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# Smart Technology Adoption and Data Analytics as Predictors of Service Innovation Among Academic Librarians in the Philippines

Mary Rose V. Navarro[1*]; Ma. Lindie D. Masalinto[2]

[12]University of Perpetual Help System Laguna, Philippines

ORCiD: [1]https://orcid.org/0009-0009-5422-9293; [2]https://orcid.org/0000-0002-6732-4179

Corresponding Author: Mary Rose V. Navarro[1*]

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**Abstract: Academic libraries are undergoing significant transformation as digital innovations reshape service delivery and user engagement. This study examined how smart technology adoption and data analytics utilization predict service innovation practices among academic libraries in the Philippines. It also explored the relationships among these variables and their combined influence on service innovation. A descriptive-correlational design was utilized, involving 242 academic librarians selected through purposive sampling. Data were collected using a validated survey instrument and analyzed using correlation and multiple regression techniques. The findings indicate that automation tools are highly adopted, while artificial intelligence (AI) and Internet of Things (IoT) applications remain at a developing stage. Data analytics utilization is very high, particularly in understanding user behavior, improving services, and supporting collection decisions. Significant positive relationships were found among smart technology adoption, data analytics utilization, and service innovation practice. Regression results further revealed that both smart technology adoption and data analytics significantly predict service innovation, demonstrating their combined role in enhancing library services. The study concludes that while Philippines academic libraries are progressing toward more technology-driven environments, further advancement in emerging technologies is needed. The findings provide insights for strategic planning and highlight the importance of integrating technological and analytical capabilities to strengthen innovation in academic libraries. The study also contributes to broader development goals by supporting the advancement of adaptive, inclusive, and data-informed library services.**

***Keywords:*** *Smart Library Systems, Analytical Data Practices, Library Service Innovation, Academic Librarians, Philippine Higher Education Institutions.*

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## I. INTRODUCTION

Academic libraries are experiencing continuous transformation as digital technologies reshape how information is created, accessed, and delivered. The emergence of smart technologies has introduced new approaches to library services through the integration of tools such as artificial intelligence (AI), the Internet of Things (IoT), big data analytics, and cloud computing. These developments enable libraries to improve operational efficiency, enhance user experience, and deliver more responsive and innovative services. As noted by Naikar and Paul (2025), smart libraries integrate traditional systems with digital innovations to streamline processes such as circulation, inventory management, and user support. Similarly, Smith (2023) emphasized that modern libraries are evolving toward proactive and personalized services supported by intelligent and predictive systems.

Beyond operational improvements, smart libraries also contribute to broader institutional and societal goals. The integration of emerging technologies can promote inclusivity, sustainability, and community engagement (Swetha & Kumar, 2024). However, challenges remain, particularly in terms of infrastructure limitations, privacy concerns, and digital inequalities (Tella et al., 2025). These issues highlight that the development of smart libraries is not only a technological shift but also an organizational and ethical concern requiring strategic planning and resource allocation.

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In the Philippine context, academic libraries are gradually adopting advanced technologies, although implementation varies across institutions. Studies have shown that tools such as augmented reality can enhance user engagement, while artificial intelligence is gaining attention among librarians despite limitations in infrastructure and technical expertise (Esposo-Betan & Santos, 2018; De Leon et al., 2024). Other research indicates that although librarians recognize the value of these technologies, adoption is often constrained by limited training opportunities and institutional readiness (Paiste & Siago, 2024). These findings suggest a gap between technological potential and actual implementation within local academic libraries.

Alongside technological advancements, data analytics has become a critical component of modern library management. By analyzing user data and service performance, libraries can make informed decisions, optimize resources, and enhance service quality. Previous studies emphasize that analytics supports user-centered services, improves operational efficiency, and strengthens institutional value (Schimmel, 2024; Roy, 2025). In addition, data-driven approaches enable libraries to adapt to changing user needs and develop more targeted services.

Service innovation is equally essential in ensuring that libraries remain relevant in a rapidly evolving digital environment. Libraries are increasingly adopting new service models, improving internal processes, and implementing technologies that enhance user interaction and accessibility. These innovations include digital platforms, automated systems, and personalized services designed to meet diverse user expectations. The integration of technology and analytics plays a key role in enabling these developments and supporting continuous improvement in service delivery (Liu, 2021). Despite these developments, limited empirical studies have examined how smart technology adoption and data analytics utilization collectively influence service innovation in academic libraries, particularly in the Philippine context. Understanding these relationships is essential in strengthening the role of libraries as adaptive and innovation-driven institutions.

Hence, this study aimed to examine how smart technology adoption and data analytics utilization predict service innovation practices among academic libraries in the Philippines. Specifically, it determined the level of smart technology adoption, the extent of data analytics utilization, and the service innovation practices implemented across institutions. It also analyzed the relationships among these variables and evaluated the predictive effects of smart technology adoption and data analytics utilization on service innovation practices. The study further sought to generate empirical evidence to support strategies for strengthening technology integration, enhancing analytical capabilities, and advancing innovation in academic libraries.

In doing so, the study aligns with the United Nations Sustainable Development Goal (SDG) 9—Industry, Innovation, and Infrastructure, particularly Target 9.c, which aims to significantly increase access to information and communication technologies (ICTs) and expand digital infrastructure, especially in developing regions. It also contributes to SDG 4 (Quality Education) by supporting inclusive and improved access to learning resources, and to SDG 17 (Partnerships for the Goals) by encouraging collaboration, capacity building, and institutional innovation. This alignment underscores the study's contribution to fostering inclusive, resilient, and technologically empowered academic library services that advance innovation and promote equitable access to digital resources.

## II. METHODOLOGY

This study employed a descriptive–correlational research design to examine the adoption of smart library technologies, utilization of data analytics, and service innovation practices among academic libraries in the Philippines. A structured, self-administered questionnaire served as the primary data collection instrument, capturing data across three domains: smart technology adoption (automation tools, artificial intelligence applications, and Internet of Things integration), data analytics utilization (user behavior, service improvement, and collection development analytics), and service innovation practices. The study targeted members of the Philippine Association of Academic and Research Librarians, Inc. (PAARL), with a total population of 648 academic librarians. Using a 95% confidence level and 10% margin of error, a sample of 242 respondents was determined and selected through purposive sampling to ensure domain-specific expertise. The instrument underwent expert validation and demonstrated excellent internal consistency, with Cronbach's alpha coefficients of 0.974, 0.988, and 0.941 for the three constructs, respectively. Responses were measured using a standardized 4-point Likert scale.

Ethical standards were strictly observed, including the acquisition of institutional permission, informed consent, and assurances of confidentiality, anonymity, and voluntary participation. Data were collected via an online survey platform and subsequently encoded and processed for analysis. Descriptive statistics, including weighted mean and standard deviation, were used to assess the levels of technology adoption, analytics utilization, and service innovation. Inferential analyses comprised Pearson's product–moment correlation to determine the relationships among variables and multiple regression analysis to evaluate the predictive effects of smart library technology adoption and data analytics utilization on service innovation practices. All statistical analyses were conducted at an appropriate level of significance to ensure the robustness and reliability of the findings.

## III. RESULTS AND DISCUSSION

This section presents the results of the study and situates the findings within the context of existing literature. It examines the levels of smart library technology adoption, data analytics utilization, and service innovation practices, as well as the relationships and predictive effects among these variables. The results are analyzed using appropriate statistical techniques and are interpreted in relation to prior empirical studies.

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Table 1 Level of Adoption of Smart Library Technologies

| Scale | Domains | Weighted Mean | Standard Deviation | Interpretation |
|---|---|---|---|---|
| **Adoption of smart library technologies** | Automation tools | 3.43 | .649 | Highly Adopted |
| | AI applications | 2.89 | .862 | Adopted |
| | IoT integration | 3.15 | .848 | Adopted |
| **OVERALL** | | **3.16** | **.694** | **Adopted** |

Table 1 presents the level of adoption of smart library technologies in academic libraries in the Philippines. The results show that among the domains of smart library technologies, automation tools obtained the highest weighted mean of 3.43 (SD = .649), interpreted as highly adopted. This indicates that libraries have extensively implemented automation technologies, particularly in routine operations and service delivery. The high level of adoption suggests that automation tools are already well-established and widely integrated into library systems, making them the most mature and fully utilized among the three domains.

This is followed by IoT integration, which obtained a weighted mean of 3.15 (SD = .848), interpreted as adopted. This result indicates that libraries have moderately adopted IoT technologies, particularly in areas such as materials tracking, security, and infrastructure management. Although IoT is already present in library operations, its level of adoption is not yet as extensive as automation tools, suggesting that libraries are still in the process of expanding and optimizing its use.

On the other hand, AI applications received the lowest weighted mean of 2.89 (SD = .862), also interpreted as adopted. This indicates that while libraries have begun integrating artificial intelligence into their services, its implementation remains at a developing stage. The relatively lower mean suggests that AI technologies are not yet fully embedded in library operations and may still be limited to specific functions or pilot initiatives.

To sum up, academic librarians in the Philippines adopted the smart library technologies, with an average weighted mean of 3.16 (SD = 0.694). These findings suggest that academic libraries in the Philippines have moderately embraced smart technologies, with strong adoption in automation tools, while IoT integration and AI applications are still progressing toward higher levels of implementation.

Rahman et al. (2025) emphasized that automation technologies are among the most widely adopted innovations in libraries, particularly in routine operations. Similarly, Neamatollahi and Danesh (2026) highlighted that while AI technologies are being explored in libraries, their adoption remains at an emerging stage. Furthermore, Hazarika (2025) noted that IoT technologies are increasingly applied in areas such as tracking and monitoring, but their implementation is still evolving, which supports the moderate adoption of IoT integration. In addition, Li et al. (2025) found that libraries tend to adopt technologies progressively, with automation leading, followed by IoT and AI, reinforcing the pattern observed in the present findings.

In contrast, Jabeen (2025) reported that advanced libraries have already achieved a high level of adoption across automation, IoT, and AI technologies, with these systems fully integrated into library operations. This discrepancy may be due to differences in technological infrastructure, funding, and institutional readiness, which influence the extent to which libraries can adopt advanced smart technologies.

Table 2 Level of Adoption of Smart Library Technologies

| Scale | Domains | *Weighted Mean* | *Standard Deviation* | Interpretation |
|---|---|---|---|---|
| **Utilization of data analytics** | User behavior analytics | 3.43 | .631 | Very High Utilization |
| | Service improvement analytics | 3.47 | .611 | Very High Utilization |
| | Collection development analytics | 3.40 | .661 | Very High Utilization |
| **OVERALL** | | **3.43** | **.604** | **Very High Utilization** |

Table 2 presents the level of utilization of data analytics in Philippine academic libraries across three domains. The findings reveal that service improvement analytics obtained the highest weighted mean of 3.47 (SD = .611), interpreted as very high utilization. This indicates that libraries most extensively use data analytics in evaluating services, guiding improvements, and supporting evidence-based decision-making. The result suggests that data-driven approaches are strongly embedded in efforts to enhance service quality and performance.

This is followed by user behavior analytics, which obtained a weighted mean of 3.43 (SD = .631), also interpreted as very high utilization. This indicates that libraries highly utilize analytics to understand user needs, preferences, and usage patterns. The strong utilization in this domain suggests that libraries place significant importance on analyzing user behavior to inform service planning and improve user experience.

On the other hand, collection development analytics obtained the lowest weighted mean of 3.40, (SD = .661), although still interpreted as very high utilization. This indicates that while data analytics is extensively used in managing and developing library collections, it is slightly less emphasized compared to service improvement and user behavior analytics. Nonetheless, the result still reflects a strong reliance on analytics in guiding collection-related decisions and ensuring alignment with user needs and institutional goals.

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Overall, academic librarians in the Philippines very highly utilized the data analytics in libraries with an average weighted mean of 3.43 (SD = 0.604). This reflects that academic libraries in the Philippines extensively use data analytics user behavior analytics, service improvement analytics and collection development analytics, demonstrating a strong commitment to data-driven decision-making, service enhancement, and effective resource management.

The findings corroborate the studies of Abas and Mustapha (2025) which emphasized that data analytics plays a critical role in assessing library performance and improving services. Similarly, Marzuki et al. (2025) highlighted that understanding user behavior through data is essential for designing responsive and user-centered library services. Mojjada and Aakundi (2025) also noted that data-driven practices are increasingly adopted in libraries to support decision-making and improve service quality across multiple domains. Furthermore, Sharma (2025) found that libraries widely use analytics to evaluate services, enhance operations, and justify decisions.

However, Garoufallou and Gaitanou (2021) reported that although libraries recognize the importance of data analytics, challenges such as limited expertise, inadequate tools, and data management issues may hinder its full utilization across all domains. Likewise, Aryee and Tetteh (2024) noted that not all libraries are able to consistently apply analytics in practice due to organizational and resource constraints. These contrasting findings suggest that while very high utilization is evident in this study, some libraries may still encounter barriers in fully maximizing data analytics across all functional areas.

Table 3 Service Innovation Practices Implemented by Philippine Academic Libraries

| Indicators | Weighted Mean | Standard Deviation | Interpretation |
|---|---|---|---|
| 1. The library has implemented automated self-service systems such as, self-checkout or automated returns. | 2.90 | 1.065 | Agree |
| 2. AI-based virtual assistance such as, chatbots or automated reference tools is implemented in the library. | 2.93 | .998 | Agree |
| 3. IoT-enabled systems such as, RFID and smart shelves are implemented for tracking and managing library materials. | 2.95 | 1.065 | Agree |
| 4. Smart access or monitoring technologies are implemented to manage library spaces or facilities. | 3.13 | .973 | Agree |
| 5. Integrated digital platforms are implemented to deliver library services. | 3.27 | .870 | Strongly Agree |
| 6. User behavior analytics are implemented to support service planning and innovation. | 3.30 | .775 | Strongly Agree |
| 7. Service performance data are analyzed to guide service improvements. | 3.36 | .772 | Strongly Agree |
| 8. Data analytics are implemented to support evidence-based service decisions. | 3.35 | .759 | Strongly Agree |
| 9. Usage analytics are implemented to evaluate the effectiveness of library services. | 3.39 | .733 | Strongly Agree |
| 10. Analytics reports are implemented as part of regular service assessment activities. | 3.30 | .777 | Strongly Agree |
| 11. Digital systems are implemented to streamline library service workflows. | 3.31 | .810 | Strongly Agree |
| 12. Automated processes are implemented to reduce service turnaround time. | 3.34 | .860 | Strongly Agree |
| 13. Technology-supported procedures are implemented to standardize service delivery. | 3.38 | .766 | Strongly Agree |
| 14. Online service transactions are implemented to extend library service access. | 3.37 | .836 | Strongly Agree |
| 15. Revised service processes are implemented across library service units. | 3.38 | .744 | Strongly Agree |
| 16. Digital services are implemented to improve user interaction with the library. | 3.36 | .788 | Strongly Agree |
| 17. Personalized services are implemented using technology-based tools. | 3.32 | .786 | Strongly Agree |
| 18. User feedback mechanisms are implemented to support service redesign. | 3.45 | .756 | Strongly Agree |
| 19. Mobile or web-based services are implemented to enhance user access. | 3.35 | .782 | Strongly Agree |
| 20. Technology-enabled services are implemented to support user learning and research. | 3.42 | .726 | Strongly Agree |
| **Average Weighted Mean** | **3.28** | **.730** | **Strongly Agree** |

Table 3 presents the service innovation practices implemented by Philippine academic libraries. The findings revealed that among the practices, the implementation of user feedback mechanisms to support service redesign appears to be the most evident (WM = 3.45), indicating that libraries highly value user input in improving and refining their services. This is followed by the implementation of technology-enabled services to support user learning and research (WM = 3.42), suggesting that libraries actively

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integrate technologies that enhance academic engagement and learning experiences.

Several other practices are also strongly implemented, including the use of usage analytics to evaluate the effectiveness of library services (WM = 3.39), the adoption of technology-supported procedures to standardize service delivery (WM = 3.38), and the implementation of revised service processes across library service units (WM = 3.38), all interpreted as strongly agree. These findings indicate that libraries are committed to continuous service improvement and standardization through the use of data and technology. Additionally, the implementation of online service transactions (WM = 3.37), digital services to improve user interaction (WM = 3.36), and the analysis of service performance data to guide service improvements (WM = 3.36), all interpreted as strongly agree, further demonstrate the integration of digital and data-driven approaches in enhancing library services.

Moreover, practices such as mobile or web-based services (WM = 3.35), data analytics to support evidence-based service decisions (WM = 3.35), and automated processes to reduce service turnaround time (WM = 3.34), all interpreted as strongly agree, highlight efforts to improve accessibility and operational efficiency. The implementation of personalized services using technology-based tools (WM = 3.32) and digital systems to streamline workflows (WM = 3.31), also interpreted as strongly agree, indicates the adoption of user-centered and efficient service delivery strategies.

On the other hand, some practices, while still implemented, are less evident compared to others. These include the use of smart access or monitoring technologies (WM = 3.13), IoT-enabled systems such as RFID and smart shelves (WM = 2.95), AI-based virtual assistance tools (WM = 2.93), and automated self-service systems (WM = 2.90), all interpreted as agree. This suggests that although these advanced technologies are present in libraries, their implementation may still be developing and not yet as widespread as other service innovation practices.

Overall, the Philippine academic libraries fully implemented the service innovation practices (WM= 3.28, SD = 0.730). This indicates that academic libraries in the Philippines are actively implementing various innovative practices, particularly those related to user engagement, digital services, and data-driven decision-making, while more advanced technologies such as AI, IoT, and self-service systems are still in the process of wider adoption.

Desmarchelier et al. (2024) emphasized that user-centered and evidence-based approaches are essential in driving innovation in library services, which supports the strong implementation of feedback mechanisms and analytics in this study. Similarly, Hotsonyame (2025) highlighted that academic libraries are increasingly adopting innovative practices such as digital services and user engagement strategies to enhance service delivery. Ku et al. (2025) also noted that assessment and data use are critical in improving library services and demonstrating value, reinforcing the strong use of analytics observed in the findings. Furthermore, Wan (2024) found that libraries are expanding their use of digital technologies and online platforms to meet evolving user needs. In addition, Adewojo et al. (2025) emphasized that the integration of emerging technologies such as AI and data analytics contributes to the continuous innovation of library services.

Table 4 Relationship Between the Level of Adoption of Smart Library Technologies and Level of Utilization of Data Analytics in Philippine Academic Libraries

| Independent | Dependent | Pearson's $r^a$ | *p*-value | Interpretation |
|---|---|---|---|---|
| Adoption of smart library | Utilization of data analytics | .735 (strong) | < .001 | Significant |
| Significant @ .05 | | | | |

Table 4 presents the relationship between the level of adoption of smart library technologies and the level of utilization of data analytics in Philippine academic libraries. The findings revealed that the Pearson's r value of .735 indicates a strong positive correlation between the two variables. This suggests that there is a strong relationship between the level of adoption of smart library technologies and the level of utilization of data analytics.

Meanwhile, the obtained p-value was less than .001, which is lower than the level of significance set at 0.05. This demonstrates that there is sufficient statistical evidence to reject the null hypothesis. Hence, there is a significant relationship between the respondents' level of adoption of smart library technologies and their level of utilization of data analytics.

This means that the higher the level of adoption of smart library technologies, the higher the level of utilization of data analytics in libraries. It implies that the integration of advanced technologies enhances the ability of academic libraries to collect, manage, and analyze data effectively. As a result, academic libraries are better able to support data-driven decision-making, improve service delivery, and optimize resource management.

The study of Khan et al. (2023) supports this finding, as it emphasized that the adoption of advanced technologies in academic libraries strengthens their capability to implement data analytics and improve overall library services. Similarly, Masenya (2023) found that the integration of emerging technologies facilitates the effective use of data analytics in library operations. Moreover, Dione and Rajaratnam (2025) highlighted that technological infrastructure plays a vital role in enabling analytics-driven practices in libraries. Furthermore, Tawalbeh et al. (2024) noted that technology adoption supports evidence-based decision-making and enhances the use of data in library management.

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In contrast, some studies offer a different perspective. For instance, Qazi and Pachler (2024) argued that the presence of technology alone does not guarantee effective utilization of data analytics, as factors such as staff expertise, organizational culture, and data management practices significantly influence its application. Likewise, Rafiq et al. (2024) pointed out that some libraries struggle to fully utilize analytics tools despite having technological capabilities due to limited training and institutional support. These contrasting findings suggest that while a strong relationship exists, the effective utilization of data analytics may still depend on additional organizational and human factors.

Table 5 Relationship Between the Level of Adoption of Smart Library Technologies and Service Innovation Practices Implemented by Philippine Academic Libraries

| Independent | Dependent | Pearson's $r^a$ | *p*-value | Interpretation |
|---|---|---|---|---|
| Adoption of smart library | Service innovation practices | .776 (strong) | <.001 | Significant |
| Significant @ .05 | | | | |

Table 5 shows the relationship between the level of adoption of smart library technologies and the service innovation practices implemented by Philippine academic libraries. The findings revealed that, the Pearson's r value (r = 0.776) indicates a strong positive correlation between the two variables. This suggests that there is a strong relationship between the level of adoption of smart library technologies and the implementation of service innovation practices.

Meanwhile, the obtained p-value ($p < 0.001$) is lower than the level of significance set at 0.05. This refelcts that there is sufficient statistical evidence to reject the null hypothesis. Hence, there is a significant relationship between the respondents' level of adoption of smart library technologies and their service innovation practices.

This means that the higher the level of adoption of smart library technologies, the more extensive the implementation of service innovation practices in libraries. It implies that the integration of advanced technologies enables academic libraries to introduce new services, improve existing processes, and enhance overall service delivery. As academic libraries adopt more smart technologies, they become better equipped to implement innovative practices that respond to users' evolving needs and expectations.

The study of Kalota et al. (2025) examined the role of emerging technologies in academic libraries and found that technology adoption drives the transformation of traditional services into more innovative and user-focused offerings. Similarly, Cheung et al. (2023) investigated the impact of digital technologies on library services and reported that these technologies enable libraries to expand and enhance their service delivery. Rahman et al. (2025) also focused on technology adoption in libraries and found that it supports the development of user-centered and innovative service models. Moreover, Zhou (2025) explored the integration of advanced technologies in libraries and concluded that such integration promotes continuous service innovation.

Conversely, some studies present a different perspective. For instance, Shonubi (2025) examined factors influencing innovation in libraries and found that innovation is not solely dependent on technology but is also shaped by organizational culture, leadership, and collaboration. Similarly, Adigun et al. (2024) studied service innovation in libraries and emphasized that it requires strategic planning and user-centered management, not just technological advancement. These contrasting findings suggest that while technology adoption significantly contributes to innovation, other institutional and managerial factors also play a crucial role in the successful implementation of service innovation practices.

Table 6 Relationship Between the Level of Utilization of Data Analytics in Libraries and Service Innovation Practices Implemented by Philippine Academic Libraries

| Independent | Dependent | Pearson's $r^a$ | *p*-value | Interpretation |
|---|---|---|---|---|
| Utilization of data analytics | Service innovation practices | .772 (strong) | < .001 | Significant |
| Significant @ .05 | | | | |

Table 6 presents the relationship between the level of utilization of data analytics in libraries and the service innovation practices implemented by Philippine academic libraries. The findings revealed that, the Pearson's r value (r = 0.772) indicates a strong positive correlation between the two variables. This suggests that there is a strong relationship between the level of utilization of data analytics and the implementation of service innovation practices.

Meanwhile, the obtained p-value ($p < 0.001$) is lower than the level of significance set at 0.05. The results imply that there is sufficient statistical evidence to reject the null hypothesis. Hence, there is a significant relationship between the respondents' level of utilization of data analytics and their service innovation practices.

This means that the higher the level of utilization of data analytics, the more extensive the implementation of service innovation practices in libraries. It implies that the effective use of data analytics enables libraries to identify user needs, evaluate services, and develop innovative solutions that enhance service delivery. As libraries increasingly utilize data analytics, they become better able to support evidence-based innovations and continuously improve their services.

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Complementing the findings, Nahotko et al. (2022) emphasized that data-driven assessment plays a crucial role in improving and innovating library services. Similarly, Shah et al. (2024) highlighted that the use of data analytics enables libraries to develop user-centered and evidence-based service innovations. Moreover, Ikwuanusi et al. (2023) noted that analytics-driven practices contribute to improved decision-making and innovation in library management. Furthermore, Kishore (2025) found that the utilization of data analytics enhances the ability of libraries to implement innovative and responsive services.

Conversely, some studies provide a different viewpoint. For instance, Okorie et al. (2024) argued that the increasing reliance on data does not always lead to meaningful innovation, as challenges related to data interpretation, quality, and ethical considerations may limit its effectiveness. In a similar vein, Sajja et al. (2025) emphasized that data analytics alone cannot fully capture user behavior and contextual factors, which may affect the accuracy of data-driven decisions. These contrasting findings suggest that while data analytics significantly supports service innovation, its effectiveness may still depend on how data are interpreted and applied within the library context.

Table 7 Model Summary of the Combined Predictive Power of the Level of Adoption of Smart Library Technologies and Level of Utilization of Data Analytics in Libraries on the Service Innovation Practices Implemented by Philippine Academic Libraries

| Model | $R^2$ | Adj. $R^2$ | $F$ | df | $p$-value | Interpretation |
|---|---|---|---|---|---|---|
| 1 | .691 | .688 | 267.279 | 2, 239 | <.001 | Significant |

- Predictors: (Constant) Adoption of smart library technologies, utilization of data analytics; Dependent Variable: Service innovation practices.

Table 7 presents the model summary of the combined predictive power of the level of adoption of smart library technologies and the level of utilization of data analytics in libraries on service innovation practices implemented by Philippine academic libraries.

The results indicate that the regression model is statistically significant ($F(2, 239) = 267.279$, $p < .001$), demonstrating that the set of predictors collectively provides a strong explanation of service innovation practices. This confirms that the model fits the data significantly better than a model with no predictors.

The coefficient of determination ($R^2 = .691$) shows that 69.10% of the variance in service innovation practices is explained by the level of adoption of smart library technologies and the level of utilization of data analytics. This reflects a strong level of explanatory power, suggesting that these factors play a substantial role in influencing the implementation of service innovation practices in libraries. The adjusted $R^2$ value (.688) further indicates that the model remains robust even after accounting for the number of predictors included. This suggests minimal inflation of the explained variance and supports the stability and reliability of the model.

Taken together, the findings reveal that both the level of adoption of smart library technologies and the level of utilization of data analytics jointly influence service innovation practices. Consequently, the null hypothesis stating that these variables have no significant effect on service innovation practices is rejected.

These findings are supported by several studies. For instance, Hamad et al. (2022) emphasized that the integration of advanced technologies and data analytics significantly enhances innovation and service development in libraries. Similarly, Wünderlich et al. (2025) found that the combined use of emerging technologies and analytics contributes to improved service design and delivery. Saura et al. (2021) also highlighted that data-driven and technology-supported environments strengthen decision-making processes and foster innovation in library services. Furthermore, Mojjada and Aakundi (2025) noted that the integration of technological tools and analytics supports evidence-based practices and continuous service improvement in libraries.

Table 8 Predictive Power of the Level of Adoption of Smart Library Technologies and Level of Utilization of Data Analytics in Libraries on the Service Innovation Practices Implemented by Philippine Academic Libraries

| Predictors | B | SE | Beta (β) | $p$-value | Decision | Interpretation |
|---|---|---|---|---|---|---|
| Adoption of smart library technologies | .478 | .056 | .454 | <.001 | Reject $H_0$ | Significant |
| Utilization of data analytics | .530 | .064 | .439 | <.001 | Reject $H_0$ | Significant |

Dependent Variable: Service innovation practices

Table 8 presents the multiple regression results examining the predictive power of the level of adoption of smart library technologies and the level of utilization of data analytics in libraries on service innovation practices implemented by Philippine academic libraries.

The results suggest that the level of adoption of smart library technologies has a significant and positive predictive effect on service innovation practices ($\beta = .454$, $p < .001$), since the p-value is less than the significance level of .05. This suggests that libraries with higher levels of technology adoption tend to implement more service innovation practices. Moreover, for every one-unit increase in the level

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of adoption of smart library technologies, service innovation practices increase by .478 units. Thus, the null hypothesis for this variable is rejected.

Similarly, the level of utilization of data analytics also shows a significant and positive predictive effect on service innovation practices ($\beta = .439$, $p < .001$), as its p-value is likewise lower than the .05 level of significance. This indicates that increased utilization of data analytics contributes to greater implementation of service innovation practices in libraries. Furthermore, for every one-unit increase in the level of utilization of data analytics, service innovation practices increase by .530 units. Hence, the null hypothesis for this variable is also rejected.

Comparatively, the level of adoption of smart library technologies ($\beta = .454$) appears to be a slightly stronger predictor than the level of utilization of data analytics ($\beta = .439$), although both variables significantly contribute to the model. This suggests that while both factors are important, technology adoption has a marginally greater influence on service innovation practices.

Overall, the findings reveal that both the level of adoption of smart library technologies and the level of utilization of data analytics are significant predictors of service innovation practices. This implies that the integration of advanced technologies, together with the effective use of data analytics, plays a crucial role in enhancing innovation in library services.

The findings corroborate the studies of Oduwole et al. (2023), which emphasized that greater adoption of emerging technologies facilitates innovation and transformation in academic library services, and Jiao et al. (2024), which underscored that the increased integration of digital technologies enhances service delivery and broadens innovative practices. They are further supported by Joergensen and Zaggl (2024), who emphasized that the combined use of advanced technologies and data analytics strengthens service development and innovation, and by Tara et al. (2024) who highlighted that a greater utilization of data analytics enhances decision-making and promotes innovation in library services. Moreover, these findings are consistent with Wheeler et al. (2022), who emphasized that the higher levels of technology adoption, when integrated with evidence-based approaches, result in more responsive and innovative library services.

## IV. CONCLUSIONS

This study concludes that Philippine academic libraries are progressing toward smart, data driven, and innovation-oriented environments. Smart library technologies are generally adopted, with automation tools highly integrated, while artificial intelligence and Internet of Things (IoT) applications remain in the developmental stage, indicating the need to further advancement in emerging technologies. Data analytics is extensively utilized, particularly in user behavior, service improvement, and collection development, reflecting a strong commitment to evidence-based decision-making and service optimization. Libraries also actively implement service innovation practices, especially in user-centered services, digital delivery, and data-driven approaches, although advanced technologies such as AI-and IoT systems are not yet fully institutionalized.

Significant positive relationships among smart technology adoption, data analytics utilization, and service innovation practices confirm their interdependence. Regression results further demonstrate that both smart library technologies and data analytics significantly predict service innovation. These findings highlight that the integration of technological and analytical capabilities is critical in enhancing innovative library services.

Hence, academic libraries are encouraged to strengthen investments in AI and IoT, institutionalize data-driven practices, and integrate smart technologies with analytics in strategic planning and service delivery. Capacity-building initiatives, infrastructure development, and policy support are also recommended to sustain innovation and ensure that academic libraries become more adaptive, responsive, and future-ready in the digital era.

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- *Competing Interests*

The authors declares that there are no financial or personal relationships that could have influenced the work reported in this study. The authors further confirm that no competing interests exist.

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