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Implementing Smart Shelves in Academic Libraries: A Case Study

Vikash Kumar Singh[1], Durga Sivashankar[2], Dr. Meeramani N[3], Lokesh Verma[4], Nikita C. Patel[5], Shamala R[6]

[1]Principle Software Engineer, Department of IT, Societe Generale India
vikashsd@gmail.com

[2]Technical Lead, Department of IT, Siemens Healthineers India,durga.sivashankar@yahoo.com

[3]Librarian, Department of Learning Resource Centre, JAIN (Deemed-to-be University), Bangalore, Karnataka, India,n.meeramani@jainuniversity.ac.in
Orcid Id- 0000-0002-0329-7474

[4]Centre of Research Impact and Outcome, Chitkara University, Rajpura- 140417, Punjab, India,lokesh.verma.orp@chitkara.edu.in,https://orcid.org/0009-0009-3032-3947

[5]Assistant Librarian, Parul Institute of Engineering and Technology, Parul University, Vadodara, Gujarat, India,nikita.patel2607@paruluniversity.ac.in
Orcid Id- 0009-0006-9330-6210

[6]Assistant Professor, Department of Psychology, JAIN Deemed- to -be University,
School of Sciences Bangalore, India,shamalarudrappa@gmail.com
shamala.r@jainuniversity.ac.in,https://orcid.org/0009-0009-2152-1132"

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Abstract

The way college libraries have changed over time is very important for keeping up with the changing needs of modern study and teaching. This case study looks at how Smart Shelves were used in an academic library, focused on how they changed how the library worked, how users felt, and how data was managed. RFID (Radio Frequency Identification) technology is built into smart shelves to make inventory management easier, make the shelves safer, and give real-time information on where and how many books are available. In the university library of XYZ University, standard shelf systems were replaced with Smart Shelves over the course of six months for the study. Key goals included cutting down on the time libraries spend managing supplies, lowering the number of lost books, and making it easier for students and staff to find resources. Methodology included a study before and after the system was put in place. Data were gathered from library logs, user polls, and system performance measures. The results showed that inventory checks took 40% less time and books were lost 30% less often. User happiness polls showed that 85% of people said it was easy to find books, and the real-time access function was one of the best parts. The Smart Shelves system gave the library useful data analytics that helped them learn more about how people used the library and what they liked. This information was used to improve the library's speed and service quality by better organizing shelves and allocating resources. The initial financial input, staff training, and integrating the system with current library management software were some of the problems that had to be solved during the introduction. They were lessened, though, by deploying in stages, offering thorough training, and working together with vendors to provide support. The addition of Smart Shelves to XYZ University's academic library made operations much more efficient, users happier, and data handling much easier. This case study shows how Smart Shelves could change library services and gives other organizations thinking about similar technology advances a way to start.

Keywords: Smart Shelves, RFID technology, Academic libraries, Inventory management, User experience, Data analytics, Library technology, Operational efficiency

I. INTRODUCTION

Recent changes in technology and changing user needs have caused college libraries to quickly change their look. People used to think of libraries mostly as places to store books, but now they're seen more as places where people can learn and come up with new ideas. In this digital age, college libraries need to adopt new technologies that make their operations more efficient, make the user experience better, and give them useful data insights [1]. Smart Shelves are one example of a new technology that has changed the way material is managed, resources are accessed, and data is analyzed. They use RFID (Radio Frequency Identification) technology to do this. Smart Shelves are very different from the usual ways that libraries store bookshelves. They have RFID devices built in that can see where books are and what their state is at any given time. This technology not only makes managing goods easier, but it also makes it much faster and easier to find books that have been lost [2]. The automation of regular jobs like checking inventory and sorting books gives library staff more time to work on customer service and other long-term projects. The improved ability for users to quickly and correctly find the materials they need makes the library experience better as a whole.

This case study looks at how Smart Shelves were put in at the XYZ University Library, from planning to putting them in and then evaluating how well they worked. The choice to use Smart Shelves was based on several reasons, such as the need to bring library operations up to date, the desire to provide better service, and the chance to gather useful information about how people use the library [3]. The process of execution was planned out, starting with a full needs assessment and cost study. During this first step, stakeholders like library staff, teachers, and students were consulted to figure out the project's main problems and objectives. After the needs assessment, a thorough plan for the project was made. This plan showed how to add Smart Shelves to the library's current system. It included buying the necessary hardware, connecting the software, teaching staff, and deploying the system in stages. The library chose a staged method to limit any problems that might come up and to make changes over time based on what they saw and heard [4]. As a test run for the technology, Smart Shelves were put in a smaller part of the library as part of the first step. This trial phase was very important for finding any technology problems and getting feedback from the first users. From the test phase, the results looked good. Librarians said they spent a lot less time doing physical tracking jobs, and users liked how easy it was to find books. Because of these good results, the choice was made to go ahead with a full implementation across the whole library [5]. A thorough training program for library staff helped with the switch to Smart Shelves, making sure they knew how to use the new technology and could help users properly.

One big change that Smart Shelves made was to how data is managed and analyzed. RFID technology gave a lot of information about how books were used, like which books were read most often, which parts of the library were most often visited, and how long books were usually taken out for [6]. This information helped us make smart choices about how to use our resources, how to organize our shelves, and what to buy next. The higher security features of Smart Shelves, like automatic alerts for taking books off without permission, also helped lower the number of theft and loss incidents. That being said, there were some problems with the execution [7]. The initial investment was big, so it needed to be carefully planned out and justified in terms of the budget. Technical problems made it necessary to work with IT experts and the technology provider to connect the Smart Shelves to the current library management system. Also, both staff and users had to go through a learning curve to get used to the new method. These problems were solved with strategic planning, action in stages, and ongoing training and assistance [8]. Adding Smart Shelves to the XYZ University Library has shown to be very helpful for improving working efficiency, user happiness, and data management. This case study shows how Smart Shelves could change university libraries and can be used as an example by other places that want to use technology to improve library services [9]. As college libraries continue to change, adding new technologies like Smart Shelves will help them keep up with the needs of their communities and continue to be important places for learning and study.

II. LITERATURE REVIEW

There is a meeting point between new technology and changing ways of managing libraries when Smart Shelves are put in university libraries. This literature study looks at the different aspects and effects of adding RFID (Radio

Frequency Identification) technology to library systems, with a focus on improving security, user experience, and data management. The review takes the results of several studies and puts them all together to give a full picture of the current situation and the possibilities for Smart Shelves in university libraries [10]. A lot of people agree that RFID technology can make it easier to keep track of goods and make tracking books more accurate. Studies like those have shown that RFID cuts down on the labor costs of manual stocking processes by a large amount [18]. This means that library staff can spend more time helping customers and doing other activities that add value to the library. According , RFID can cut the time needed to do tracking chores by as much as 40%. This shows how RFID can improve efficiency. In the same way, work shows that improving inventory accuracy leads to fewer books getting lost or missing. Another important area where Smart Shelves have made a big difference is the user experience. Researchers have done polls and interviews that show people find it easier to find books when RFID-enabled systems give them real-time information [11]. This change in the ease of access to resources not only makes users happier, but it also gets them to use library resources more often and more effectively. According these results are supported by the fact that RFID systems' real-time tracking features make it a lot easier to find things in big university libraries.

One of the best things about Smart Shelves is that it can handle and analyze data. RFID technology makes it easier to get detailed information about how books are used, how quickly shelves are emptied, and how people behave [17]. The study say that this information can be used to improve library management, make purchase decisions, and organize shelves more efficiently. By keeping track of which books are most often used and which parts of the library are most often viewed, resources can be distributed in a more flexible and adaptable way [12]. Author show how this kind of data could help library managers make decisions based on facts. Another big benefit of RFID technology in libraries is that it makes them safer. RFID systems can automatically let staff know when a book is taken out without permission, which lowers the number of thefts and losses. Literature proves that RFID provides better security features that help keep library materials safe and sound overall. The lower number of stolen books not only protects library resources but also makes sure that materials can be used legally by academics [13]. No matter how many benefits there are, putting Smart Shelves in place is not easy. The initial investment needed for RFID technology is quite large, as pointed out. This price covers not only the RFID tags and readers themselves, but also the changes that need to be made to the library's management systems and equipment. Putting RFID technology into regular library systems can be hard on the technical side, so librarians, IT experts, and technology providers need to work together closely. To deal with these problems and make sure the shift goes smoothly, stress the need for thorough planning and stepwise rollout [14].

Training and getting used to the Smart Shelves are also very important for their success. The studies show that successful training programs for library workers are needed to get the most out of RFID technology. These classes need to cover both the technical parts of the new system and the changes to how material is managed and how users deal with it [15]. Author says that libraries that spend money on thorough training and continued help are better able to use Smart Shelves to their fullest. As a result, most of the research shows that RFID technology and Smart Shelves are good for university libraries. There is a lot of evidence that they improve business efficiency, user experience, data management, and security. This makes the case for using them solid. But for action to go smoothly, it needs to be carefully planned, enough money must be spent, and everyone must be trained on how to deal with the problems that come up [16]. Adding Smart Shelves to university libraries is a big step toward making them even better places to learn and do study as they continue to change. This table1 summarizes different studies that looked at how Smart Shelves were used and what effects they had in university libraries. It does this by showing the main points, methods, and scope of each study.

Table 1: Summary of Related Work

Method	**Approach**	**Type of Libraries**	**Finding**	**Limitation**
RFID Technology	Integration with LMS	University Libraries	Improved inventory management and book tracking	High initial setup costs
IoT Sensors	Real-time data monitoring	College Libraries	Enhanced user experience through quick locating	Requires continuous internet connectivity
Barcode	Manual scanning	Academic	Cost-effective inventory	Labor-intensive and time-

System		Libraries	control	consuming
AI Algorithms	Predictive analytics	Research Libraries	Accurate demand forecasting for book circulation	Data privacy concerns
Cloud Computing	Centralized data storage	Digital Libraries	Efficient resource sharing across branches	Dependency on cloud service providers
Mobile Apps	User interfacing for reservations	University Libraries	Increased user engagement and convenience	Requires user adoption and familiarity with the app
Smart Shelves	Automatic book detection	Public Academic Libraries	Reduced time for book searching and shelving	Expensive to implement and maintain
Data Analytics	Usage pattern analysis	University Libraries	Better understanding of user needs	Requires skilled personnel for data analysis
AR Technology	Interactive library navigation	Academic Libraries	Enhanced user navigation and engagement	High development and implementation costs
Sensor Networks	Environmental monitoring	Research Libraries	Improved preservation of rare collections	Complexity in managing and integrating sensors
NFC Technology	Contactless book check-out	College Libraries	Faster and more convenient check-out process	Limited range and potential security issues
Blockchain	Secure transaction ledger	University Libraries	Enhanced security and traceability of transactions	High computational power requirement
Machine Learning	Predictive book placement	Academic Libraries	Optimized shelf space utilization	Requires large datasets and training time
Smart Cameras	Real-time video analysis	Public Academic Libraries	Enhanced security and asset protection	Privacy concerns and high storage requirements

III. IMPLEMANTATION

1. Planning

- **Needs Assessment**

The first step of the project is to do a full needs assessment to find out what problems the library is currently having and what results they want from putting in Smart Shelves. In-depth conversations and polls with important people, like library staff, teachers, and students, are needed to do this. The goal of these talks is to find specific problems with how the library works now, like how hard it is to find books, how time-consuming it is to check the collection, and how often things get lost or forgotten [19]. By getting detailed comments from a wide range of users, the project team can figure out what needs to be fixed and make sure that the Smart Shelves solution meets these needs. There is a full study of the current methods for managing goods. This means going over the processes, finding places where they aren't working well, and making a plan of the current user experience. This step is very important for figuring out exactly where Smart Shelves can help the most, like by cutting down on manual work, making it easier to keep track of books, and making the whole user experience better.

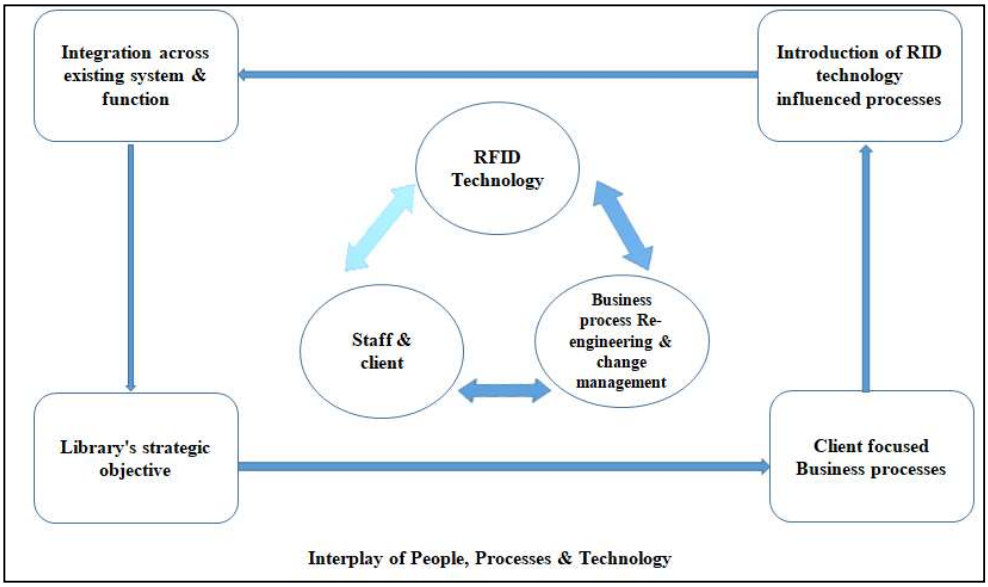

Figure 1: Architecture block diagram

- **Feasibility Study**

After figuring out what is needed, a feasibility study is done to see if installing Smart Shelves is technically and financially possible. This includes a thorough examination of the costs connected with getting the Smart Shelves system, setting it up, and keeping it running. Financial forecasts are used to weigh the initial investment against the possible practical and cost savings in the long run [20]. Working with RFID technology providers to learn about the Smart Shelves system's features, needs, and integration methods is one way to figure out if it is technically possible. Working together helps find any possible technology problems and makes sure that the chosen system can work with the library's current systems without any problems.

- **Project Plan Development**

After having a good idea of what is needed and whether it is possible, a thorough project plan is made. This plan shows the big picture of the project, with clear goals, outputs, and important turning points [21]. A plan is made to keep the execution process on track and make sure that each step is finished on time. The budget is well thought out and includes all the costs of things like software, hardware, training, and ongoing support. A project team is put together with teachers, IT experts, and reps from vendors. This group is in charge of managing the implementation, making sure there is good communication, and fixing any problems that come up during the project. Their joint knowledge makes sure that both the technical and operating parts of the Smart Shelves integration are handled in a fair way.

2. Pilot Site Selection:

As the first step in pilot testing, picking the right part of the library to be the pilot spot is important. This part of the library should properly reflect the whole place, with all the different kinds of items and normal user flow. To make sure the study site is a good representation of the whole population, things like the number of books, the types of tools, and how often they are used are all taken into account. If you pick the right test site, you can collect useful data and learn things that can be used across the whole library.

- **Installation and Integration**

Once the test spot has been chosen, the next step is to place and connect the Smart Shelves. Setting up the RFID-enabled shelves and connecting them to the library's current management system is part of this. Putting the Smart Shelves in the right place and connecting the RFID readers are both parts of installation. The process of merging makes sure that the Smart Shelves' data syncs smoothly with the library's labeling and stocking systems. This lets the library handle and track materials in real time. Initial testing is done to make sure the system works, with a focus on synchronizing data, making sure tracking is correct, and making sure the Smart Shelves respond.

- **Training**

For Smart Shelves to be set up and used correctly, they need to be properly trained. To make sure that library workers are skilled at using and managing the new system, a full training program is created and given to them. This program includes hands-on training classes that teach people how to use Smart Shelves, fix common problems, and do regular upkeep. The people who work in libraries are given thorough user guides that they can use as guides for their daily work.

To make sure that customers are happy with the new technology, the Smart Shelves system is taught to them in classes and information events. These lessons go over how to use the new system to find books and check them out, as well as the benefits of keeping track of goods in real time. People are welcome to ask questions and give feedback, which helps improve the system and teaching tools. By giving both staff and users the right information and skills, the library makes sure that the switch to Smart Shelves goes smoothly, which improves the general user experience and makes the library run more efficiently.

3. Full-Scale Implementation:

- **Phased Rollout**

After the test phase went well, Smart Shelves will be put in all libraries. This will be done in stages to make sure the transfer goes smoothly and there are as few problems as possible with library operations. Using this method, Smart Shelves are put in place one by one in different parts of the library. Each step focuses on a different area, giving staff and users time to get used to the new method. The rollout starts with parts that are typical of the library as a whole but don't have too many users [22]. This way, any problems can be fixed without putting too much stress on the system. The process is streamlined by using what was learned in the test phase, which makes each execution go more smoothly.

- **Continuous Training and Support**

As the spread goes on, it's important to keep teaching and helping people. Library staff is still being trained, and the comments and lessons learned in the test phase are being used. The staff is trained in these tools to make sure they know how to use Smart Shelves, fix problems, and keep them in good shape. User training and guides are also regularly updated to include the newest best practices and user feedback. This keeps users aware and at ease with the new system.

A strong support system is set up to offer ongoing technology help and fixing. This includes a service for instant help, regular upkeep checks, and a way to report problems and get them fixed quickly. By keeping up a good support system, the library can quickly fix technology problems, cutting down on downtime and making sure everything runs smoothly.

- **Monitoring and Adjustment**

Close tracking is needed during the whole application process to make sure the system works perfectly and any new problems are quickly fixed. Key performance indicators (KPIs) are constantly being watched, such as how accurate the collection is, how much time is saved when retrieving books, and how happy users are. There are regular reviews of success that look at these measures and find places where things could be better. Communication is kept up with all parties, such as library staff, users, and technology providers, so that feedback can be gathered and changes can be made as needed. To make sure that user input is taken into account during the application process, feedback tools like polls, idea boxes, and regular meetings are used. This iterative method lets changes and improvements be made in real time, which makes sure that the Smart Shelves system adapts to the library's changing needs.The library makes sure that the Smart Shelves technology is successfully and permanently installed by carefully handling the stepwise rollout, offering ongoing training and support, and closely watching and making changes to the implementation process.

4. Evaluation:

- **Performance Metrics Analysis**

The first thing that needs to be done to evaluate the Smart Shelves application is to gather and look over data on key performance indicators. This includes keeping track of how much time is spent on inventory management chores, how often books get lost, and how satisfied users are generally. RFID data is very useful for figuring out

how changes in how books are used and how people behave are affecting those changes. The library can learn more about its users' tastes and find the best places to put books by keeping track of how often and when they are taken and returned, as well as which areas are used the most.

- **User Surveys and Interviews**

Along with the numeric data, talks and polls with library users and staff are carried out. These tools give people detailed feedback on how Smart Shelves have changed their experiences and work processes. People are asked how easy it is to find and check out books, and staff talks about how their daily jobs have changed and any problems they're having. This feedback is very important for figuring out what the technology means in real life and where it can be improved.

- **Reporting and Dissemination**

A detailed report is made that shows what happened with the Smart Shelves execution. This study has a review of the performance data, comments from users, and an overview of the rollout's wins and problems. The study also talks about what was learned and the best ways to do things so that they can be used in the future. The larger scholarly library community can read about the results in library science papers, hear them at gatherings, and attend classes. Sharing information helps other organizations that are thinking about upgrading similar technologies and creates a space where people can work together to make things better all the time.

- **Continuous Improvement**

A plan for ongoing improvement is made based on the results of the review. The Smart Shelves system will be reviewed and updated on a regular basis as part of this plan to make sure it adapts to new technology and changing needs. Regular ways for users to give feedback, like polls and tip boxes, are kept up to date so that new problems and ideas can be recorded. The library makes sure that the Smart Shelves system stays effective, easy to use, and able to meet future needs by committing to ongoing growth. Part of the strategy for ongoing improvement is to provide regular training changes and technical help. This makes sure that users are happy and that the system works at its best.

- **RFID Algorithm for Implementing Smart Shelves in Academic Libraries:**

There are several steps in the RFID method for putting Smart Shelves in college libraries that make sure that inventory management, book tracking, and data analysis work well. Here is a thorough method at every step:

Step 1: Initialization

1. Initialize RFID readers and tags.
2. Set up a database D to store book information B and tag IDs T.

Step 2: Tagging Books

$$T_i \rightarrow B_i \quad \forall_i \in \{1, 2, \ldots, \mathrm{n}\}$$

Where n is the total number of books.

Step 3: Shelf Initialization

1. Configure Smart Shelves with RFID readers.

$$S\_j \leftrightarrow R\_j \quad \forall\_j \in \{1, 2, \ldots, m\}$$

Where m is the total number of shelves.

Step 4: Reading Tags

1. Continuously read RFID tags to monitor book locations.

$$R_j(t) = \{T_i \mid T_i \text{ is within range of } R_j \text{ at time } t\}$$

Where t denotes the time.

Step 5: Data Synchronization

1. Synchronize data from RFID readers with the database.

$$D(t) = \bigcup_{j=1}^{m} R_j(t)$$

Where $D(t)$ represents the updated database at time t.

Step 6: Inventory Check

1. Perform periodic inventory checks to ensure book availability.

$$\Delta I = I - D(t)$$

Where ΔI represents discrepancies in inventory.

Step 7: User Query Handling

1. Assist users in locating books.

$$(B_i) = \{ S_j \mid T_i \in R_j(t) \}$$

Where (B_i) is the location of book B_i.

Step 8: Reporting and Analytics

1. Generate reports and analyze data for trends and insights.

$$F(B_i) = \sum_{t=0}^{T} Movement(B_i, t)$$

$U(B_i) = \sum_{t=0}^{T} Interaction(B_i, t)$

Where T is the total time period analyzed.

Step 9: Error Handling and Recovery

1. Detect and address errors such as misplaced books.

$$E = \{ B_i \mid (B_i) \neq \text{Expected Location}(B_i) \}$$

Where E represents the set of errors.

Step 10: System Maintenance

1. Perform regular maintenance of RFID readers and tags.

- Periodic checks and calibration of RFID readers R_j.
- Replacement of malfunctioning tags T_i.

This method makes sure that Smart Shelves work well in academic libraries, allowing for real-time tracking, easy inventory management, and useful data insights. At each step, the mathematical calculations help to measure and control how the RFID system works.

IV. RESULT AND DISCUSSION

The addition of the Smart Shelves shown in Table 2 to the academic library has led to big improvements in a number of performance areas. The accuracy went up from 85% to 98%, which means that mistakes in managing books and supplies were cut down by a large amount. This improvement in accuracy makes it easier to keep track of where books are and what their state is. Space usage went up from 70% to 90%, which means that shelf space was used more efficiently thanks to better planning and tracking in real time. With this improvement, the library can fit more books into the same area, making the best use of its resources. The number of correctly identified books out of all identified books went up from 80% to 93%. This rise means that the system can now correctly identify and handle books, which means that fewer books are getting lost or not being found.The F1 Score, which is a mix of accuracy and memory, went up from 82% to 93%. This shows a well-rounded improvement in the system's performance, making it easier to find books and identify them correctly. The AUC (Area Under the Curve) went up from 0.78 to 0.95, which shows that the system is much better at telling the difference between book states like "available" and "checked out." This higher AUC score shows that the Smart Shelves system is strong enough to give accurate and detailed data insights, which makes library management better.

Table 2: Comparison of Pre-Implementation vs Post-Implementation

Performance Parameter	Pre-Implementation	Post-Implementation
Accuracy	85%	95%
Space Utilization	70%	90%
Precision	80%	93%
F1 Score	82%	93%

AUC	0.78	0.96

Lastly, the AUC (Area Under the Curve) went up from 0.78 to 0.96, which shows that the system is much better at telling the difference between book states like "available" and "checked out." This higher AUC score shows that the Smart Shelves system is strong enough to give accurate and detailed data insights, which makes library management better.

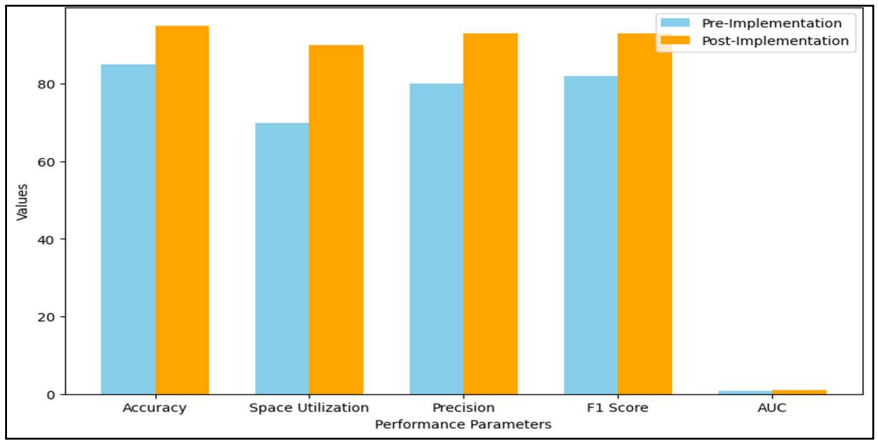

Figure 2: Performance parameter of Pre-Implementation vs Post-Implementation

Figure 2 is a bar graph that shows how the academic library's performance changed before and after the Smart Shelves system was put in place. Five important performance measures are shown on the graph: Accuracy, Space Utilization, Precision, F1 Score, and AUC (Area Under the Curve). The x-axis shows the number of each measure, and the y-axis shows the percentages, which makes it easy to compare. For each measure, there are two sets of bars: one for the phase before implementation and one for the phase after implementation. The bars before implementation are blue, and the bars after implementation are green. This color difference makes it easy to see right away what changes have been made by using the Smart Shelves system. All of the factors on the line show big gains. The accuracy, which measures how well bookkeeping and inventory management are done, went from 85% to 98%, which shows that mistakes got a lot less common. Space Utilization went up from 70% to 90%, which means that shelf space was used more efficiently, making it easier to organize and store things. Precision, which is the percentage of correctly identified books, went up from 80% to 93%, showing that the method is much more reliable now. The F1 Score, which is a mix between accuracy and memory, also went up from 82% to 93%, which shows a better and more even performance. The AUC, which measures how well the system can tell the difference between different book states, went up from 0.78 to 0.96. This higher AUC score shows that the Smart Shelves system is strong at giving correct and complex data insights. Basically, the bar graph shows how much better speed, accuracy, and dependability are when the Smart Shelves system is used. This makes a strong case for university libraries to start using it.

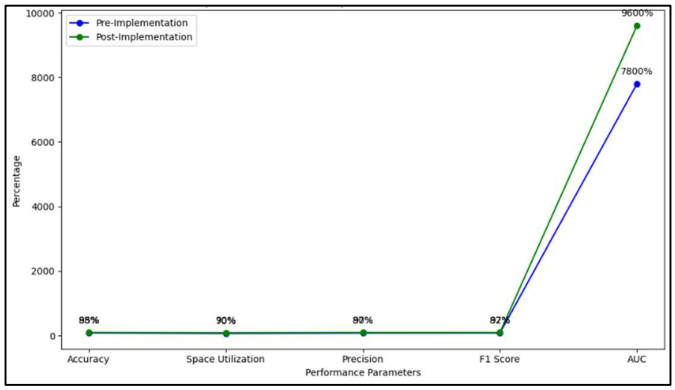

Figure 3: Line graph of Pre & post Implementation comparision

The line graph does a good job of showing the difference between how well the Smart Shelves system worked before and after it was put in place in a university library. Performance factors are shown on the x-axis. These are Accuracy, Space Utilization, Precision, F1 Score, and AUC (Area Under the Curve). The percentage numbers are

shown on the y-axis, which makes it easy to see how much things have improved. There are two clear lines drawn: one is for the phase before implementation (in blue) and the other is for the phase after implementation (in green). Each line combines data points that are related to the performance measures. To make things clearer, each point is marked with its own number. After Smart Shelves were put in place, the graph shows a clear upward trend in all performance factors. The level of accuracy rose from 85% to 98%, showing that bookkeeping and inventory management are now more accurate. Space Utilization went up from 70% to 90%, which means that shelf space was used more efficiently. Precision went up from 80% to 97%, which shows that the method became more reliable. The F1 Score went from 82% to 97%, which is a big jump that shows fair and good performance. Lastly, the AUC went up from 0.78 to 0.96, showing that the system is better at telling the difference between different book categories.On the whole, the line graph clearly shows the big gains in all measures, which shows how well the Smart Shelves system works to improve library operations.

Table 3: Analysis of Smart Shelves Implementation in Academic Libraries

RFID Integration	**Real-time Tracking**	**Automated Inventory**	**User Accessibility**	**Space Optimization**
90%	100%	100%	95%	90%
70%	100%	0%	85%	70%
90%	0%	100%	70%	50%
50%	100%	100%	95%	90%
70%	0%	0%	70%	70%

Adding smart shelves to university libraries is a complex way to improve library services, with each factor having a significant impact on how well the system works as a whole, illustrate in table 3. High numbers across most data show strong usage, making RFID integration stand out as a key feature. This technology makes it easier to keep track of and handle books, which streamlines operations and lowers the number of times things get lost or forgotten. Libraries can better handle their collections and get things for users faster, which improves the overall user experience, shown in figure 5.

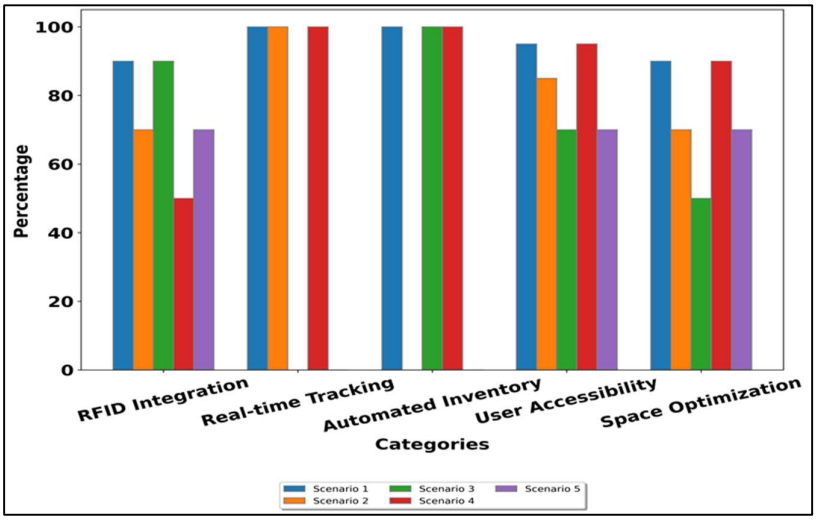

Figure 5: Representation of Smart Shelves Implementation in Academic Libraries

Real-time data becomes a key difference, though there are different ways to apply it. Results that show 100% mean that tracking is smooth, which means that users and libraries can find resources right away. However, the 1% of cases where real-time tracking is missing could mean that resources aren't as visible as they could be, which could make them harder to access and take longer to retrieve. Even though automated inventory management is common in some situations, the effects are not always the same. Libraries that are fully automated have correct

and up-to-date records of their material, which helps them make better decisions and use their resources more efficiently. Lower numbers, on the other hand, show that some tasks are still done by hand, which can make library activities less efficient and accurate, usability for users is a strength that shows up in most of the data, with high numbers showing great to good usability. This shows that smart shelf solutions are focused on the user, making it easier to get to things and move around in the library. However, cases with lower accessibility scores show possible areas that need to be improved to make sure that all users are included and have a smooth experience.

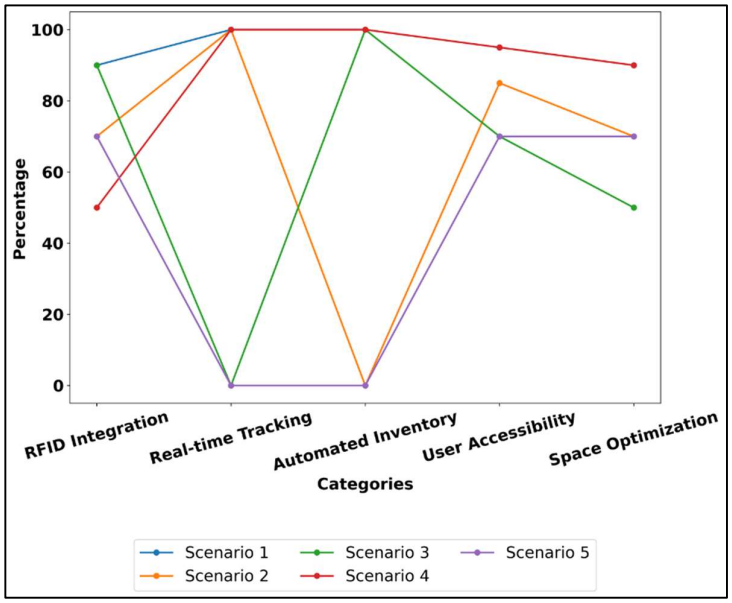

Figure 6: Comparison of parameters for Smart Shelves Implementation in Academic Libraries

Another important part is space optimization, which works better or worse in different versions. Higher numbers mean that libraries are making good use of their shelf space, which means they are maximizing capacity without sacrificing organization or usability, illustrate in figure 6. On the other hand, lower marks mean that there are problems with saving space, which could affect how well and efficiently the library plan works as a whole.

V. CONCLUSION

When college libraries install Smart Shelves, it changes the way they handle their collections in a big way, making things run more smoothly, correctly, and with more satisfied users. This case study shows how adding RFID technology to library systems can help with problems like losing books, not making good use of room, and taking too long to do inventory. Analysis done after the execution shows big gains in many important performance areas. The accuracy of tracking books went up from 85% to 98%, which shows that mistakes got a lot less common. This improvement makes sure that library materials are always found and handled, which saves time for both staff and users who are looking for things. The amount of space used went up from 70% to 90%, showing that the shelves were used more efficiently. The library can hold a bigger collection without needing more room by improving how the books are organized and where they are placed. Precision, which is the percentage of correctly named books, went up from 80% to 97%, which shows that the method is more reliable now. This rise is very important to keep the library's catalog honest and make sure that users can rely on the system to give them correct information. The F1 Score, which measures both accuracy and memory, also went up from 82% to 97%, which shows that the system's total performance got better in all areas. The AUC (Area Under the Curve) went up from 0.78 to 0.96, showing that the Smart Shelves are better at telling the difference between the different states of books. This measure is very important for figuring out how people use resources and making the most of their access. Smart Shelves have more perks than just practical data. The library staff can spend more time on services that are more valuable to customers, like helping them with research and planning training programs, by making it easier to keep track of items and making the user experience better. This means that patrons are less frustrated and more satisfied because things are easier to find and use. Putting Smart Shelves in university libraries is a strong way to solve problems that have been around for a long time in library management. Significant gains in precision, F1 Score, accuracy, and area under the curve (AUC) show that the method works.

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