Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways

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Abstract — **Digital Mapping Services are typically available to a user through a web browser on a computer or a portable electronic device. One of the uses of a digital mapping service is mapping library systems. This study aims to provide the book's location inside the library through an Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic. The focus of this study is to provide a video pathway of the shelves' location, a printable pathway of the shelves' location, and to determine the book's availability inside the library. The system was developed using Microsoft Visual Studio with Visual Basic as the programming language, while MySQL was used for database management. The Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic, performance in User Interface achieved a 97% satisfaction rate, and the performance in the Administrator Interface achieved a 100% satisfaction rate.**

Index Terms – **Microsoft Visual Studio, MySQL, Digital Kiosk, Video mapping, 2D-mapping**

I. INTRODUCTION

Multi-platform and multi-sensor integrated mapping technology has been established for fast geospatial data acquisition. Maps are becoming mobile and dynamic due to the expansion of the internet and wireless communication networks [1]. Maps are used to locate the exact locations of items. Both digital and analog maps are possible. Digital mapping is gathering and compiling data to create a virtual image, operating on the combination of graphic elements assigned to it in electronic information [2]. It is performed through a digital interface like a computer system with a Graphical User Interface (GUI). The graphic representation connected with data permits the creation of a graphic map with visual references to a utility resource [3].

Digital mapping uses Geographic Information System (GIS), a framework that gathers, manages, and analyzes data. After analyzing spatial location, GIS integrates layers of data into visualizations using maps and 3D scenes [4]. Digital Mapping Services (DMS) are typically available to users through a web browser, running on a computer or a portable electronic device, such as a cellular phone, personal digital assistant, etc. DMS allows users to view a map in various formats (e.g., 2D, 3D, aerial, road, etc.) [5].

Location-based services are provided in libraries using a mobile application enabled by the Internet of Things (IoT) to install Bluetooth beacons into the book stacks of a college library. Application of a location-based recommendation system that bases recommendations on a user's location on subject classifications of the primary IoT services for library technology [6]. Mobile mapping systems (MMS) were first limited to applications that allowed for determining exterior orientation from ground control that was already in place [7]. The primary reason to use any MMS is its capacity to deliver precise, quick, and affordable mapping solutions. This approach improves the effectiveness of gathering spatial data for several GIS applications, including mapping utilities, infrastructure, roads, and trains [8]. MMS used sophisticated statistical techniques to attain precision and accuracy. A multi-sensor system primarily comprises three mapping sensors: a) LiDAR Scanner, b) Camera Sensors, and c) GNSS + IMU [9]. Focusing on the key issues to ensure proper data acquisition and outlining how those issues were handled in a terrestrial MMS developed at the University of Portal, MMS technology must include using less expensive sensors and simplifying calibration and data acquisition procedures [10].

Electronic mapping can be an effective educational tool for administering campuses and local governments, and for enhancing student learning in the classroom. Geographic information systems (GIS), which make mapping and cartography capabilities accessible and affordable, make electronic mapping possible in educational settings [11]. Electronic maps will be displayed on a high-resolution screen. This device includes a power management system that powers off various portions of the device depending on the device's movement [12]. Identifying pathways to locations or locations of interest is one of the useful services offered by navigation systems or devices. The navigation system may identify the best path the user can take to get from one place to another. The navigation system uses a database of locations (called nodes) and streets (called

links). The mapping database has limited information [13]. Modern digital mapping is revolving, ruggedized personal digital assistants (PDAs), and tablet PCs can record a wide spectrum of geologic data and facilitate iterative geologic map construction and evaluation on location in the field using Google Maps [14]. The digital tile-based mapping techniques enable the efficient online serving of pleasing maps. It is configured to generate map tiles during offline sessions and serve selected sets of tiles to a client when requested [15].

The reviewed studies discussed the current applications of mapping systems and emphasized their benefits in locating destinations through road path visualization. While traditional library systems are already in use, the proposed Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways, developed in Visual Basic, enhances functionality by identifying the precise location of books within the library. It provides 2D map assistance and video-guided pathways to help users locate books, along with their corresponding reference numbers.

This study aims to provide the book's location inside the library by providing an Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways. The specific objectives of this study are as follows: (1) to provide a video pathway of the shelf's location; (2) to provide a printable pathway of the shelf's location; and (3) to determine the availability of the book inside the library.

This study is significant to students, visitors, administration, and staff. As for students and visitors, this study provides convenience and versatility in finding the book they want, as the location is available and can be viewed through a video and a printable path that provides the exact location of the shelf. This study is significant for the administration and staff because it helps them locate books more conveniently and easily for visitors and students to use.

The focus of this study is to provide a mapping system that locates the book by giving a video presentation of the book and a printable pathway to the shelving location. Book availability is also part of this study. Researchers will implement the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways at the Tagum City Library & Learning Commons. Determining the real-time location of the book is not part of this study. Reservation and borrowing of books are not part of this study.

II. MATERIALS AND METHODS

A. *Conceptual Framework*

author/s, book titles, and the genre of books, as shown in Fig 1. Then the system will use a modified search algorithm, which is the combination of finite automata search algorithm and Knuth Morris Pratt search algorithm in acquiring data from the system. And modified sort algorithm is a combination of selection and insertion sort algorithms in sorting the data. Lastly,

the system's output is displayed in the software's graphic user interface, showing a printed 2-Dimensional guide of the bookshelves and 3D animation video.

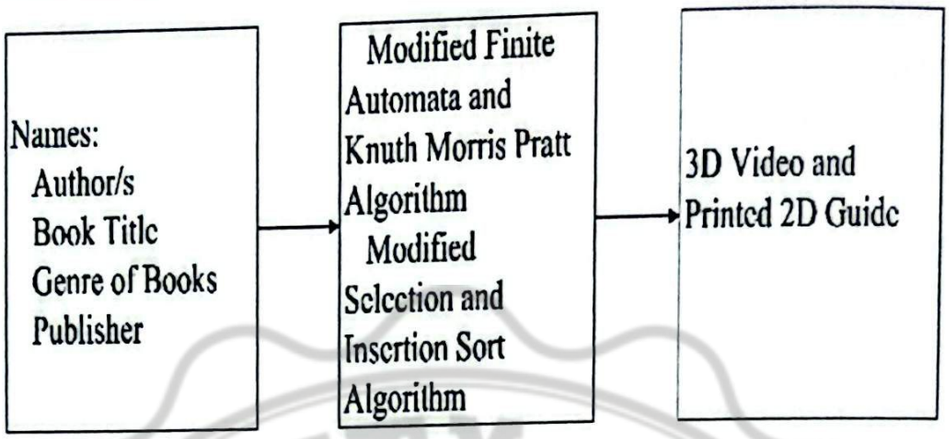

Fig 1. *Conceptual Framework*

B. Software Development

The software was developed using Microsoft Visual Studio Professional 2017, version 15.9.43, with Visual Basic as the programming language and Visual Basic tools version 2.10.0. MySQL is used to store gathered data. An open-source relational database management system. The software uses an offline database. The open-source, cross-platform web server used in this study is XAMPP v3.2.2. XAMPP provides an environment for testing MySQL databases.

The system has three types of users: the super-administrator, the administrator, and the client user. The super-administrator can register administrators. Also has the privilege of updating the information of the administrator saved in the database. The administrator can modify the book by deleting, adding, and updating the book information in the database. The client user will only be allowed to search the book by searching the book title, author/s, publisher, and genre of their wanted book. The book details, 3D video pathway and a 2D pathway integrated into the software that can be printed using the thermal printer connected to the computer.

To develop a convenient pathway for locating specific books, the researcher adopted the "Approach, Enter, and Find" strategy by David Gibson. This strategy involves three key steps in user navigation: first, the "Approach" phase, where the user identifies and moves toward the destination; second, the "Enter" phase, where the user gains access to the environment (e.g., the library); and finally, the "Find" phase, where the user locates the specific item or place they are seeking. In applying this strategy, the researchers took the perspective of a first-time library visitor, simulating the experience of a client user. The visitor's decisions are based on the accessibility and readability of the information provided. By simplifying navigation into these stages, this strategy supports the development of a structured and user-centered mapping system [16].

C. *Software Development Life Cycle*

The researchers will use the waterfall model as this study's software development life cycle. The waterfall model has six phases: requirement analysis, system design, implementation, testing, deployment, and maintenance. In the requirement analysis, the researchers gathered data on the basic requirements for creating the library system. As this study is implemented in the Tagum City Library & Learning Commons, the researchers ask for basic information about the books inside the city library. After knowing the requirements needed, the researcher started the system design, where specifying the hardware, understanding the system requirements, and defining the system architecture are required. In this phase, the researchers seek answers to the questions about the system's use and how it will be developed. In the third phase, which is the implementation, the system design is implemented by creating user interfaces for the administrator and client user. The researcher uses Visual Studio as the integrated development environment to design the system. The source code is written with the use of VB.NET. The researchers turn the physical design specifications into working code. After creating the system design, unit testing is conducted in this phase. The testing is done by unit, where the researchers test the design individually and look for failures before integrating it into a functional system.

The database will be tested by inputting 200 books with the necessary information and classifying them into ten books per genre or type. Debugging and trials are made in this phase. After all the trials the researchers or developers conducted, the software is deployed into a customer environment to let the client test the system's performance. The system is deployed into the Tagum City Library & Learning Commons. The researcher let the visitors and students use the system to test its performance. After the deployment phase, the last step is to provide support and maintenance of the software. The developers will maintain the software every three to five years to ensure it runs smoothly and immediately fix issues every time the client says so.

D. *Hardware Design and Development*

The researchers used digital kiosks as the hardware for this study. The kiosk will act as the assistant for the student who wants to locate the shelf of the book they want. This kiosk provides a 2-dimensional map and a 3-dimensional animation video to allow for simplified navigation, allowing the user to find the exact book location. Pathway, printable, and video pathways will be displayed in this kiosk. The dimension of the digital kiosk consists of 4 feet in width, 3 feet in depth, and a height of 5 feet and 1.57 inches, which is the average height of a Filipino [17]. The Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic contains input devices such as a mouse and keyboard, and for the output devices, it has a monitor and thermal printer. As for the input devices, the researchers use a wireless mouse to can be easily used by the client user without having cords connected. The user can achieve good ergonomics for navigating the digital kiosk. A wired keyboard is used in this study to deal with the risk of interference, input lag, and battery life. As for the output devices, the researchers use LED monitors to have a broader picture range,

greater longevity, and reduced environmental impact. They operate at a lower temperature and use a lot less energy. The thermal printer version used in this study is XP-58IIH Receipt Printer Bluetooth USB Portable Thermal OFFICOM with a high speed of 90mm/s, uses 58 mm of rolling paper, and supports Linux, Android/iOS SDK, Windows XP/7/8/10, and Android/iOS for printing a receipt.

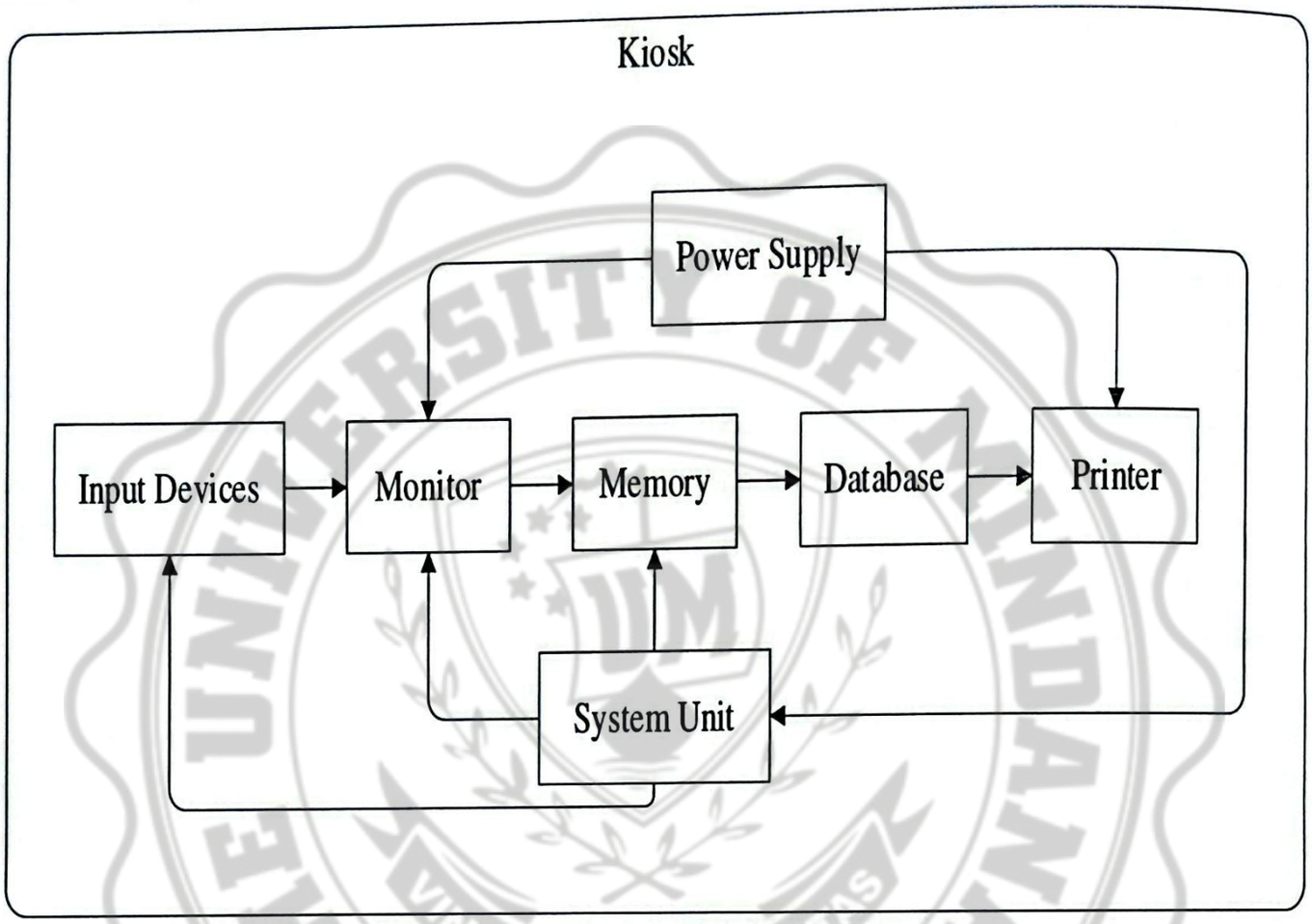

Fig 2. *Block Diagram for Digital Kiosk*

D. Materials and Procedures

The block diagram process of the client user is shown in Fig. 3, where the system will start from having an input given by the user, where it needs the information of the book, like the author/s, book title, or genre of the book. The system will now process the inputs the user gave and show the list of books available in the database. After finding the right and available book, the user will proceed to the display of the location of the shelf through a printable pathway and a video presentation of the pathway. The system will ask the client user if they will print the pathway to the shelf of the book. However, if the book is unavailable in the database, the client user will go back to entering the book's information.

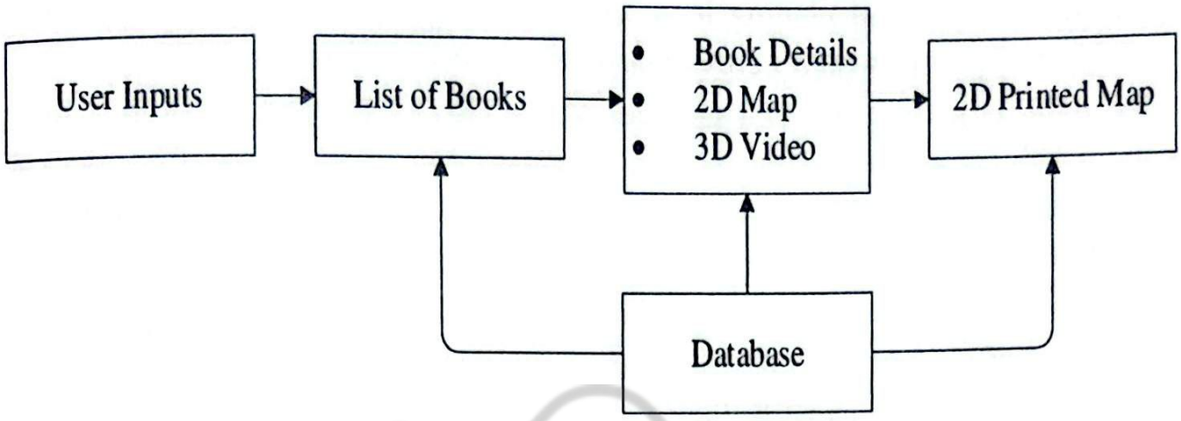

Fig 3. *Block Diagram for User*

The search algorithm used for this study is modified from two search algorithms: the Finite Automata algorithm and the Knuth-Morris-Pratt algorithm. The algorithm starts when the user gives input to the string to be searched in the database. The data from the database will be saved in the value i, while the string will be saved in j. The system will create a table that will determine the repeating pattern inside the given string by the user and provide indices that will be used later in the algorithm. The next step is to compare the characters on i and j. If j and i do not match, j will be back to the position based on the index given in the table. If j and i match, i will now be equal to i + 1, and j will be equal to j + 1. If the value of j is the last character saved on the string, the system will now get the information from the database, while if not, the system will go back to comparing the value of i and j.

The block diagram process of the administrator is shown in Fig. 4, where the system administrator will start by providing the credentials for logging in. After the login, the administrator will be given a chance to modify the book's information and show a command if the administrator will add new book/s and delete book/s. In adding a new book, the administrator user will fill out all the information about the book. And for deleting book/s, the administrator user can delete the book on the system.

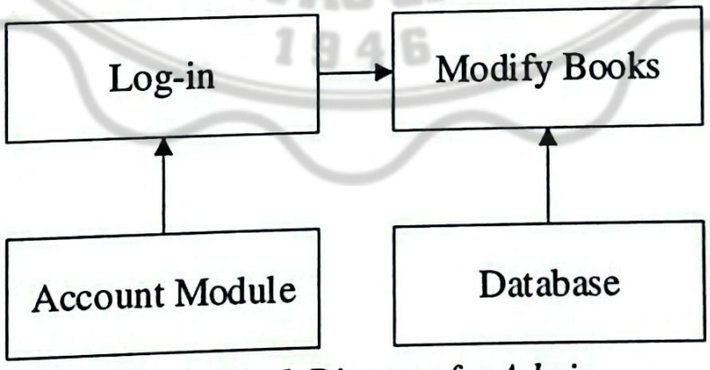

Fig 4. *Block Diagram for Admin*

The revised sort algorithm is based on combining the selection sort algorithm and the insertion sort algorithm. Both sorting algorithms use two components to sort a list from unsorted to sorted; their only difference is how well they do the sorting. The flow will begin by collecting

the book's information and placing it in an array. Books are categorized by number using the Dewey Decimal System, which helps identify each book's precise subject [18]. The first process to sort the book is getting the first element of the Dewey Decimal System, which contains the book's main subject class and the book's subclass. After sorting the first element, if the first element is not sorted clearly, it will go back to the first element's first process until the sorted books satisfy the condition. If the first element is sorted, it will continue to the second process of sorting. The next process is the second element of the Dewey Decimal System, which includes the section area of the book, book title, author, and book's shelf level. After the second process, the second condition is the same as the first element. Lastly, the final process of sorting the book is the third element of the Dewey Decimal System, which covers the year the book was published. The last condition is the same as the first and second elements.

III. RESULTS AND DISCUSSIONS

A. Results of Electronic Mapping GUI

The Main Interface of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways, developed in Visual Basic, offers two options: one for users to search for books and another for administrators to manage the system. The user button allows user to be directed to the User Interface, where the user can search for a book that shows the book's information, and the 2D-map and 3D animation video where the book is located on the specific shelves and level of the shelves. Second is the administrator button, which the administrator will be directed to the Administrator Interface, where the user can log in with an administrator account or super-administrator account and modify the books or administrator accounts to add, delete, and update books.

The User Interface of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic is where the user can search for books already available in the database. In searching for the book, the system shows the category drop-down button, which filters the type of book the user is searching for. The Category drop-down button will filter the books by book title, author, publisher, and section where the books can be found. The User Interface also shows the details of the books and displays the 2D and 3D pathways for the book's location. It also enables the 2D pathway to be printed by the user.

The Administrator and Super-Administrator interface is where the user must log in to an account to modify a certain book or admin account. In the Administrator Interface, the user will see the list of books already available in the database. These books can be modified by updating their information or deleting the book from the database. The administrator interface allows the user to add a book by filling in all the needed information, like a book title, author, publisher, calling number, section, book location by shelf and by level, and the book cover. The 2D and 3D pathways will automatically be provided by the system based on the selected shelf and section

by the user. In the Super-Administrator Interface, the user can see the registered administrators in the database and modify their information. Full name, position, username, and password are the needed information for the administrator to be registered and be able to modify books in the database.

B. Digital Kiosk

The Digital Kiosk is the specialized housing hardware of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways developed in Visual Basic. The digital kiosk is made of thick plywood combined to make a particular hardware design. The researchers make use of the Tagum City official color banner, emerald green, that symbolizes the pride of Tagumeños, the "Palm City of the Philippines' ' where different varieties of palm trees are located throughout the crossroads and parks. The digital kiosk of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic comprises a plurality of input devices, such as a keyboard to enter characters by clicking the buttons or keys, and a wireless mouse to interface with the computer. It also comprises a plurality of output devices, such as computer monitors to display the information in a text or graphic form, and a thermal printer for printing receipts and other documents.

C. 3D and 2D Pathway

2D pathway contains the information book such as title, author, publisher, year, call number or Dewey decimal number, section, shelf number, and level from the shelf where the book is located. The printable book details include legends and symbols: You are here, Bookshelf, and Pathway. It also contains the 2D pathway of the shelf where the book is located. The system provides 21 different 2D pathways corresponding to every shelf inside the library. The library has four different sections and a number of shelves. The Filipiñiana section has three shelves, the Reference section has four shelves, the Circulation section has eight shelves, and the Elementary section is composed of 3 shelves.

The system provides a 3-dimensional pathway for users to be guided in locating the shelf of the book. The animated pathway starts from the library door, going to the section where the shelf of books is located. The system integrates nine different animated videos for the 3D pathway. The Filipiñiana section consists of 1 animated video, the Reference section has 1 video, the Circulation section has four videos, and the Elementary section is composed of 3 videos.

D. Database of the Book

The MySQL database stores 200 sample books, each containing details such as title, author, publisher, genre, publication year, Dewey Decimal Number, shelf location, and shelf level. To store and manipulate data, MySQL generates a database by specifying the connections

between each table. MySQL can perform certain operations such as data query, data manipulation, and access control[19].

E. Results of Function Testing

The researchers surveyed 200 respondents, including the users and administrators, using evaluation forms. Simple Random Sampling is a type of probability sampling in which the researcher randomly selects a subset of participants from a population. It is a probability sampling technique wherein the researchers randomly select a population subset [20].

This study uses simple random sampling of age, gender, and occupation. To classify the population of the respondents, the researchers use the Age standard bracketing by the Australian Bureau of Statistics (ABS) to collect and disseminate age data for statistical purposes; a general survey standard output category is being used in this study [21].

The researcher used rating scale survey questionnaires displaying a corresponding scale: 5 - Very Highly Satisfied, 4 - Highly Satisfied, 3- Moderately Satisfied, 2- Less Satisfied, and 1 - Unsatisfied. The respondent selects the number that most accurately represents their response, and these survey questionnaires are considered valid and reliable for gathering the needed data [22]. The survey questionnaire consisted of two subparts, the User and the Administrators.

Figure 5 shows the Function Test of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic in terms of flexibility, color schemes, readability, and error recognition regarding the transaction response and functionality. The ratings range from 1-5, 5 being the highest and one being the lowest. The results are as follows: for flexibility, it has 4.89; for the color scheme, it has 4.27; for readability, it has 4.98; for error recognition, it has 4.85; for transaction response, it has 4.82; for functionality, it has 4.96.

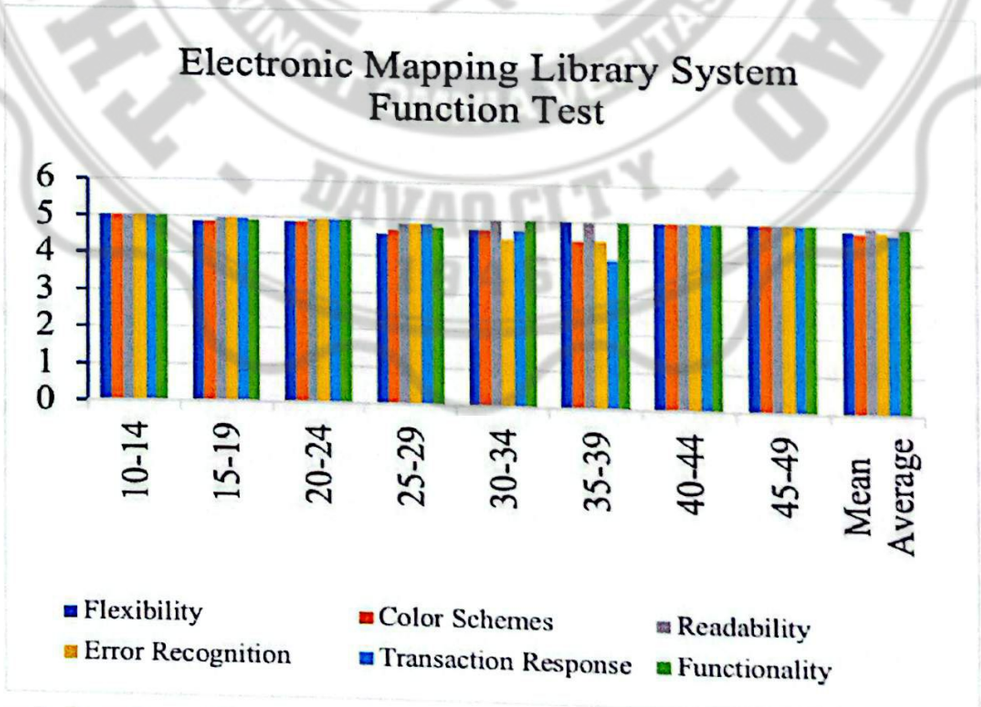

Fig 5. *Feedback Results of Function Testing (Flexibility, Color Schemes, Readability, Error Recognition, Transaction Response, and Functionality)*

Figure 6 shows the function test of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways in terms of accessibility, the quality of video animation, the quality of the 2D Map Screen, the Quality of 2D Map Printed Copy, user-friendliness, effectiveness, and adaptability. The results are as follows: for the quality of the 2D map screen, it has 4.71; for the quality of the 2D map printed copy, it has 4.91; for user-friendliness, it has 4.93; for effectiveness, it has 4.91; and for adaptability, it has 4.98.

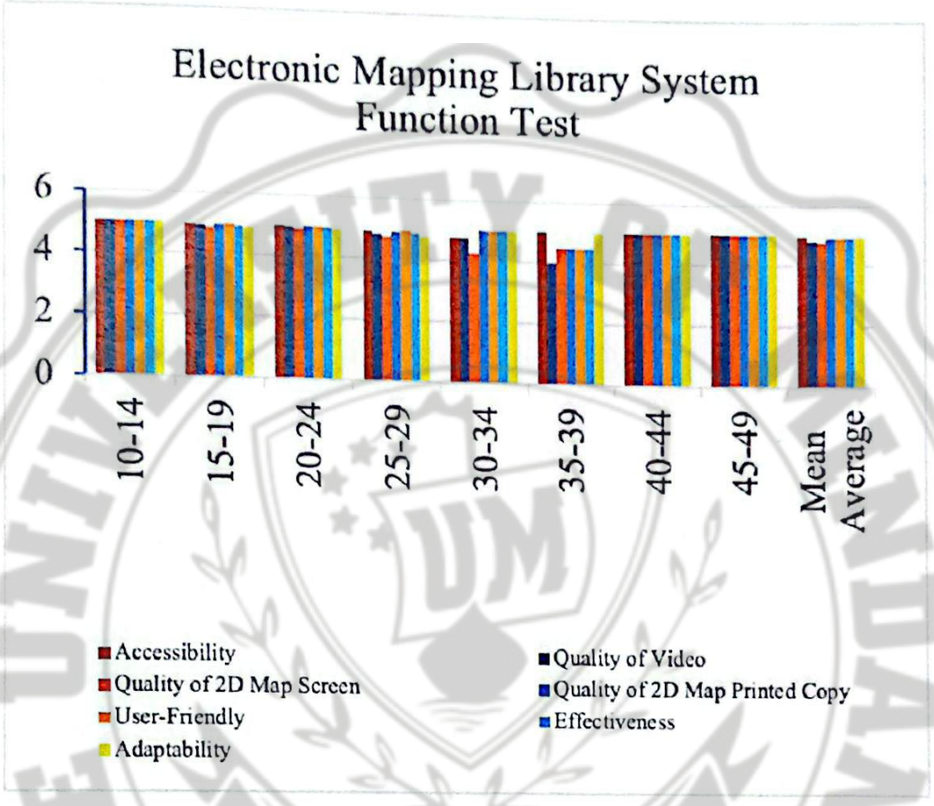

Fig 6. *Feedback Results of Function Testing (Accessibility, Quality of the Video, Quality of 2D Map Screen, Quality of 2D Printed Copy, User-Friendly, Effectiveness, and Adaptability)*

Figure 7 shows the function test result for the administrator interface of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways. The second subpart of the survey question is answered by the librarian staff of Tagum City Library and Learning Commons, wherein they test the system to modify some books, which can be done by adding, deleting, and updating a book. Adding the books in the database garners 5, also the deleting and updating of books, out of 5 satisfaction rate.

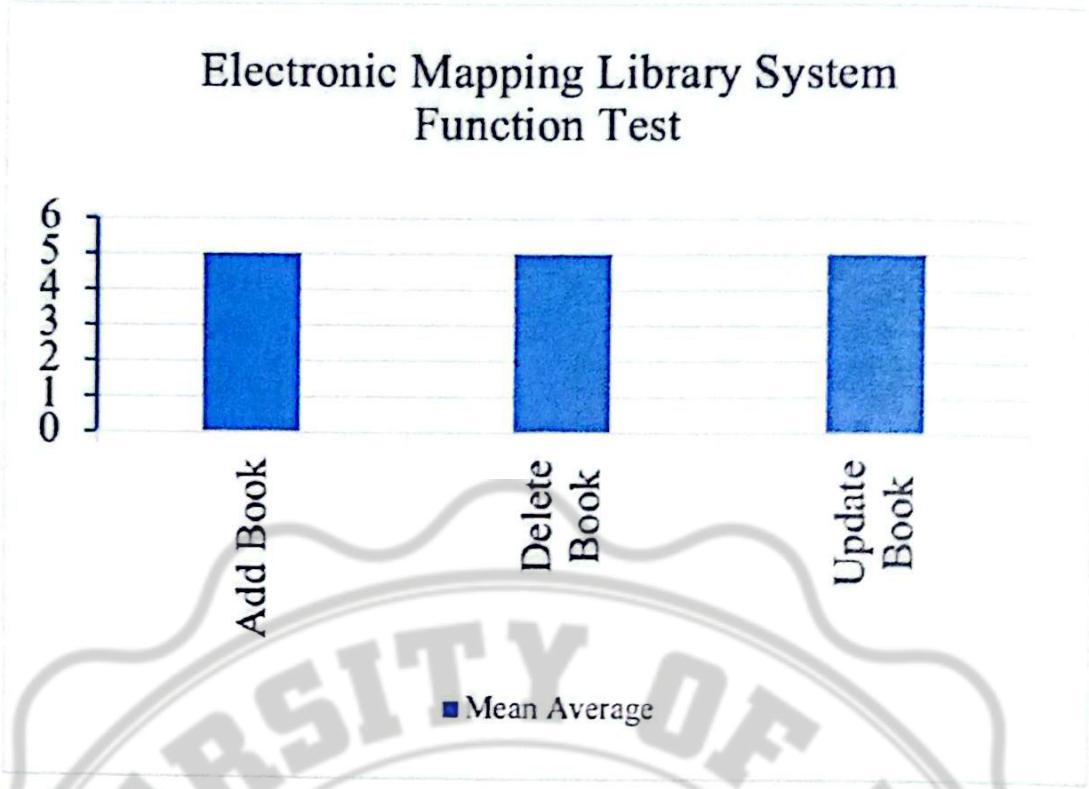

Fig 7. *Feedback Results of Function Testing (Add Book, Delete Book, Update Book)*

IV. CONCLUSION AND FUTURE WORKS

The overriding purpose of this study was to provide the book's location inside the library by providing an Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic. It is necessary to reach the main objectives to accomplish the researchers' main goal. The main objectives are: (1) to provide a video pathway of the shelf's location; (2) to provide a printable pathway of the shelf's location; and (3) to determine the availability of the book inside the library. This study provides a 2D Map picture, a 2D Map Printed Copy, and 3D animation video pathway for the books where they are located. Based on the data collected, the performance of the Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways Developed in Visual Basic in the User Interface achieved a 4.85 out of 5 or 97% satisfaction rate, and the performance of the Electronic Mapping Library System in the Administrator Interface achieved a 5 out of 5 or 100% satisfaction rate. The Interactive Library Mapping and Book Tracking System with Printable and Video-Based 2D/3D Pathways is very helpful to students and visitors. It gives a convenient and versatile way of finding books through a video and a printable pathway that provides the exact location of shelves where the book is located, and for administrators to have an easier way to provide the book's location to the users.

For future work, the system should be able to be used for reservations and borrowing books. The system should be able to use one database that is enabled for multiple users of the system. Moreover, administrators should be able to use RFID to log in and see the statistics of the common books being searched by the visitors. Lastly, for future researchers, the system must be able to print colored pathways and legends.

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