



DEVELOPMENT OF A GENERIC ON-LINE DEPARTMENTAL E-LIBRARY USING THE ITERATIVE DESIGN APPROACH

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ABSTRACT

This work was based on the development of a departmental digital library that is generic in nature as can be adopted by departments of any specialisation. It aimed at providing easy access to textbooks, lecture materials, past questions, project reports, research theses, published articles, current innovations in the field of study of the department, and various online resources to facilitate academic excellence, efficient delivery of information and advance research activities. A generic iterative and incremental software design approach deployed and a well-structured database directory for managing e-resources was designed. The implementation took the two dimensions of the front-end client-side which involved designing both the user interface and user experience while considering factors such as accessibility, readability and usability and the back-end server-side operations which involved creating a connection between the front-end and the server and managing the database. HTML, CSS and Java Script were employed in programming the front-end while the back-end server side was programmed with PHP, MySQL, and a Content Management System. With e-resources uploaded into the cloud and results of tests conducted on the website showed average time to complete an e-resource search and download is 16.2 seconds, result of the readability test is 8.2 and the result of the accessibility test is 79 aggregated from the results of four different accessibility testers. The generic departmental e-library was developed with website designed to provide easy of online accessibility to students and staff of the department.

1.0 Introduction

The information technology revolution has greatly transformed and enhanced the human existence and activities, making life much easier in many areas. Numerous technologies and tools have been developed and deployed as a result of the fast shift in the usage of information technology. A library as a collection of information resources accessible to authorised individuals preserved such resources in either physical (hard copies) or digital form (soft copies), or both. Going historical lane, libraries have been a form of gateway to accessing information, knowledge, and recreation (Alarape and Edet, 2017). Access to books used to be majorly confined to the library building, but advancements in technology, now make it possible to access information resources through online means right at the users' comfort. Information resources in digital form are accessed using electronic infrastructures, providing a paradigm shift from what we are used to online access to information resources (Igbo et al., 2022).

The utilisation of modern technology has become vital for rapid and effective information storage, retrieval and exchange, as well as for offering superior services to users (Odunola et

al., 2018). Ordinarily, any library plays the role of supporting, facilitating and expanding the frontiers of knowledge in both formal and informal education. The digital library interfaces library and information science with computer and communication technologies. It is an offshoot of the electronic libraries with the addition of online network access made available to users to be able to remotely access the contents of the library in electronic form. Several key elements of the digital library are mentioned in (Hiremath et al., 2019).

The Digital Library (DL) platforms provide varieties of digital contents to users, like: managing courseware that enable the provision of documents in different formats, assigning access to contents based on types of users, emphasizing content sharing, and allowing for interactivity (Abraham, et al., 2020; Anyim, 2017). Building a digital library involve activities like acquisition and management of collections, content dissemination and online service provision (Rathee and Kaushik, 2019; Sejane, 2017). The digital library has greatly enhanced library management system to be more dependable, efficient, remote and simple to use. Figure 1 shows a collection of resources and services required in a digital library (Ahmmod, 2016).

Locally stored digital content can have remote access through computer networks. Organisers of e-libraries make use of the catalogue to categorize, classify, and search for books and periodicals. A virtual library is a digital space in which resources are stored and organized. Additionally, it may mean a location where books can be read using computers and mobile devices connected to the internet. Some virtual libraries are operated on free access, while some requires membership registration. Types of digital library discussed in (Henry, 2021) include virtual, automated, hybrid and open libraries, and examples of major internationally operated digital library are the World Digital Library and the Project Gutenberg, which provide free online access to millions of e-books and other e-resources.

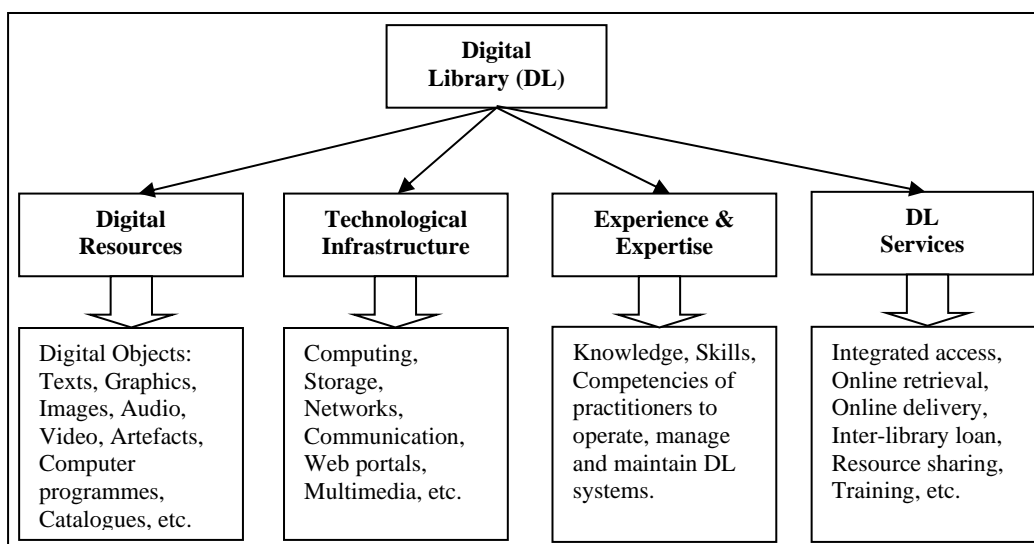


Figure 1: Components and Services of a Digital Library.

Some of the benefits of developing a generic departmental digital library are that it:
 Creates some relief for the central institutional library system.
 Provides opportunity for repository of specialized e-resources.
 Encourages distributed digitalized repository system of e-resources and library resources, as we have in distributed database (DDB) system used in E-learning. Such DDB system maximizes local processing of data, placing it closer to where it is required thereby enabling high level of

data security and availability, and efficient use of each CPU capacity in each location through parallel data processing (Husam, 2020).

Reduces possibilities of high down-time of web links and access to library e-resources.

Brings library resources digitally closer to the students on departmental basis thereby increasing usability of these resources.

Provides better management and preservation of research outputs of the department.

Saves time in searching for intellectual resources. Provides round the clock 24/7 access to relevant departmental and other academic resources to students of the department.

Guarantees possibilities of finding solutions to academic problems and issues without need to seek for appointments with faculty members, except when it becomes very crucial.

The objectives that were set out for implementation in this study are to:

implement open-source e-resources management software that will effectively serve the academic needs of the students of the Department.

source for relevant and adequate e-resources for the e-library.

create a secure access and authentication system that gives access to only the students and staff of the Department.

design a well-structured database directory for the e-resources.

launch the e-library on the internet by creating a dedicated website for it.

The computerized system for managing library operations offers a complete solution for reducing physical work, simplifying the manual method, and reducing costs and stress among other benefits (Thirunavukkarasu et al., 2023). For proper administration of an e-library, a search automation is created and built into the system with the use of a software program such as: Cascading Style Sheets (CSS), Hypertext Pre-processor (PHP), Hypertext Mark-up Language (HTML), or MySQL database. This is done with the V-Model software development process adopted in this work (Adebesin, 2015; Abdulrazzaq and Mustafa, 2017).

An e-library, unlike conventional libraries, organizes and manages collection of resources of knowledge electronically and virtually makes them available to users in digital format via computer network links particularly through the internet. Users access the services with the use of a computer or any network connection devices and an internet connection (Pyrounakis et al., 2014).

Several research efforts have been made on the digitalization of libraries, digital preservations and repositories of institutional knowledge resources. Also, a number of digital system model plans have been developed for effective safeguarding of university library resources (Pyrounakis et al., 2014; Md Monirul et al., 2022).

Roy et al. (2018) developed a library management system that has several features which include user login and an administrator login that enables the administrator to control the entire system. It was aimed at creating a computerized system to manage all of the library's daily operations including software requirement specification (SRS) and had the objectives of increasing control and performance, cutting cost, saving time, creating online notice board option and providing materials for lectures.

Naveed et al. (2021) in their work gave recommendations for improving the library management system in Lahore as follows:

Libraries should give regular practical training to working library staff to help improve their professional capabilities particularly on library management system automation and customizing skills to meet unique needs.

Widely used and publicly accessible LIMS (Access-based) software should be adopted as the standard application for data exchange throughout Lahore's libraries after its renovation.

Foreign software producers should provide low-cost software to poor nations, allowing developing-country libraries to more effectively use foreign software.

Modules such as a mobile app should be connected with Pakistani libraries' library management systems.

Each library should have its budget to guarantee effective software management.

An assessment of online interfaces for library management software systems was conducted by (Shailendra and Namrata, 2011). They indicated that today's libraries have challenges of implementing cutting-edge technology, in preserving of resources and providing access to those resources at the face of shrinking finances, more competition, and increasing demand for more user-friendly services. Hussain, (2020) mentioned some of the popular cutting-edge technologies adopted in library services to satisfy the users' needs as: big data, virtual reality, augmented reality, artificial intelligence, block-chain technology, internet of things, library mobile apps, 3D printers, drones, robots, digital interface for printed books, user-focused interfaces and application, driverless cars, library maker-space, learning management system (LMS), and easy video creations. Jha (2023) made extensive discussion of the application of block-chain technology in the modern library.

Oyetola et al. (2023) noted that global practices are being changed by new technologies such that traditional ways of doing things are giving way to new skills, and information delivery in libraries is experiencing integration and use of artificial intelligence (AI) of robotics, chatbots, use of AI in teaching, learning and research, and so on. Subaveerapandiyan (2023) made an extensive review of employing AI in digital libraries operations like AI chatbots, intelligent libraries, robots, and some other AI applications and how these can revolutionize library operations like retrieval of information, automating routine tasks, streamlining cataloguing, classification and recommendation processes, personalizing interaction with users, and provision of some other innovative services. Hussain (2022) wrote about Augmented Reality (AR) as a new technology which is used to make accessing library information easy and in very short time as it organizes this information in sequential order.

The challenges of digital library were mentioned by Sharma and Chauhan (2019) and Perdana and Prasojo (2020) to include: knowledge and resource management, technological constraints, preservation of resources, inadequate finance and infrastructure, software issues, security problems, lack of expertise, service approaches, and intellectual property rights. In the digital library initiatives of the Library of Congress, ten different challenges categorized under building the resources, interoperability, intellectual property, providing effective access and sustaining the resources were listed. It was noted that technological solutions are not always available to these challenges, but new ways of thinking and ideas sharing may help in resolving some of them.

The challenges of digital libraries in Nigeria were particularly discussed by Igboechesi and Dang (2019) to include, among others: traditional bureaucracies, meritocracy and mediocrity, librarians' indifference, inadequate infrastructure/financial challenge and network and connectivity. With the ever-changing landscape of information technology, libraries must increasingly focus on considerations of the total cost of ownership, as they must choose the greatest, most future-proof items for IT investments and growth. Information retrieval among massive amounts of information in digital library systems has also sparked a couple of research efforts like that carried out by AL-Juboori (2014). Then coming the challenges of utilization and users' satisfaction with the provisions of e-library resource could be dissatisfaction with the type and quantity of the collection of books and other e-resources, displays and menus that may not be easily understood, and so. Features that determine the level of functionalities of an e-library being web-based are noted as: user friendly interface, usability, operative links, accessibility, extensibility, interoperability, reliability, maintainability, response time, scalability, and security (Abdulrazzaq and Mustafa, 2017).

2.0 Methodology

2.1 The Iterative and Incremental Approach

The iterative and incremental approach is one of the generic software design processes used when developing software from algorithms for specific applications. It divides the process of creating software into smaller steps. Each step is called iteration, and each iteration contains processes of planning, designing, development, and testing phases. The iterative approach, in contrast to the waterfall approach, develops elements one at a time, delivering a usable product after each iteration and enhancing functionality as it moves from iteration to iteration. The iterative approach counters the requirement bloating limitation of the waterfall model and also combines the benefits of prototyping and the waterfall models.

The key phases of the generic iterative and incremental model are discussed in the following subsections.

2.1.1 Planning and Analysis

This is the first step in the iterative method. Here the developer meets with the business owner, stakeholder, or client to discuss the requirements.

2.1.2 Design

The design phase was embarked upon after obtaining the iteration requirements. Since this stage is expected to deliver the best results to the client with less cost, the design was an appropriate one. It therefore requires that the design is either an entirely original specification or an expansion of an existing one.

2.1.3 Implementation

In this process, the developer puts the chosen design into practice using a chosen coding technique. While writing the code, the software engineer and developer perform unit test at each phase of the process.

2.1.4 Testing

After implementing the code, then testing is carried out to find bugs in the code, and before they are addressed by the developer if no bugs are found. The developer can create new test

cases or use a previous one created with thorough testing carried out to avoid any error affecting the software's specification.

There are 3 types of testing activities in the testing phase. These are:

Unit testing: involves the testing of individual units of codes,

Integration testing: involves verifying the units of code function when integrated, and

User acceptance testing: is used in determining whether or not the systems met the user requirements for that iteration.

2.1.5 Evaluation and Review

In this stage of the iteration, the entire project is examined to ensure it meets all the client's requirements that have been established at the time. The client is given the project to review and if completely satisfied, the cycle is ended else the adjustments or feedback made by the client is incorporated into the planning phase of the next iteration.

2.2 System methodology workflow

The system shown in Figure 2 depicts the methodology workflow. A website was created in the name of the department and accessed through the domain name. Then, its homepage was loaded; the homepage contains links to the login portal for 3 different types of individuals, which are the staff and students of the department, and the administrator of the e-library website. The flowchart shows a decision tree to determine if the visitor is already registered on the e-library and the next steps that should be taken by the visitor. It also shows the activities the administrator should perform to view, edit, add or delete books and other e-resources, and users.

2.3 Materials requirement

The software used for the design of the e-library system are listed as follows: i. Operating System: Microsoft Windows 7, 8, 10 SPI Professional Edition (64 bits) and later editions., Mac or UNIX OS. For this work, the Windows 10 operating system was used. ii. MYSQL database software: was used to build the e-resources database.

The minimum hardware requirements are Intel® Core™ 2 Duo, 4GB, Web access and peripherals.

Table I: Acquired and Uploaded E-resources.

S/N	Category	Subject	Number
1	E-books	Mathematics	80
		Electronics	136
		Tutorials	234
		Computer	400
2	Articles	Electronic/Computer Fields	272
3	Past Questions	Various Subjects	95
4	Lecture Notes	Various Subjects	65

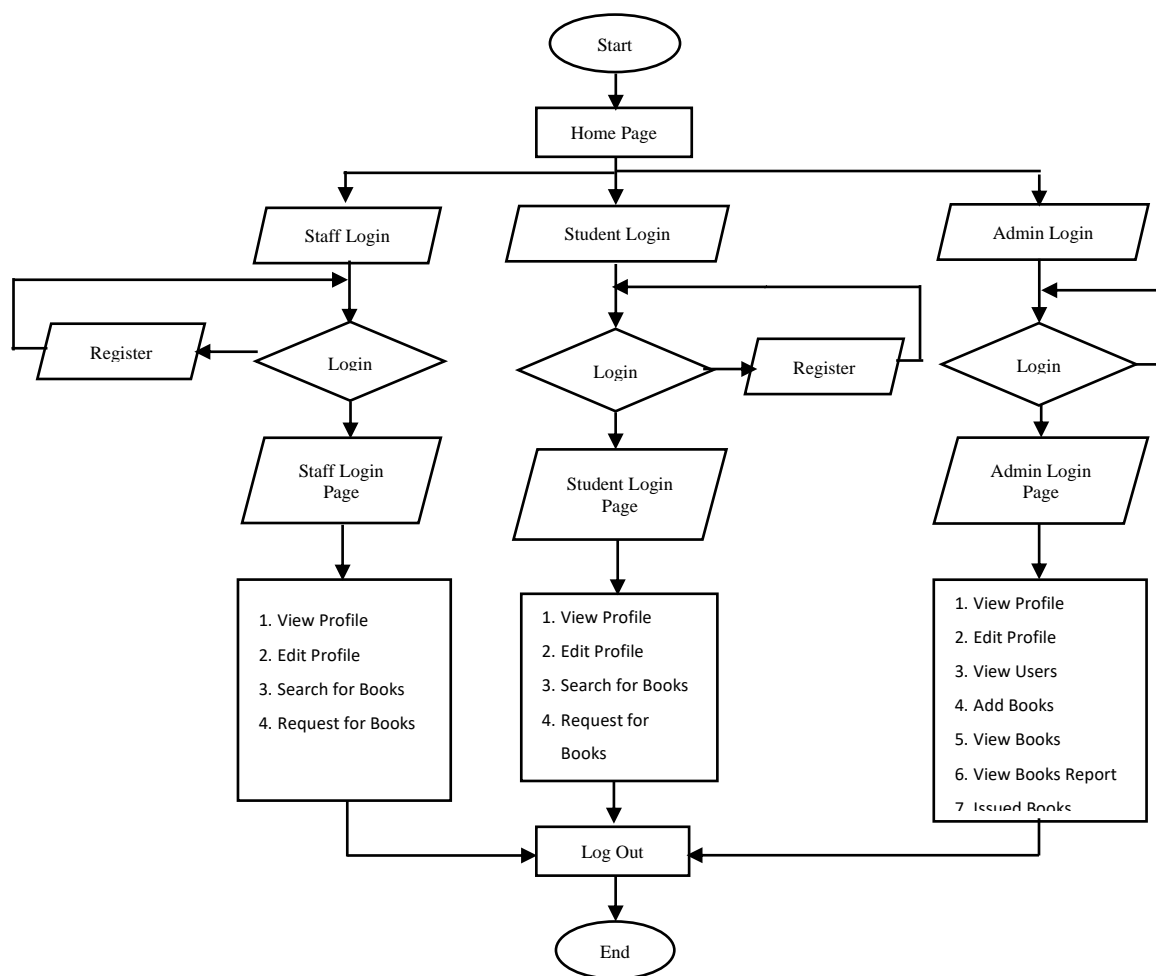


Figure 2: Flowchart of system methodology

2.4 Catalogue tree

A detailed cataloguing process shown in Figure 3 was developed based on areas in which available materials would be harnessed to assist students in their studies. The catalogue majored on core specialization areas that make up Computer Engineering, which are electronics engineering, computer programming and mathematics. Materials in the major subject areas of these specializations that are listed in the catalogue include: past questions, lecture materials/notes, published articles in areas relevant to programme, memos of important concern to the students and e-books in various subjects/courses taught in the programme at different levels of study. The catalogue process was implemented to enable students search for relevant e-resources in an optimized, less-clumsy manner while saving search time. Students can easily locate an item from the digital library's catalogue depending on their preferred method of access. It could function as subject, author, or title catalogue depending on the student's preference due to the filtering and sorting technique implemented.

The process for developing the Catalogue which is displayed on the website page for users of the e-library to help ease their search for relevant e-resource at the shortest time, involves the following tasks:

An Excel spreadsheet was used to construct a catalogue with the fields mentioned above.

The spreadsheet was linked to the SQL database (so it can be retrieved via URL)

The worksheet was updated as new e-resources get added and the cataloguing process progressed.

The excel spreadsheet was used to create a retrieval system search field.
The database was configured using the URL for the spreadsheet.

The Hyper-Text Markup Language (HTML) as the standard markup language for documents designed to be displayed in a web browser was used to write codes which was pasted into the catalogue website so that students can access the catalogue and use it for effective searching of materials (e-resources) they require from the site.

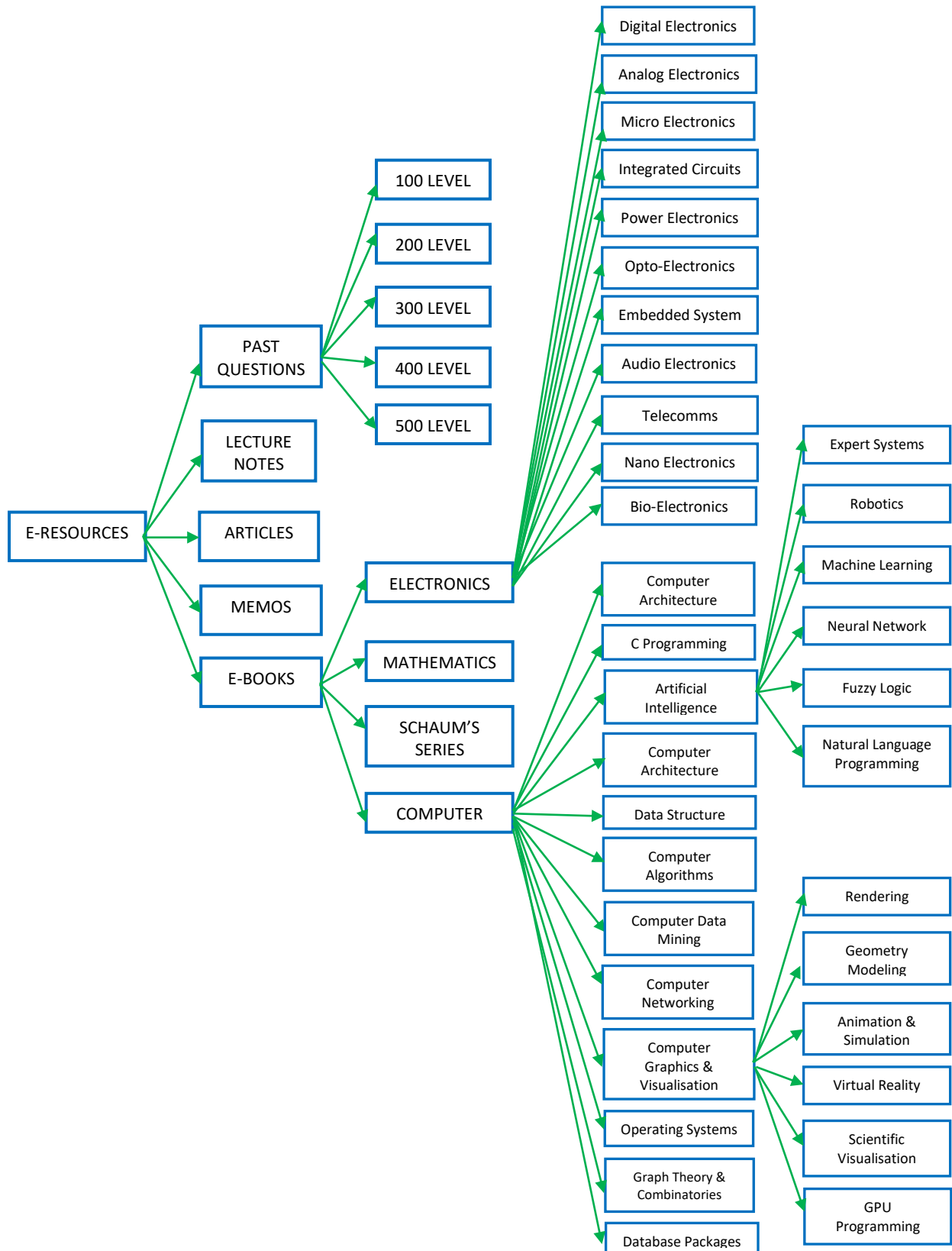


Figure 3: Catalogue tree for e-library resources.

2.5 Acquisition of E-resources

While setting up the e-library system, materials such as e-books, past questions and solutions, journals articles, handouts and lecture materials, college lectures of previous years, and so on, were acquired from academic members of staff, the school library, the internet and the college of engineering of the institution. Past questions and some hard copy lecture notes were scanned using android and flatbed scanners, while softcopy of lecture materials, past questions and marking guides/solutions were obtained from academic staff. Copyright issues where necessary for certain e-resources, particularly for materials that are not published Open Access (OA), were being handled by the University’s central library. This is inclusive of handling the issue of subscription to relevant non-Open Access journals from where articles would be downloaded.

Implementation of the well-defined and structured catalogue includes filtering and sorting technique implemented with the main entry for each e-resource material. This is made up of: Book Title, Author, Publisher, Year of Publication, Category and Language. Evaluating this e-library development, a case of electronics and computer subject related e-resources was embarked upon resulting in acquiring materials listed in Table I. These were acquired, categorized and uploaded unto the e-library site for a test-run.

Table I: Worksheet for Cataloging

S/N	BOOK TITLE	AUTHOR	PUBLISHER	YEAR OF PUBLICATION	CATEGORY	LANGUAGE
1	Artificial intelligence for dummies	John Paul Mueller and Luca Massaron	Wiley	2018	Computers	English
2	Analog and Digital Electronics circuits	R. Prasad	Springer	2021	Electronics	English
3	Introduction to Mathematical Statistics	Robert V. Hogg, Joseph W. Mcken, Allen T.Craig	Persons	2019	Mathematics	English

2.6 Measuring Users’ Satisfaction

There are various methods used in reporting the satisfaction of users of an e-library. These include: End-user Computing Satisfaction (ECS) and Importance Performance Analysis (IPA). From any of these methods, the Customer Satisfaction Index (CSI) can be calculated to obtain the overall user satisfaction (Simon and Ogom, 2015; Hamzah et al., 2022). Users’ satisfaction to a large scale can also be rated using Usability Testing, discussed in subsection 2.7.3.2 and used to determine user’s satisfaction index for this work.

2.7 Methods for administering the Webpage

The e-resources uploaded to the site at start-up are stated in Table 2.

Table 2: E-resources uploaded at the onset.

S/N	E-RESOURCES	NO. OF E-RESOURCE
1	E-books	850
2	Articles	272
3	Past questions	308
4	Lecture Notes	195
5	Memos	5

2.7.1 Users' registration and book search

Users of the e-library, which are students and staff of the department, are meant to register on the e-library website. Figures 4 to 7 show the e-resources uploading page, the e-resources collection page, the users' registration page and a search engine usage page, respectively. To have access to the e-resources after registration, users login to the site, then search for materials they so needed.

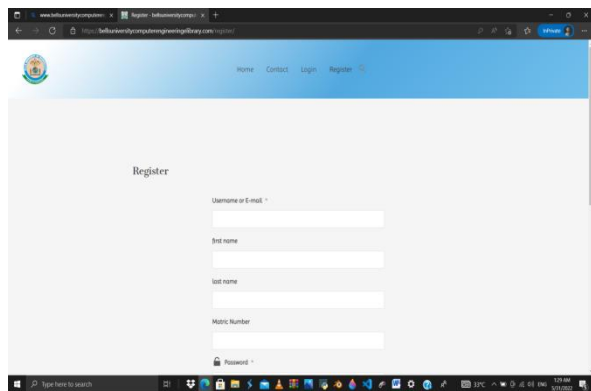


Figure 4: Membership Registration

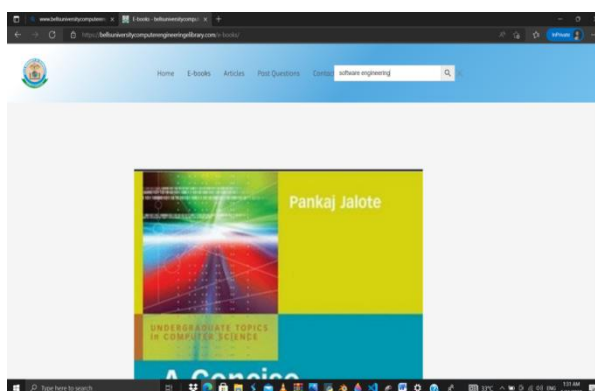


Figure 5: Search engine

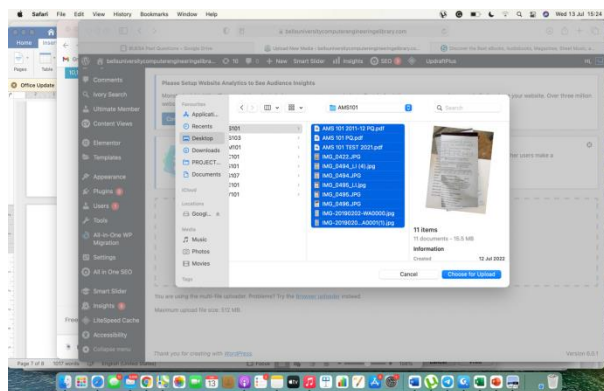


Figure 6: Uploading page screenshot

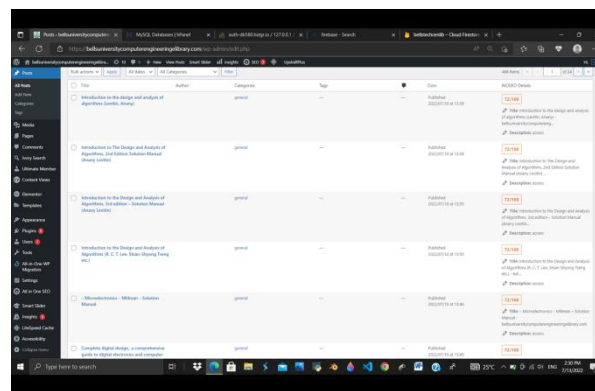


Figure 7: E-resources collection

2.7.2 Analysis of the database management system

The e-library database management system was implemented and tested using the following parameters:

2.7.2.1 Efficiency testing

The implementation of a digital library system makes books transaction (uploading new materials and accessing them) easier for the Department of Computer Engineering students and staff.

2.7.2.2 Reliability

The system's membership registration, validation, books transaction, generation of the report, and search engine were accurately performed.

2.7.2.3 Usability

The system is a user-friendly environment that makes it easy for the students and staff of the Department to perform tasks more effectively by rating how usable or satisfying the e-library platform has been.

2.7.2.4 Readability testing

The readability test was carried out by using the automated software WebFX that evaluated the website by applying multiple readability formulas. Most readability tests hope to achieve readability scores that fall in the range of content that can be easily understood by fifth graders. Hence, the readability score for the E-library should be measured with respect to its target audience, which are the Department’s students and staff.

3. Results and Discussion

Tables 3 and 4 show the results of the e-resources of e-books and past questions that were loaded into the database for use by students of the Department of Computer Engineering. It is expected that over time, with further administrative efforts, the number of e-resources would be increased. Table 5 gives the result of the usability test conducted for five participants with the use of the Hallway test. The average time to complete a task of accessing the site, searching for required e-resource and obtaining it is 16.2 seconds with the task completion rate of 100 % for each participant without any error.

Table 3: E-book Classes loaded in the database.

S/N	E-BOOKS TYPE/SUBJECT	NO. OF E-BOOKS
1	Mathematics	80
2	Electronics	136
3	Schaum’s Series	234
4	Computer	400

Table 4: Result of past question e-resources in the database.

Level	Session		
	2020/2021	2021/2022	2022/2023
100	15	15	18
200	18	20	24
300	17	21	22
400	9	8	10
500	16	19	20

Table 5: Result of the Usability Test.

Parameter	Participant1	Participant2	Participant3	Participant4	Participant5	Avg
Average time to complete task (in seconds)	17	15	13	23	13	16.2
Task completion rate	100%	100%	100%	100%	100%	100%
Number of errors	0	0	0	0	0	0

Shown in Figure 8 is the result of the Readability Test. This test result shows that the site has an average reading ease of about 8.2 of 100 and should be easily understood by 17 to 18-year-olds. It shows a generally low readability score, which is understandable to the target audience and acceptable for now.

Shown in Figure 9 is the result of the accessibility test carried out with the use of four different automated software tools, namely: Audioeye, WAVE, axe and HTML_Codesniffer. Each tool gave individual total number of tests, as well as failures encountered. What is shown in Figure

9 is the average test score of 79 for the four test tools. This result shows that the E-library website is largely compliant with accessibility guidelines.

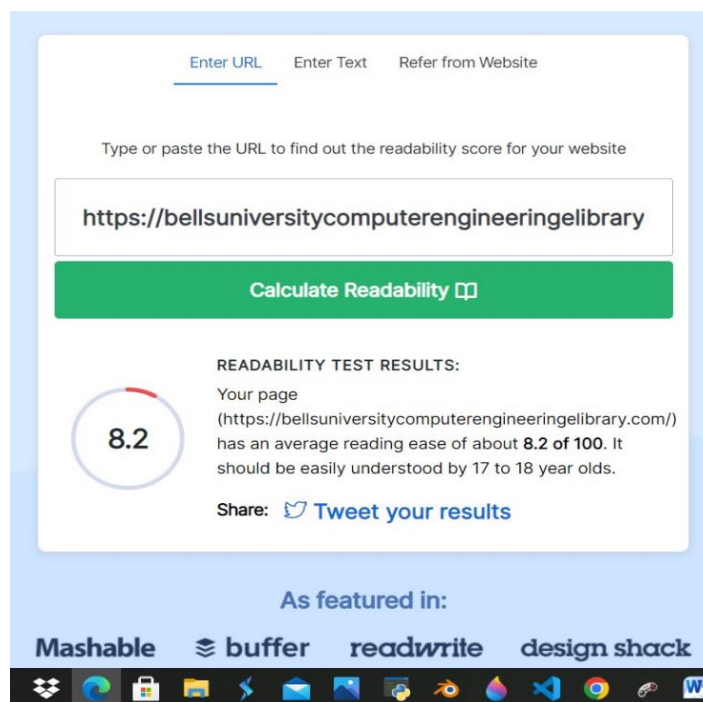


Figure 8. Result of readability test

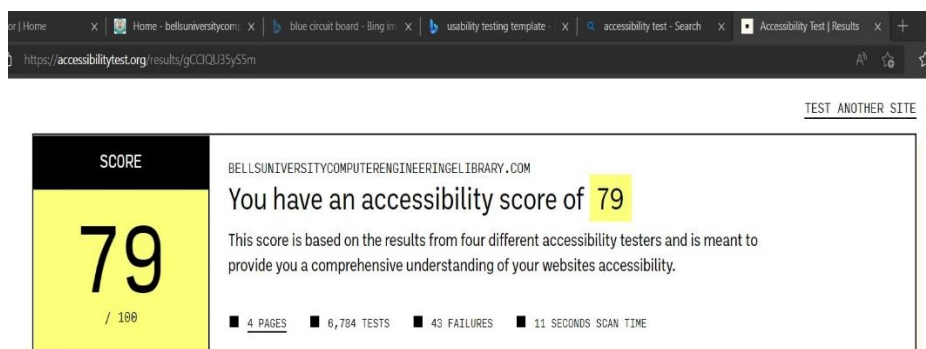


Figure 9. Result of accessibility test

4. Conclusion

The aim to develop a generic departmental digital library that will be accessible to its students and staff to obtain e-resources was achieved. E-resources in major subject areas of computer engineering were loaded from the backend of the content management system using the catalogue tree into the e-library website in the cloud to ensure smooth and easy management. The verified process helps to restricted access to the e-library. Algorithms for more advance search engine, fascinating web crawler for e-library systems and automatic users' registering and authentication will enhance future works.

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