialization is weakened when lecturers lack the physical facilities required for experimentation, testing and product development.

Minor Theme Two: Limited Digital and Technological Infrastructure

Participants also described digital and technological infrastructure as limited. They explained that modern STEAM research requires reliable internet, research software, digital repositories and ICT platforms, but these are either weak or inconsistently available. One participant stated, *"Internet access is not reliable enough for serious collaborative research, especially when one has to work with external partners"* (P2). Another participant observed, *"Some of the software needed for simulation, design and analysis are either unavailable or not licensed"* (P4). Similarly, a participant noted, *"Digital infrastructure is still treated as secondary, but without it, modern STEAM research cannot compete"* (P11). These responses produced codes such as unstable internet access, weak ICT systems, inadequate research software, poor digital repositories and lack of innovation management platforms. This finding indicates that infrastructural development for STEAM research is not limited to buildings and laboratories, but also includes the digital systems needed for collaboration, simulation, design, data analysis and commercial engagement.

Minor Theme Three: Inadequate Funding Support for Research Development

Participants further explained that funding support for research development is inadequate. They noted that available grants are often irregular, small or difficult to access, making it difficult to move research beyond publication into prototype development and market testing. One participant stated, *"The grants available are usually not enough to move research beyond publication"* (P4). Another participant

explained, *"Prototype development requires money, and most lecturers do not have access to that kind of support"* (P6). A third participant added, *"Many of us spend personal money on research, but personal funding cannot take an idea to the market"* (P9). These responses produced codes such as irregular research grants, inadequate internal funding, lack of prototype funding, difficulty accessing external grants and dependence on personal funds. This finding shows that lecturers perceive funding as a major part of infrastructural development because Commercialization requires financial support from idea development to product testing and scaling.

Minor Theme Four: Weak Institutional Structures for Commercialization

Participants also explained that institutional structures for Commercialization are weak. They reported that there are no clearly active systems to guide lecturers through patenting, licensing, incubation, industry partnership and market entry. One participant noted, *"There is no clear office that takes a lecturer from research output to patenting or Commercialization"* (P5). Another participant explained, *"When you finish a research project, you are almost on your own if you want to commercialize it"* (P8). Similarly, one participant stated, *"The structure for moving research to industry is not visible or active enough"* (P12). These responses produced codes such as absence of active technology transfer offices, poor incubation support, weak intellectual property guidance, lack of Commercialization desks and poor coordination between research units and University management. This finding shows that even when lecturers produce useful research, the absence of institutional pathways prevents such research from becoming commercially useful.

Minor Theme Five: Poor Maintenance and Sustainability Culture

Participants further identified poor maintenance and sustainability culture as part of the current infrastructural problem. They explained that some facilities are provided but later become non-functional because of poor maintenance, delayed repairs and weak accountability. One participant stated, *"Equipment may be purchased, but after some time it stops working because there is no maintenance plan"* (P2). Another participant noted, *"Sometimes the problem is not that facilities were never provided; the problem is that they are not sustained"* (P7). A further participant explained, *"Research infrastructure requires continuous maintenance, but this is often ignored until the facilities become useless"* (P11). These responses produced codes such as abandoned equipment, lack of maintenance plans, delayed repair of facilities, poor monitoring of research assets and weak accountability for infrastructure use. This finding shows that infrastructural development must involve not only provision of facilities, but also maintenance, monitoring and long-term sustainability.

Research Question Two: What infrastructural barriers do public University lecturers perceive as limiting the Successful commercialization of STEAM research in Rivers State?

Major Theme Two: Multiple Infrastructural and Institutional Barriers Limit the Movement of STEAM Research from Academic Output to Market Value

Participants explained that successful Commercialization requires more than research production. It also requires stable utilities, industry linkage, intellectual property protection, supportive institutional policy, incubation systems and access to markets. However, the data showed that these supporting conditions are weak or insufficient in public Universities in Rivers State.

Minor Theme One: Power Supply and Utility-Related Constraints

Participants explained that power supply and utility-related constraints strongly limit STEAM research Commercialization. They noted that unstable electricity affects laboratory experiments, equipment use, data processing, prototype development and product testing. One participant stated, *"You cannot run serious laboratory work where electricity is unpredictable"* (P1). Another participant explained, *"Some experiments are affected when power goes off suddenly, and this discourages continuous research"* (P3). A further participant added, *"Sensitive equipment needs stable power, and without that, commercial-level research is almost impossible"* (P10). These responses produced codes such as unreliable electricity supply, high cost of alternative power, interrupted experiments, inability to run sensitive equipment and unstable operating conditions. This finding shows that basic utilities remain central to STEAM research

Commercialization because research outputs cannot be reliably tested, developed or scaled in unstable operating environments.

Minor Theme Two: Weak University-Industry Linkage

Participants also explained that weak university-industry linkage prevents research from reaching commercial users. They noted that Universities and industries often operate separately, making it difficult for lecturers to understand market needs or for industries to recognize University research capacity. One participant stated, *"Industries are not sufficiently connected to what Universities are doing"* (P3). Another participant noted, *"Many companies prefer imported solutions instead of working with researchers around them"* (P5). A third participant explained, *"There is no strong platform where lecturers and industry people regularly meet to discuss problems and possible solutions"* (P8). These responses produced codes such as limited industry partnership, poor communication with the private sector, lack of industry-funded projects, low industry trust in University research and absence of joint research centers. This finding shows that Commercialization is difficult where research producers and potential users of research are not institutionally connected.

Minor Theme Three: Poor Intellectual Property and Patent Support

Participants further identified poor intellectual property and patent support as a barrier to Commercialization. They explained that lecturers may be discouraged from disclosing or developing inventions when ownership rights, patent procedures and legal protection are unclear. One participant noted, *"Some lecturers are not sure who owns the invention if they disclose it through the university"* (P4). Another participant explained, *"Patent processing is complicated, and many academics do not know where to begin"* (P6). A further participant stated, *"There is fear that ideas can be taken without proper protection"* (P11). These responses produced codes such as limited knowledge of patent procedures, absence of IP advisory units, high cost of patenting, fear of idea theft and unclear ownership of inventions. This finding shows that weak intellectual property support limits Commercialization because lecturers need assurance that their ideas, inventions and creative outputs will be protected and fairly rewarded.

Minor Theme Four: Bureaucracy and Weak Institutional Policy Support

Participants also explained that bureaucracy and weak institutional policy support limit effective commercialization. They noted that approval processes are slow, commercialization policies are unclear and academic promotion systems still prioritize publication over innovation outputs. One participant stated, *"The approval process for collaboration can be too slow and discouraging"* (P1). Another participant observed, *"There is no strong policy that clearly guides lecturers on how to commercialize research"* (P6). A further participant explained, *"Promotion is still largely based on publication, so lecturers focus on papers rather than products"* (P7). These responses produced codes such as slow approval processes, bureaucratic grant procedures, unclear Commercialization policy, and weak reward system for innovation, publication-based promotion and poor leadership commitment to Commercialization. This finding shows that institutional culture can either promote or suppress innovation, and where policy support is weak, lecturers are more likely to focus on academic publication than commercial outcomes.

Minor Theme Five: Limited Incubation and Market-Readiness Support

Participants explained that research ideas often stop at the academic stage because there are no structured systems to support business development, investor linkage or product scaling. One participant noted, *"A lecturer may have a good idea, but there is no incubator to help shape it into a business"* (P2). Another participant explained, *"Commercialization requires more than research; it requires market testing and business support"* (P4). A further participant stated, *"There should be a structured pathway from research to product development, but that pathway is weak"* (P8). These responses produced codes such as lack of start-up incubation centers, absence of business development support, weak mentoring for research entrepreneurship, lack of product testing facilities, poor access to investors and no structured pathway from research to market. This finding shows that commercialization is a process that requires sustained support beyond the completion of research.

Overall Analysis

Overall, the deductive thematic analysis shows that public University lecturers perceive infrastructural development for STEAM research commercialization in Rivers State as inadequate, fragmented and weakly sustained. The analysis further shows that the barriers limiting commercialization are both physical and institutional. Poor laboratories, weak digital systems, inadequate funding, unstable electricity, weak industry linkage, poor intellectual property support, bureaucratic procedures and lack of incubation structures combine to prevent STEAM research from moving from academic output to commercial value. Therefore, successful commercialization requires a more coordinated infrastructural ecosystem that supports research generation, prototype development, patent protection, industry collaboration, business incubation and market adoption.

DISCUSSION OF FINDINGS

The findings show that public University lecturers perceive infrastructural development for STEAM research commercialization in Rivers State as inadequate, fragmented and weakly sustained. This finding is consistent with wider evidence from Nigeria and other African contexts showing that research commercialization is often constrained not by the absence of academic knowledge, but by weak systems for converting knowledge into usable economic value. For instance, studies on Nigerian universities have reported that inadequate laboratories, poor research funding, weak technology transfer structures and limited industry collaboration reduce the capacity of universities to transform scientific research into patents, prototypes and marketable products (Okwelogu et al., 2023; Olasupo et al., 2024; WIPO, 2025). Similarly, Eitu, Muramuzi and Lwanga's study on Uganda found that although innovation hubs and incubation centers are expanding, their effectiveness is limited by poor resources, weak Commercialization pathways and low private-sector engagement (Eitu, Muramuzi and Lwanga, 2026). This supports the present finding that lecturers in Rivers State do not simply lack research ideas; rather, they operate within an infrastructural ecosystem that does not sufficiently support prototype development, patent protection, business incubation and market access.

The finding on poor laboratories, weak digital systems and unstable electricity also aligns with broader African higher education literature. In many African universities, infrastructure gaps affect both research quality and the capacity to scale innovation beyond the academic environment. This is particularly important for STEAM research because Commercialization requires experimentation, testing, simulation, creative production, fabrication and industry validation. A South African study on university innovation ecosystems found that maker spaces and innovation mechanisms can strengthen Universities' capacity to transform theoretical knowledge into practical outcomes, especially in 4IR-related research (Kruger and Steyn, 2024). This contrasts with the Rivers State findings, where lecturers perceived prototype spaces, workshops and digital systems as insufficient. The comparison suggests that where Universities invest in maker spaces, innovation hubs and interdisciplinary platforms, STEAM research is more likely to move toward commercial application. However, where facilities are outdated or poorly maintained, commercialization remains aspirational rather than practical.

The findings also reveal that weak University-industry linkage is a major barrier to STEAM research commercialization. This agrees with Rossoni, Vasconcellos and Rossoni's systematic review, which shows that university-industry collaboration is central to research, development and innovation, but is often weakened by fragmented communication, institutional mistrust, different timelines and weak partnership structures (Rossoni, Vasconcellos and Rossoni, 2024). Similarly, O'Dwyer, Filieri and O'Malley (2023) found that successful university-industry collaboration depends on trust, relational commitment and clear mechanisms for engagement. The Rivers State finding therefore reflects a wider global problem, but with stronger local severity because industries in Nigeria often prefer imported solutions or external consultants rather than locally developed university research. This weakens the Triple Helix relationship among Universities, industries and government, and reduces the possibility that academic knowledge will be absorbed into productive sectors.

However, some contrary findings from other contexts show that the mere existence of technology transfer offices, incubation centers or Commercialization structures does not automatically guarantee successful research Commercialization. In Ghana, Abdulai et al. (2022) found that technology transfer offices do not always produce straightforward positive effects on firm innovation performance, especially where formal transfer mechanisms are poorly integrated with informal human interaction and practical industry needs. Similarly, an Australian study found that outsourcing Commercialization activities to a sophisticated technology transfer office produced some short-term gains, but these gains declined after disengagement, with limited evidence of lasting organizational learning (Günzel-Jensen et al., 2023). These contrary findings are important because they caution against a simplistic recommendation that Rivers State public Universities only need to establish Commercialization offices. Rather, such offices must be active, adequately funded, trusted by researchers, connected to industry and embedded in the University's research culture.

The finding on poor intellectual property and patent support is also supported by international evidence. Studies from Europe and Asia show that uncertainty around intellectual property ownership, legal complexity, patent cost and lack of Commercialization expertise can discourage academics from disclosing inventions or engaging with technology transfer systems (Ravi and Janodia, 2022; Suominen and Deschryvere, 2024). Battaglia, Paolucci and Ughetto (2024), in an Italian university-industry technology transfer study, also found that research-based inventions often fail to reach the market because of barriers in readiness, validation, and market alignment and transfer processes. This supports the present study's finding that lecturers may hesitate to commercialize STEAM research when they lack guidance on patenting, ownership, licensing and protection from idea theft. At the same time, evidence from Finland and Australia suggests that even advanced research systems experience IP and Commercialization barriers, meaning that the issue is not exclusively Nigerian. The difference is that developed systems often struggle with efficiency and market fit, while Nigerian and African universities often struggle first with basic infrastructure, funding and institutional capacity.

The findings on bureaucracy and publication-based promotion are particularly critical. Participants indicated that lecturers are more likely to prioritize journal publication because university promotion systems reward publications more clearly than patents, prototypes or start-ups. This is consistent with academic entrepreneurship literature, which argues that commercialization depends not only on infrastructure but also on incentives, institutional culture and researcher motivation (Perkmann et al., 2021; Guerrero et al., 2024). Kruger's South African study also found that successful innovation commercialization requires motivated professors, private funding, mentorship and institutional incentives that treat innovators as owners of their research (Kruger, 2023). This suggests that Rivers State public universities may need to revise academic reward systems so that patents, licenses, prototypes, industry-funded projects, creative outputs and start-up formation are recognized as valid scholarly achievements.

Practically, the findings imply that public Universities in Rivers State need a coordinated research commercialization ecosystem rather than isolated infrastructural interventions. This aligns with Perkmann et al. (2021), who argue that university research commercialization depends on organized institutional support, industry engagement and knowledge-transfer mechanisms rather than research production alone. Investment should therefore prioritize functional laboratories, reliable power systems, digital research infrastructure, prototype workshops, creative studios and fabrication spaces, since research infrastructure is central to innovation capacity and knowledge application (OECD, 2023; WIPO, 2024). Universities should also strengthen technology transfer offices, intellectual property advisory units, innovation hubs and incubation centers because these structures help researchers move from invention disclosure to patenting, licensing, product development and enterprise creation (Etzkowitz, 2003; Guerrero et al., 2024). In addition, stronger university-industry platforms are needed so that lecturers can work directly with firms, government agencies, communities and investors to identify problems requiring STEAM solutions. This supports Rossoni, Vasconcellos and Rossoni's (2024) argument that effective university-industry collaboration requires structured engagement, trust and sustained interaction between knowledge producers and users. For policy makers, the findings suggest that research funding should include specific

allocations for prototype development, patent support, product testing and market-readiness activities, not only conference attendance or publication support (TETFund, 2024; Perkmann et al., 2021).

Theoretically, the findings reinforce the relevance of the Triple Helix model because they show that STEAM commercialization depends on interaction among Universities, industries and government. Etzkowitz and Leydesdorff (2000) argue that innovation is strongest where universities, industries and government operate as interconnected actors rather than isolated institutions. The weak commercialization outcomes reported by participants therefore reflect a weak Triple Helix system in which universities produce research, industries remain disconnected and government support is insufficiently coordinated (Etzkowitz, 2003; Leydesdorff, 2012). The findings also extend the Technology-Organization-Environment perspective by showing that commercialization barriers operate across technological factors, such as laboratories and digital tools; organizational factors, such as bureaucracy and reward systems; and environmental factors, such as industry trust, market linkage and policy support. This agrees with Tornatzky and Fleischer (1990), who argue that innovation adoption is shaped by technological, organizational and environmental conditions, and with Oliveira and Martins (2011), who show that organizational readiness and external pressures influence technology-related innovation. Therefore, the study contributes to theory by showing that infrastructural development for STEAM Commercialization should be understood as a multi-level ecosystem rather than a purely physical or financial issue (Perkmann et al., 2021; Guerrero et al., 2024).

The study had some limitations. First, it used a qualitative design and purposively sampled twelve professors from three public Universities in Rivers State. This means that the findings cannot be statistically generalized to all lecturers or all Nigerian Universities. However, this limitation was mitigated by selecting information-rich participants with senior academic experience and by drawing participants from all three public Universities, with four from each institution. In addition, the study relied on self-reported interview data, which may be influenced by participants' personal experiences or institutional frustrations. This was mitigated by using a semi-structured interview guide, probing for examples and comparing patterns across participants rather than relying on isolated opinions. Furthermore, the study focused only on professors, excluding other stakeholders such as early-career lecturers, university managers, industry partners, students, entrepreneurs and policy makers. This was partly mitigated by selecting professors because they possess long-term knowledge of research systems, funding structures and Commercialization challenges. Finally, because the interviews dealt with institutional weaknesses, participants may have been cautious in their responses. This was mitigated through informed consent, anonymity, participant coding from P1 to P12, confidentiality assurances and deletion of recorded files after transcription. Therefore, while the study has contextual and methodological limitations, the steps taken strengthened the credibility, trustworthiness and ethical integrity of the findings.

CONCLUSION

This study has systematically explored the perceived barriers to infrastructural development for Commercialization of STEAM research among public University lecturers in Rivers State. The results of the qualitative data gathered and analyzed revealed that infrastructural development remains a critical condition for the successful Commercialization of STEAM research in public Universities in Rivers State. The findings showed that lecturers perceive existing infrastructure as inadequate, fragmented and weakly sustained, particularly in relation to laboratories, digital systems, funding, electricity, intellectual property support, industry linkage and incubation structures. These weaknesses prevent promising research outputs from progressing into prototypes, patents, start-ups, licenses or market-ready solutions. The study further concluded that the problem is not simply low research productivity, but the absence of a coordinated ecosystem that supports the movement of knowledge from academic spaces to practical and commercial use. The findings also confirm the relevance of the Triple Helix and Technology-Organization-Environment perspectives, as Commercialization depends on the interaction of University capacity, industry engagement, government support, institutional policy and technological readiness. Therefore,

strengthening STEAM Commercialization requires systemic, sustained, inclusive and not isolated, reform.

RECOMMENDATIONS

The study recommends that:

1. Public Universities in Rivers State should establish coordinated STEAM commercialization ecosystems linking laboratories, prototype workshops, creative studios, digital platforms, technology transfer offices, intellectual property units, incubation centers and industry desks.
2. University management should prioritize reliable power supply, laboratory renewal, software access and maintenance plans to ensure that research facilities remain functional beyond initial procurement.
3. Government and funding agencies should create dedicated grants for prototype development, patent registration, product testing, business modelling and investor engagement, rather than limiting support to publications and conferences.
4. Universities should also revise promotion and reward systems to recognize patents, licenses, start-ups, industry-funded projects and creative innovations as legitimate academic achievements.
5. Structured University-industry-government platforms should be created to identify market problems, co-design research projects, mentor lecturers and connect STEAM outputs with firms, communities, investors and policy actors. These measures would make Commercialization deliberate, measurable and institutionally sustainable.

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