Multidisciplinary

Bayesian inference for evaluating the effectiveness of digital technology on degree project output of students of Biotechnology Federal University, Lokoja

Musa Amina Ladidi[1*], Muhammed Abubakar[1], Ajare Emmanuel Oloruntoba[1-4], Sani Sade Muhammad[1]

[1] Federal University, Lokoja, Nigeria

[2] School of Quantitative Sciences, College of Art and Sciences, University Utara Malaysia, Sintok, Malaysia

[3] Department of Mathematical Sciences, Faculty of Sciences, Federal University Gusau, Gusau, Nigeria

[4] Department of Mathematics and Statistics, Austin Peay State University, Clarksville, Tennessee, USA

*Correspondence Author: Musa Amina Ladidi

Received 8 Dec 2025; Accepted 19 Jan 2026; Published 04 Feb 2026

DOI: https://doi.org/10.64601/v5p7ap71

Abstract

Digital library systems have transformed academic research by providing access to vast repositories of information, facilitating knowledge acquisition, and enhancing research output. At Federal University Lokoja (FUL), the adoption of digital library systems has become crucial for supporting academic activities and overcoming challenges associated with traditional library systems. This study evaluates the effectiveness of digital library systems effectiveness of biotechnology degree project output students research at FUL using Bayesian inference, a statistical approach that allows for robust analysis by incorporating prior knowledge and evidence from observed data. Findings reveal positive relationship exists between digital technology library usage and research output among Biotechnology students. The Bayesian analysis confirms that lack of technical support and poor internet connectivity are the two most significant challenges facing Biotechnology students in their use of the digital library system with both recording. The result of the analysis also shows that students are willing to use the digital library but are being stopped by factors outside their control. Digital library is contributing positively to research output but is limited by barriers such as poor internet connectivity and inadequate training.

Keywords: Information and Communication Technology, Trend change, Intellectual development, Bayesian multiple regression

1. Introduction

Digital libraries have become essential tools in academic institutions, revolutionizing the way researchers and students access information. These systems provide seamless access to vast repositories of e-books, scholarly journals, and research databases, enabling scholars to acquire knowledge and produce high-quality research efficiently. For institutions like Federal University Lokoja (FUL), digital library systems represent a significant advancement over traditional libraries, which are often constrained by limited physical resources, restricted accessibility, and outdated materials. By leveraging digital library resources, universities can enhance research productivity, foster innovation, and improve the academic experience for both students and faculty members Liu *et al*., (2025) [1].

The global academic community widely acknowledges the effectiveness of digital libraries in influencing research output. Studies have shown that access to digital resources is associated with improved academic performance, higher publication rates, and better-quality research. Digital libraries enable researchers to access current and comprehensive information, facilitating the development of innovative ideas and scholarly contributions. However, the actual impact of digital libraries on research output can vary based on factors such as user awareness, accessibility, frequency of usage, and the availability of relevant materials. These variations highlight the need for institution-specific evaluations to understand how digital libraries contribute to academic success in different contexts, Adeyemi, & Ojo, (2019) [2].

At FUL, where the adoption of digital library systems is relatively new, understanding their impact on research activities is particularly important. With a growing emphasis on fostering a research-driven academic environment, it is crucial to assess whether these systems are effectively meeting the needs of students and staff. Such an evaluation will help identify gaps in system usage, accessibility, or awareness, enabling the university to implement strategies for optimizing its digital library services. This study employs Bayesian inference to evaluate the effectiveness of digital library systems on research output at FUL. Bayesian inference offers a robust analytical approach by combining prior knowledge with observed data to model complex relationships between variables. By examining factors such as user engagement, access frequency, and publication records, this research seeks to determine the extent to which digital library usage influences the quantity and quality of research output. The findings will provide evidence-based recommendations for improving digital library systems and fostering a culture of academic excellence at FUL, ensuring the institution remains competitive in the evolving academic landscape. Digital libraries have

emerged as transformative tools in academic institutions, providing unparalleled access to vast repositories of information, including e-books, journals, databases, and multimedia resources. Their introduction has significantly altered how researchers, students, and educators interact with information, offering a platform that overcomes many limitations of traditional library systems. This literature review explores the role of digital libraries in enhancing research output, the challenges associated with their use, and the relevance of Bayesian inference as a methodological approach for evaluating their effectiveness, Onwuegbuzie, & Wilson, (2018) [3].

This study is justified by the need to assess the relationship between digital library usage and research output in a context-specific manner. While global studies emphasize the potential of digital libraries to improve academic performance, the unique challenges faced by Nigerian universities, such as inconsistent internet connectivity and inadequate training, necessitate localized research. Using Bayesian inference, this study will provide a nuanced understanding of how digital library systems influence research productivity at FUL by incorporating both observed data and prior knowledge.

2. Literature review

Bayesian inference is particularly useful in this study because it allows for the integration of uncertainty in the model, improving its predictive power. For instance, it can account for incomplete or missing data by assigning prior distributions to unobserved variables. The results will be presented in the form of probability distributions, providing insights into the likelihood that increased digital library usage leads to higher research productivity. The analysis will be conducted using statistical software such as R or SPSS, which are capable of performing Bayesian analysis and generating the necessary modelsm, Kumar, & Goudar, (2020) [4].

Methodological approach for evaluating their effectiveness of digital technology libraries and research output Adeyemi, & Ibrahim, (2018) [5]. Digital technology library systems are widely acknowledged for their ability to enhance research productivity. By offering instant access to high-quality and up-to-date resources, these systems enable researchers to broaden their knowledge base and produce innovative, impactful work. Studies highlight that access to digital libraries is associated with increased publication rates, improved research quality, and greater academic engagement. According to Onwuegbuzie and Wilson (2018) [3], digital libraries significantly reduce the time and effort required to gather research materials, thereby enabling scholars to focus more on analysis and interpretation Lau, & Hong, (2016) [7].

The role of digital technological libraries in supporting interdisciplinary research is also notable. By providing resources across diverse fields, digital libraries facilitate collaborative research efforts and the integration of knowledge from multiple disciplines Williams, & Taylor, (2020) [11].

This is particularly beneficial for institutions like Federal University Lokoja (FUL), where resource constraints often limit access to specialized physical materials. Moreover, digital libraries enable researchers to stay updated with the latest developments in their fields, ensuring that their work remains relevant and competitive Tashman, & Harris, (2017) [6].

Challenges in Utilizing Digital Technology Libraries. Despite their advantages, the effective utilization of digital libraries faces several challenges, particularly in resource-constrained settings Abraham, & Mansur, (2019) [8]. One of the primary barriers is limited awareness among users. Many students and faculty members are either unaware of the resources available or lack the technical skills needed to navigate digital library platforms. A study by Adeyemi and Ojo (2019) [2] found that inadequate training programs for users significantly reduce the impact of digital libraries on academic performance.

Evaluating the impact of digital technology libraries on research output is a complex task, given the multifaceted nature of academic productivity. Traditional metrics, such as publication rates or citation counts, provide valuable insights but fail to capture the nuanced relationship between library usage and research outcomes. For instance, a researcher's ability to access relevant materials may enhance their theoretical framework without immediately translating into a publication Johnson, & Burns, (2017) [9].

Bayesian inference, in particular, offers a robust approach to assessing the effectiveness of digital libraries. Unlike traditional statistical methods, Bayesian inference incorporates prior knowledge into the analysis, allowing for a more comprehensive understanding of the relationships between variables. For example, if prior research indicates that frequent library users are more likely to publish high-quality work, Bayesian models can integrate this information with new data to refine predictions, Raju, & Dlamini, (2018) [10].

Bayesian Inference in Evaluating Digital Technology Library Systems. Bayesian inference has been successfully applied in various fields to model complex relationships and evaluate systems' effectiveness Allard, & Thornton, (2017) [13]. In the context of digital libraries, it can be used to analyze how factors such as user engagement, resource availability, and access frequency contribute to research output. Bayesian models offer several advantages: they handle missing data effectively, account for uncertainty, and provide intuitive results that can inform decision-making, Zhang, & Zhang, (2019) [12].

3. Methodology/Materials

The study adopts a quantitative research design, incorporating both descriptive and inferential statistical techniques to assess the impact of digital library usage on academic productivity. By combining prior knowledge with new data, Bayesian methods will allow for a more accurate and robust analysis of the relationship between library system usage and research outcomes.

Study area and population was conducted at Federal University Lokoja, located in Kogi State, Nigeria. Established in 2011, FUL offers a range of undergraduate and postgraduate programs. The population for this study consists of both students and faculty members who utilize the digital library

resources provided by the university. This population is chosen because of their direct interaction with the digital library systems, which play a key role in supporting academic and research activities.

Sample size and sampling technique was sample size of 350 participants will be selected using stratified random sampling to ensure representation across different faculties and academic levels. Stratified sampling is ideal in this case, as it allows for capturing diverse user experiences with the digital library system, whether in terms of frequency of usage, resource accessibility, or research output. The sample will include 250 students and 100 faculty members to adequately capture the experiences and academic outputs from both groups.

Primary data was collected through a structured questionnaire designed to assess the usage patterns of the digital library, the perceived effectiveness of the system, and the correlation between library usage and research output.

The questionnaire will be divided into three sections:

Demographic information: This section will gather data on the participants' age, gender, faculty, academic level, and research experience.

Digital library usage: This section will measure the frequency of digital library use, the types of resources accessed (e.g., e-books, journals, research databases), and the participants' satisfaction with the library services.

Research output: This section will gather information on research output, such as the number of publications, conference presentations, and research projects completed. It will also assess the perceived impact of digital library resources on the quality and quantity of research conducted.

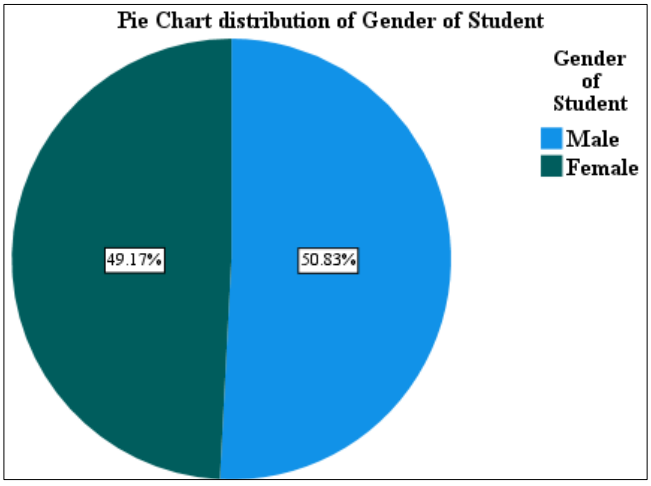
The questionnaire will be administered online and in-person to ensure a high response rate, and participants will be asked to answer honestly and anonymously to encourage truthful responses.

4. Analysis

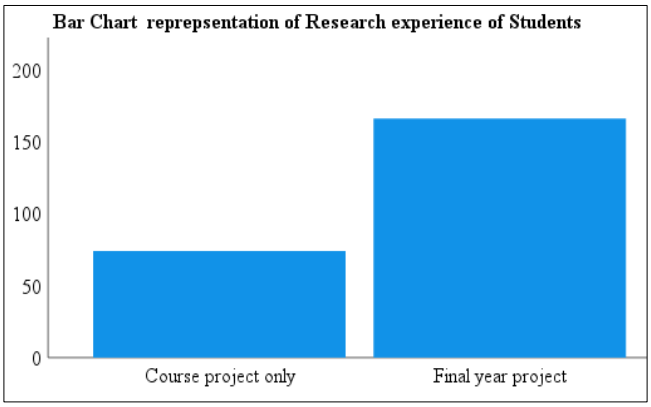
The data was analyzed using both descriptive and inferential statistics. Descriptive statistics, such as frequencies, percentages, and means, will be used to summarize the demographic characteristics of the participants and their responses to questions regarding library usage and research output.

For the inferential analysis, Bayesian inference will be used to model the relationship between digital library usage and research productivity. Bayesian methods allow for incorporating prior knowledge or existing research on the subject, improving the accuracy of the findings. Specifically, Bayesian regression models will be used to estimate the effects of factors such as the frequency of digital library use, the types of resources accessed, and user satisfaction on research output. This probabilistic approach will enable the study to account for uncertainty and make more nuanced conclusions about the factors influencing research success.

Demography analysis



This pie chart distribution among the 240 respondents, with males constituting the highest percentage (50.83%) while females for 49.17% of the sample. This balanced representation indicates that both male and female in the department have equal access to digital library. The study recorded a near-equal engagement with the digital library system.



The bar chart distribution reveals that the majority of students that participated in the research (170) were final year project students, this dominance of final year students is highly significant to the study, as these students are the most active users of the digital library system and have the most direct experience with its impact on research output.

Objective 1

To evaluate the relationship between digital technology library usage and research output among students of department of biotechnology, Federal University Lokoja.

Bayesian estimate of coefficient

Parameter	Posterior		
	Mode	Mean	Variance
(Intercept)	2.935	2.935	.019
Research Output	.017	.017	.002

Hypothesis statement

H_0: There is no significant relationship between digital technology library usage and research output among Biotechnology students.

H_1: There is a significant relationship between digital technology library usage and research output among Biotechnology students.

Test Statistic: Bayesian Linear Regression

(P/mean) = **0.017** (Intercept) = **2.935** (σ^2_e) = **0.224**

Level of significance

$\alpha = 0.05$

Decision rule

If the posterior mean > 0, there is evidence in support of alternative hypothesis if otherwise, the data provides evidence in support of H_0.

Conclusion

Since the posterior mean is 0.017 confirms that a positive relationship exists between digital technology library usage and research output among Biotechnology students at Federal University Lokoja, supporting the alternative hypothesis. Even though the effects is little tells us that the digital library system is moving in the right direction.

Objective 2

To identify the key challenges associated with the use of digital technology library systems at Federal University Lokoja.

Factros	Posterior		
	Mode	Mean	Variance
Lack of technical support	3.1458	3.1458	.009
Internet connectivity	3.1458	3.1458	.009
Difficulty in navigating the platform	2.9042	2.9042	.008

Hypothesis statement

H_0: There is no significant challenge associated with the use of digital technology library systems among Biotechnology students.

H_1: There is a significant challenge associated with the use of digital technology library systems among Biotechnology students.

Test Statistic: Bayesian One-Sample Mean

Level of significance

$\alpha = 0.05$

Decision rule

If the posterior mean > 3.0 there is evidence in support of H_1 that the challenge is significant; if the posterior mean ≤ 3.0, the data provides evidence in support of H_0.

Conclusion

The Bayesian analysis confirms that lack of technical support and poor internet connectivity are the two most significant challenges facing Biotechnology students in their use of the digital library system with both recording posterior means of (3.1458) exceeding the neutral of 3.0.

Difficulty in navigating the digital library platform, while still a concern, recorded a posterior mean of (2.9042) which falls slightly below the neutral, indicating it is a less dominant barrier compared to the infrastructure and support challenges. The result of the analysis shows that students are willing to use the digital library but are being stopped by factors outside their control.

Objective 3

To apply Bayesian inference in analyzing the effectiveness of digital library systems on research output

Parameter	Posterior		
	Mode	Mean	Variance
(Intercept)	2.851	2.851	.046
Library usage	.028	.028	.005

Hypothesis statement

H_0: There is no significant effect of digital library systems on research output among Biotechnology students.

H_1: There is a significant effect of digital library systems on research output among Biotechnology students.

Test Statistic: Bayesian Linear Regression

(Library Usage) = 0.028 (Intercept) = 2.851

Level of significance

$\alpha = 0.05$

Decision rule

If the posterior mean > 0, there is evidence in support of alternative hypothesis if otherwise, the data provides evidence in support of H_0.

Conclusion

The posterior mean of 0.028 confirms that digital library systems have a positive effect on research output among Biotechnology students, supporting H_1. The effect is small but meaningful, indicating that the digital library is contributing positively to research output but is limited by barriers such as poor internet connectivity and inadequate training. Every unit increase in library usage produces a 0.028-unit improvement in research effectiveness.

Objective 4

To propose recommendations for optimizing digital library systems to enhance research output

- The university should urgently invest in improving internet infrastructure across campus, as poor connectivity was identified as the most significant problem preventing

students from effectively utilizing the digital library system for research purposes.

- The university should establish a dedicated technical support unit specifically for the digital library system, addressing the equally significant challenge of lack of technical support that is currently limiting student engagement with the library.
- The university should implement mandatory digital library orientation and training programs for all students, particularly final year project students who represent the majority of library users and have the most direct need for research resources.
- Library administrators should improve the navigability and user interface of the digital library platform, as difficulty in navigation was identified as an additional hinderance reducing the quality of student library usage.
- Institutional policies should be developed to monitor and evaluate digital library usage patterns regularly, using evidence-based approaches such as Bayesian inference to track improvements.

5. Discussion

The bar chart distribution reveals that the majority of students that participated in the research (170) were biotechnology final year project students. This dominance of final year students is highly significant to the study, as these students are the most active users of the digital library system and have the most direct experience with its impact on research output.

Since the posterior mean confirms that a positive relationship exists between digital technology library usage and research output among Biotechnology students at Federal University Lokoja, supporting the alternative hypothesis. Even though the effects is little tells us that the digital library system is moving in the right direction.

The Bayesian analysis confirms that lack of technical support and poor internet connectivity are the two most significant challenges facing Biotechnology students in their use of the digital library system with both recording posterior means of (3.1458) exceeding the neutral of 3.0.

Difficulty in navigating the digital library platform, while still a concern, recorded a posterior mean of (2.9042) which falls slightly below the neutral, indicating it is a less dominant barrier compared to the infrastructure and support challenges. The result of the analysis shows that that students are willing to use the digital library but are being stopped by factors outside their control.

The posterior mean of 0.028 confirms that digital library systems have a positive effect on research output among Biotechnology students, supporting H_1. The effect is small but meaningful, indicating that the digital library is contributing positively to research output but is limited by barriers such as poor internet connectivity and inadequate training. Every unit increase in library usage produces a 0.028 unit improvement in research effectiveness.

6. Conclusion

In conclusion, some recommendation includes: The university should implement mandatory digital library orientation and training programs for all students, particularly final year project students who represent the majority of library users and have the most direct need for research resources. Library administrators should improve the navigability and user interface of the digital library platform, as difficulty in navigation was identified as an additional hinderance reducing the quality of student library usage. Institutional policies should be developed to monitor and evaluate digital library usage patterns regularly, using evidence-based approaches such as Bayesian inference to track improvements.

7. Weakness and Future research

This study provides valuable insights into the effectiveness of digital technology on degree project output of students of biotechnology; it is important to note that certain limitations may arise. These include potential biases in self-reported data, as participants may overestimate or underestimate their library usage or research productivity. Additionally, the study will focus on a single department, single university, limiting the generalizability of the findings to other institutions. This study is restricted to federal university Lokoja. Increasing the scope and frame to extend to other institutions in Nigeria can be a full study.

8. Authors contributions

All authors contributed immensely in the aspect of technical writing.

9. Acknowledgment

The authors thank the Federal University Lokoja and tertiary education trust fund (Tetfund) that makes resource material available to perfect this article.

10. Ethics

This is the original manuscript; there will be no expectation of any ethical problems. Ethical approval for this study will be sought from the relevant institutional review board at Federal University Lokoja. Participation will be voluntary, and informed consent will be obtained from all participants. The study will ensure confidentiality and anonymity of responses, with all data used strictly for research purposes. Participants will have the right to withdraw from the study at any point without consequence.

References

1. Liu X, *et al*. Exploring the impact of ICT on educational administration. Educ Sci. 2025;15(9):1114.
2. Adeyemi M, Ojo M. Digital library systems in Nigerian universities: challenges and opportunities for academic development. J Inf Knowl Manag. 2019;9(1):56–67.
3. Onwuegbuzie AJ, Wilson VA. The impact of digital libraries on research output: a review of literature. Inf Technol Libr. 2018;37(4):34–50.

4. Kumar S, Goudar RH. Assessing the role of digital libraries in academic research: a case study of university systems in Nigeria. Libr Philos Pract. 2020;2020(1):1–14.
5. Adeyemi A, Ibrahim S. Digital library services and research productivity in Nigerian universities: an assessment of Federal University Lokoja's library system. J Acad Librariansh. 2018;44(3):345–52.
6. Tashman E, Harris M. Utilizing Bayesian inference in academic research productivity analysis. J Quant Res. 2017;8(2):117–30.
7. Lau J, Hong F. Barriers to digital library adoption in higher education: an exploration of issues in developing countries. Educ Inf Technol. 2016;21(3):567–86.
8. Abraham K, Mansur B. The role of digital libraries in supporting interdisciplinary research: a case study of Nigerian higher education institutions. Inf Res. 2019;24(4):45–63. Available from: http://www.informationr.net
9. Johnson P, Burns R. Evaluating the effectiveness of digital libraries in promoting academic success: a Bayesian approach. J Educ Technol Syst. 2017;45(2):115–30.
10. Raju R, Dlamini S. The impact of digital library systems on research output in universities: a Nigerian perspective. Afr J Libr Arch Inf Sci. 2018;28(1):67–78.
11. Williams R, Taylor H. Optimizing digital library access to enhance academic and research performance. J Acad Inf Syst. 2020;35(1):23–35.
12. Zhang X, Zhang H. Understanding the impact of digital libraries on research productivity: a Bayesian analysis. J Res Eval. 2019;28(3):45–59.
13. Allard JD, Thornton R. Barriers to effective use of digital libraries in higher education: a case study of Nigerian universities. Libr Manag. 2017;38(1):24–41.