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ADAPTIVE LEARNING SYSTEM BASED ON DESIGN THINKING TECHNIQUES

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ABSTRACT

In today's fast-paced and ever-evolving educational landscape, students, lecturers, professionals, and researchers often struggle with traditional learning methods that do not cater for individual learning preferences. Conventional systems fail to adapt to the varying cognitive abilities of learners, leading to inefficiencies in knowledge retention and skill development. To address this challenge, the Adaptive Learning System Based on Design Thinking Techniques was developed. This system leverages the principles of design thinking to create a personalized learning experience tailored to individual learners. By integrating adaptive learning models, the system dynamically adjusts learning materials based on user interaction, performance, and feedback. It provides real-time assessments, interactive content recommendations, and personalized learning pathways that evolve as the learner progresses. Experimental results demonstrate that the system significantly improves engagement and knowledge retention by offering a flexible, student-centered approach. By integrating design thinking technique, the learning process becomes more innovative, problem-driven, and user-focused, ensuring that learners not only acquire knowledge but also develop critical thinking and problem-solving skills essential for real-world applications.

Keywords: Adaptive Learning System, Design thinking, Personalized Learning, Knowledge Retention, Student-Centred Approach

INTRODUCTION

Adaptive learning is a technology-based educational approach that customizes teaching methods and learning experiences by analyzing a student's performance in real time (Lynch, 2017). Also known as adaptive teaching, it employs computer algorithms to orchestrate learner interactions and deliver tailored resources and activities that address each learner's unique needs (Andreas, 2021). Unlike conventional systems, adaptive learning environments dynamically modify the type or level of curriculum content based on student abilities and progress. These systems enhance learning outcomes by providing just-in-time feedback, personalized learning paths, and adaptive resources (Taylor et al.,2021). Their overall aim is to improve learning speed, accuracy, and quality through both automated processes and teacher interventions (Weber, 1999).

Adaptive e-learning systems can be categorized based on their level of responsiveness. Santally and Senteni (2005) explain that adaptation in e-learning occurs at two levels: adaptable systems, where users directly change parameters to suit their preferences, and adaptive systems, where the system itself automatically modifies its behavior in response to assumptions about user needs. Тищенко and Стрюк (2018) further emphasize that adaptive systems enable learners to study at their own pace, which enhances the efficiency of knowledge acquisition. They also highlight the objectivity of adaptive technologies in educational assessment and their ability to generate individualized sets of tasks tailored to each learner's cognitive profile.

A crucial component of adaptive learning is the accurate assessment of learner ability, which ensures that personalization is meaningful and effective (Contrino, 2024). Item Response Theory (IRT), as discussed by Van der Linden and Hambleton (1997), has become one of the most widely recognized psychometric models for measuring learner ability. Its integration into adaptive systems allows for precise, data-driven adjustments that improve both instructional delivery and outcome evaluation.

This research is important because it addresses the real challenges that many students face in traditional learning environments. Every student learns differently, and a one-size-fits-all approach doesn't work for everyone. Some students may struggle with the pace or format of traditional lessons, and this system is designed to help those students by offering a more personalized learning experience. By tailoring lessons to fit the needs of individual learners, the project aims to ensure that no student is left behind and that each one is given the best opportunity to succeed.

The findings of this research will enable raising of awareness of the need for adaptive learning systems to be integrated into school curriculums. Many educational institutions are still using outdated methods that do not fully address the diverse needs of today's students. The findings will be used to encourage schools and educational policymakers to take steps toward adopting these modern approaches, ultimately improving the learning experience for all students, not just those who struggle. Hence, this research therefore develops a web-based application to address the need for adaptive learning system that can be adopted in schools and higher educational institutions.

MATERIALS AND METHODS

The phases of design thinking process are Empathize (acquiring information or knowledge through conducting interviews and distributing questionnaires) and Determination of Student's Learning Style.

There are numerous types of learning style models that a user can determine to us to learn, here are some of these models

namely: Kolb's Learning Model, VARK Model, Felder–Silverman Learning Style Model and Dunn and Dunn Learning Style Model (Emily, 2023). In this research, the VARK (Visual-Auditory-Read/Write-Kinesthetic) Model was implemented in order to gather information and determine the learning style of users. VARK Model: This model is made up of four models; Visual, Aural, Read/Write, and Kinesthetic learning styles.

A web application was developed for the system using the following tools using HTML, CSS, JavaScript, PHP, Bootstrap, and SASS. The Visual Studio Code was used as Integrated Development Environment (IDE). The MongoDB database was used to store, retrieve, and manage application data efficiently. A 64-bit Core i5, 2.4GHz system and a 2GB RAM was used.

Model Development

This section outlines the steps in a combined Agile and design thinking approach for developing the application. The Agile model, known for its iterative and user-centered nature, aligns well with design thinking, supporting continuous improvements based on user feedback. This diagram details the steps taken in a design thinking approach in the development of the application as shown in Figure 1.

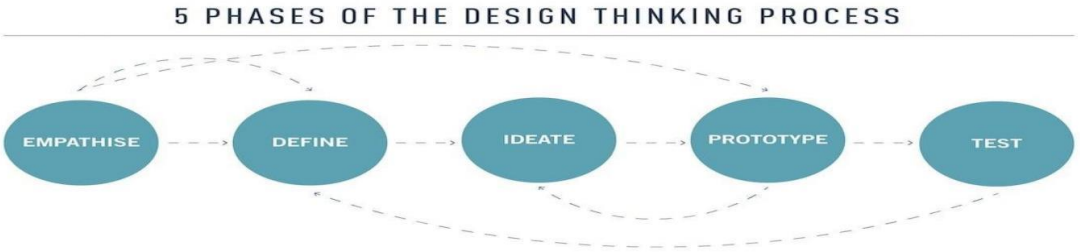

Figure 1: Phases of the Design Thinking Process (Emily, 2023)

Empathize

Acquiring information was done through conducting interviews and distributing questionnaires to determine Student's Learning Style. This involves getting to know the user and understanding their wants, needs, and objectives. This includes gathering knowledge or data from the students. You may also be required to immerse yourself in users' physical environments (such as classrooms and learning centers) to gain a deeper, personal understanding of the issues involved—as well as their experiences and motivations. This goes a long way in identifying and addressing students who require Adaptive Learning Systems. This information provides a foundation for defining the problem.

Define

After the initial stage, data collected from various sources (schools, special centers, educational, and students) is analyzed to define users' core needs. This is done by using the statistical functions of Ms Excell package. The primary problem identified is that students with knowledge gaps require an opportunity to learn as effectively as their peers within a similar timeframe. Knowledge gaps can vary, meaning some students need more tailored attention than others. The problem can thus be defined by identifying these knowledge gaps and determining the appropriate learning paths for each student.

Ideate

With a clear understanding of users and a defined problem, potential solutions are generated through ideation techniques. Brainstorming is a primary technique used here, enabling the creation of as many ideas as possible at the beginning. Toward the end of ideation, ideas are narrowed down to a few viable options to proceed with.

System Design

In this phase, the application's structure, interface, and data requirements are laid out in detail based on the problem and solutions identified during ideation. System design includes database architecture, interface design, and the technology stack, ensuring that the prototype aligns with the project requirements and objectives.

Prototyping

Using various tools and frameworks, the prototype is developed. JavaScript, a popular client-side programming language, is utilized to create the web application, allowing for a cross-platform solution from a single codebase.

Testing

The system is tested with students who require Adaptive Learning Systems to assess its effectiveness and usability. Testing includes functionality, user acceptance, and performance testing to ensure the application meets the users' needs and resolves the defined problem effectively.

System Architecture

The system architecture (Figure 2) of this system involves the interactive mechanism between the user and the system. The user inputs data which is used to determine the learner's level of understanding. Based on the level of understanding, an appropriate lesson is recommended for the user. Learners who are utilizing the system for the first time must first register with the system by filling out a registration form. Once a learner registers, a learner profile is established to house all of his data and is saved in the

database. The learner is then assigned a unique identity (ID) for future use.

Fleming's visual, aural, read/write, and kinesthetic (VARK) learning type model (Jumrah, 2022). The system divided pupils into the following four groups: a preference for the visual, which includes how information is represented in maps, diagrams, flow charts, and all other symbolic forms; a perceptual style of hearing that expresses a preference for hearing or speaking information; Kinesthetic modality, which refers to the perceptual preference associated to the use of experience and practice and Read/Write preference for the information shown as text. The domain model, which incorporates a collection of domain concepts like facts, lessons, and problems to build a sort of semantic network, is a knowledge representation of the contents that the learner must master. It refers to the environment that the learner actually learns.

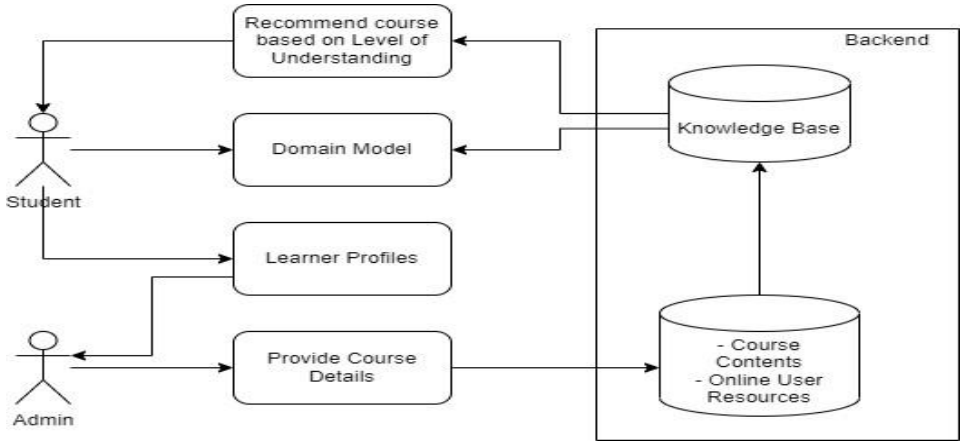

Figure 2: System Architecture

Flowchart of the System

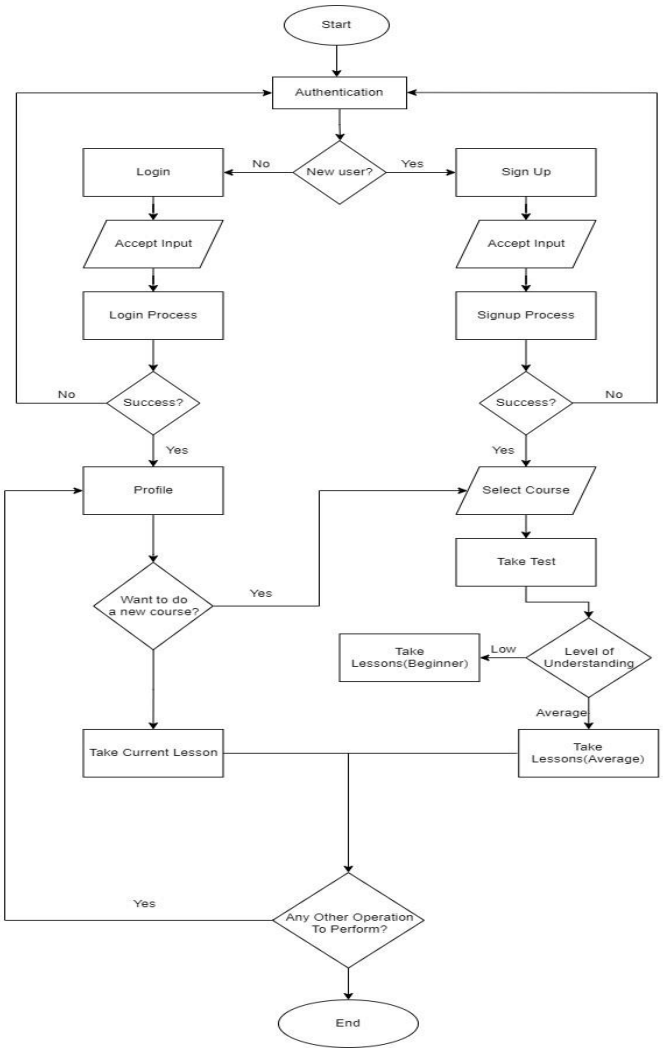

Figure 3: Flowchart of the system

A flowchart is a visual depiction of a process. It was developed in computer science as a representational tool for algorithms and logical programming, but it has now expanded to be used in all other sorts of processes. These days, flowcharts are crucial for displaying information and supporting arguments. They aid in the visualization of complex processes or make the structure of issues and activities clear. A flowchart can also be used to outline a project or procedure that has to be put into action. Figure 3 presents the flowchart of the system.

RESULTS AND DISCUSSION

The result of VARK Model is given in Fig.5 as follow:

Visual: Visual Learners are those who learn by seeing or watching demonstrations. The representation for that in the chart ss “Interesting design and visual features

Auditory: Auditory learners are those who learn through verbal instructions from themselves or others. The representation for that in the chart is "Audio channels where I can listen to podcasts or interviews"
Read-Write: Read-Write learners are those who prefer to use words and textbooks to learn new information. The representation for that in the chart is "Interesting written descriptions, lists, and explanations"
Kinesthetic: Kinesthetic learners are those who prefer to learn by doing and with direct involvement. The representation for that in the chart is "Videos showing how to do or make things" As the Figure 4 entails, most of the users are kinesthetic learners with over 64% of the input gathered.

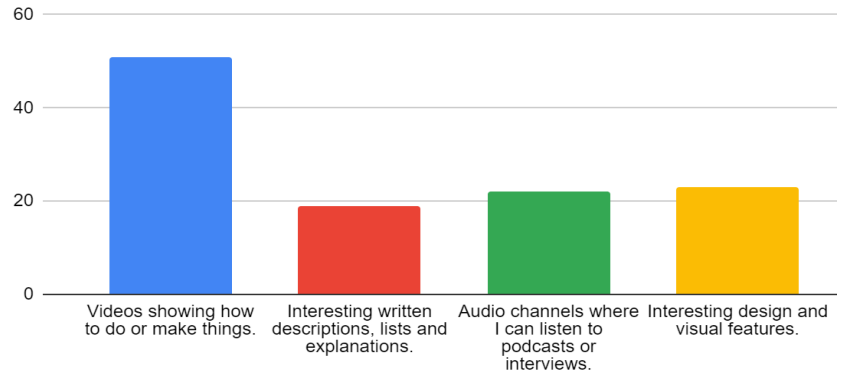

Figure 4: Determination of Student's Learning Style

Amount of Time Used by Users
The amount of time spent on the users' current adaptive learning system is represented here as it shows that the majority of users spend about 15 minutes or less learning each day. Figure 5 is a pie chart representation of the record:

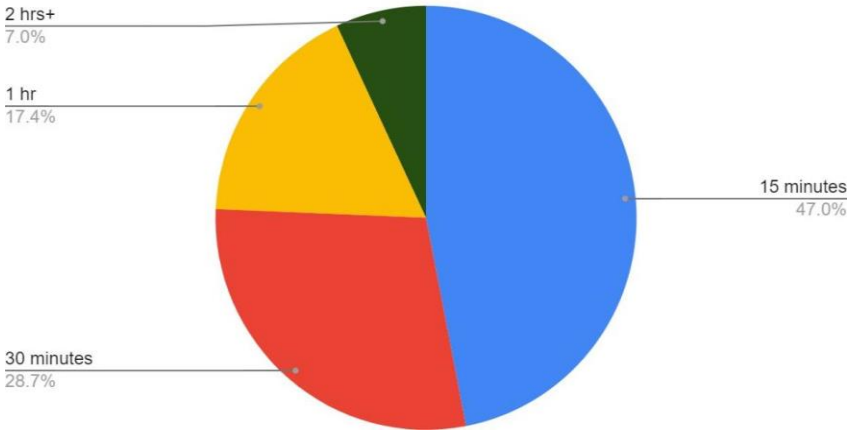

Figure 5: Amount of Time Used by Users' Analysis

Traditional Teaching Method
The different representations with 115 responses also show the responses where a number of respondents strongly agree (18.3%), agree (39.1%), neutral (33.9%), disagree (7.0%), and strongly disagree (1.7%). Figure 6 is a pie chart representation of the inputs:

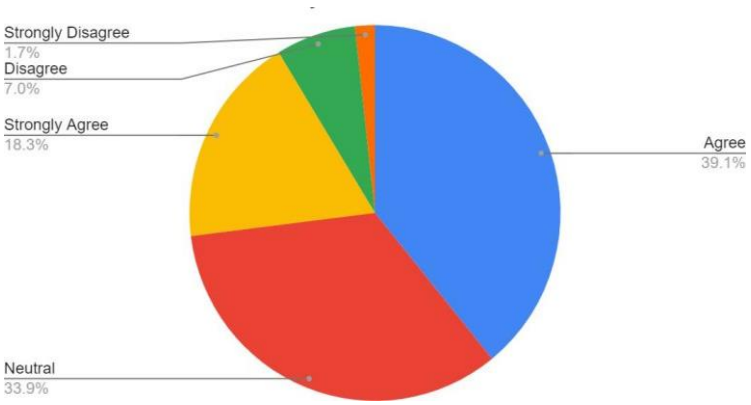

Figure 6: Traditional Teaching Method

Demographics of Prospective Users

A group's demographics are its traits. Demographics commonly utilized in data collecting include things like gender, age, education, profession, and occupation. The following were the demographics recorded:

Age Determination

The different representations with 115 responses show the age of respondents where there is a larger population of the age 19-23 group (58.3%), followed by the 16-19 age group (33.9%), and lastly, the 24+ age group with only 7.8%. Figure 7 is a bar chart displaying the records inputted:

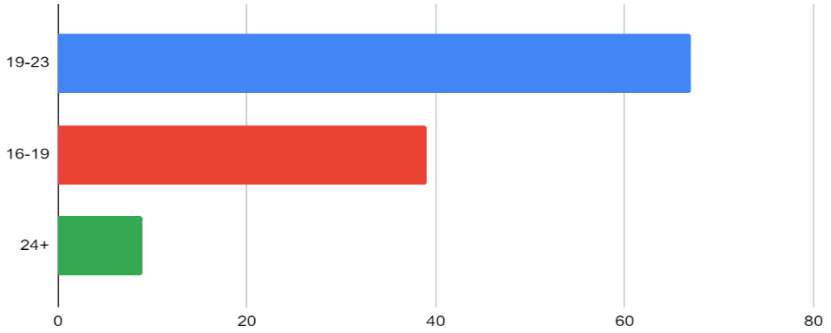

Figure 7: Age Analysis

Gender classification

The different representations with 115 responses show the gender of respondents separating the males with a percentage of 54.7% from the females with a percentage of 41.7% and a very small percentage of 0.9% preferred not to say. Figure 8 is a bar chart displaying the records inputted:

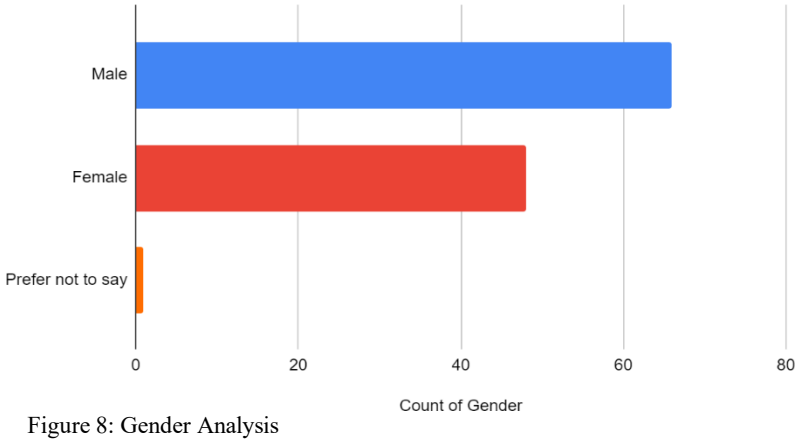

Figure 8: Gender Analysis

Reasons For Using Adaptive Learning Systems

The different representations with 115 responses show the different reasons that would cause a learner to use an ALS; To meet up with your educational standards (19.8%), For fun with a percentage of 23.3%, For Work (52.6%), For studying (4.3%). See figure 9.

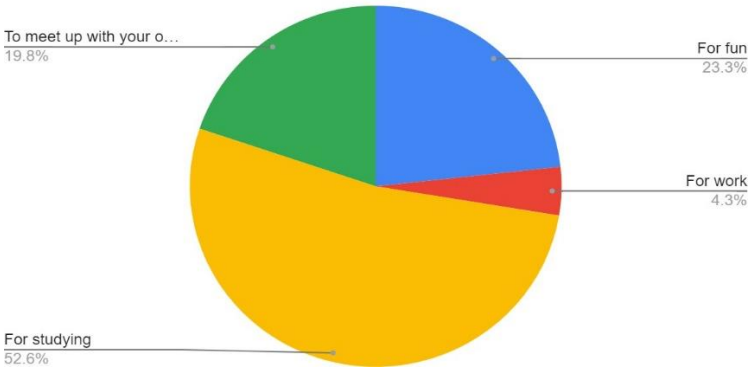

Figure 9: Reasons for using Adaptive Learning Systems

System Deployment

The system was deployed on a web application. It was developed to make the whole system user friendly. Students that have been determined to require adaptive learning systems are the initial user of the application. The students have direct access to the home page where the learning takes place. The design thinking application pages has sign in, sign up, Landing page, courses Select, home, Java course, course description, testing and course material. Some of the figures are presented below:

Sign-In Page

Existing users must enter their email address and password in a form on the sign-in page. To sign up, new users must click the sign-up text, which will direct them to the sign-up page. Matching users to their accounts is the aim of this page. Figure 10 shows the Sign-in page.

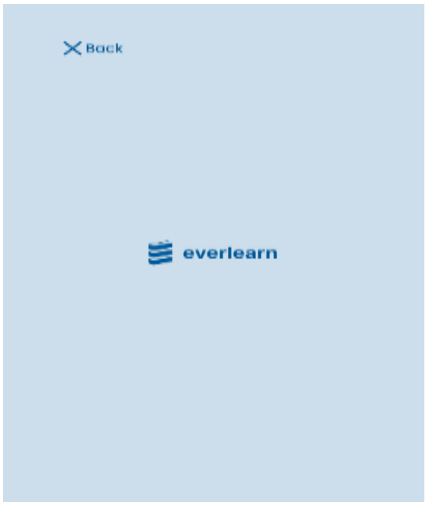

Figure 10: Sign-in Page

Landing Page

The landing page is divided into three (3) sections. These sections are structured based on their content focus. The first section is the Hero Section, which includes a welcoming message for learners, a call-to-action button labeled "Get Started," and a notification banner indicating that a new course is available. This section also showcases category tags such as Python, C++, UI/UX, and Web Design, allowing users to filter courses easily. Additionally, there is a grid of images displaying students engaging in online learning activities.

The second section is the Courses Section, which highlights various courses available on the platform. Courses are visually represented with their respective icons and titles, including C++, Python, Web Design, React, British IELTS, and C#. A description under each course provides a brief summary of the learning outcomes. A call-to-action text labeled "Engaging Courses" is present, along with another "Get Started" button for user engagement.

The third and final section is the Programs Section, which introduces Everlearn as a course solution offering adaptive learning experiences. It contains a detailed explanation of how the platform delivers high-quality content to improve student outcomes. This section also features a footer with navigation links (Home, Courses, Programs) and a subscription field for users to get product updates. Social media icons for LinkedIn, Facebook, and Twitter are also available.

A user can explore courses, learn about available programs, and sign up by clicking the "Get Started" button. The structured layout ensures easy navigation and access to learning resources. Figure 11 shows the landing page of the system.

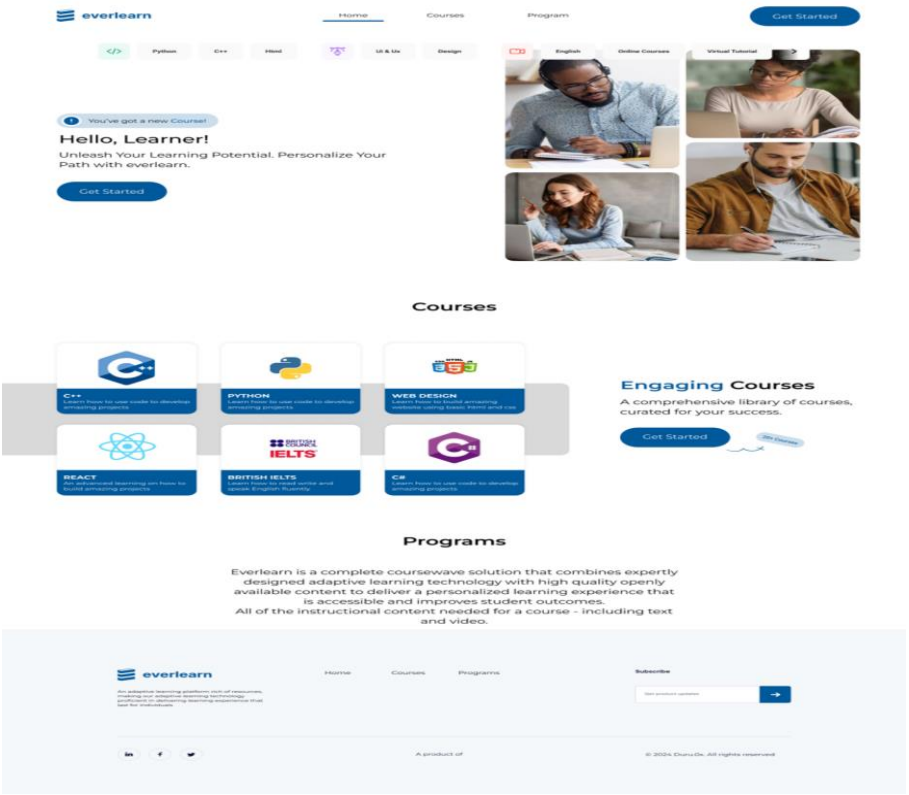

Figure 12: Learner's Landing Page

Home Page

The user dashboard page is divided into three (3) columns. These columns are separated based on their topics. The first column is Computer Science which includes C++, Java, and Python. The second column of Language includes English and French. The third and final column is the Engineering column including Software Engineering, Aerospace Engineering, and Chemical Engineering. A user can also access the profile and log out of the account by clicking the 'sign out' button. Figure 12. Shows the home page.

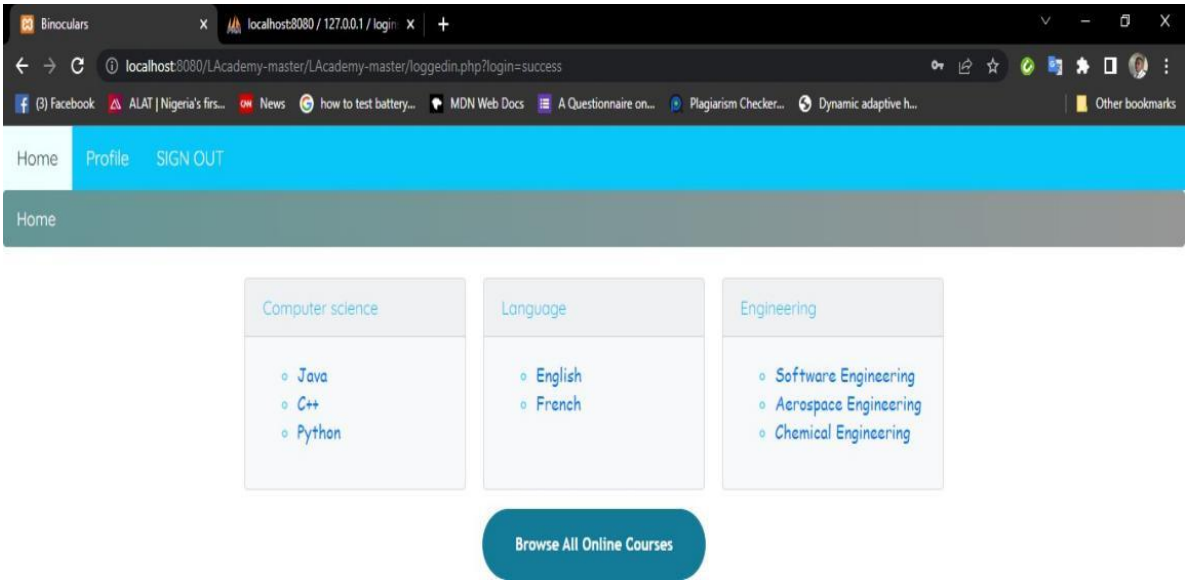

Figure 12: Home Page

Course Material Page

After the introductory test, the learner now knows where to begin his/her learning path using the information gotten. This is where the learning takes place. On this page, a user is required to select a chapter of the course which displays a dropdown menu of the topics under that chapter. A topic is selected which proceeds to play a YouTube video explaining that topic. See figure 13.

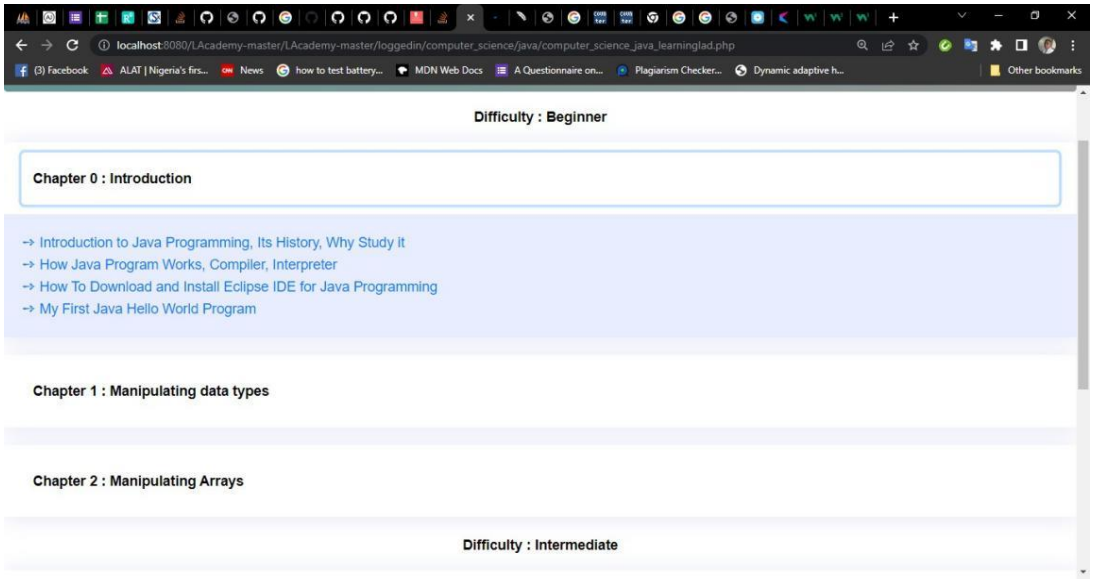

Figure 13: Course Material Page

Testing

Tests were conducted to guarantee that the implemented adaptive learning system performed as intended. Software testing called "integration testing" involves integrating and testing various software components at once. The web application developed was tested on students who require ALS in Babcock University. A total of ten students (five males and five females) aged between 19 and 24 interacted with the application. The level of understanding and comprehension of these students are assumed to be low. Each student takes the learning style test and pre-introductory test before starting a course.

Table 1: Summary Data of Tests

ID	Test Description	Expected Result	Actual Result	Result
3	Take Test	Loads Test	Loads Tests	Pass
7	Reset Password	Reset Password Successful	Reset Password Successful	Pass
8	Authentication	Successful Authentication	Successful Authentication	Pass
9	Logs out	Logs user out.	Logged userOut	Pass
10	Update Profile Picture	Updated Profile Picture	Updated Profile Picture	Pass

Discussion of the System

The systems authentication allows students to register with their name, email, and password and the system shall inform the customer if the account creation was successful. Also, the system allows registered customers to authenticate with their email and password. The full name, educational level and preferred mode of learning of users was collected. Furthermore, the system allows the student to select the course they wish to learn and makes the users take an introductory test before starting a course to determine the users' level of understanding. The system would maintain an easy-to-use interface across all its components for users.

The system's interface is compatible with all commonly used Web browsers. The system can scale based on the number of users that will be using the system. The system is protected from unauthorized access. And the database is protected from attacks and unauthorized. The system can run on a variety of operating systems such as Linux, macOS, and Windows. It can also run on a variety of web devices irrespective of the manufacturer. The system is easy to maintain with clear separation between the business, logic and presentation layer.

CONCLUSION

This research aimed to develop a web application to provide students that require adaptive learning systems with a personalized and tailored learning experience to be able to keep up with those who do not require ALS using the design thinking approach. The research has been able to successfully capitalize on a design thinking approach to understand the requirements of students that require an adaptive learning system. The developed system provides an effective and efficient way for students to learn course content and determine their learning style. It also shows how the adaptive learning systems in better than the traditional method; for example, adaptive learning helps in providing focused attention to an individual, i.e., it provides a more personalized learning experience. Further research will focus how application can be tweaked and fine-tuned to support multiple platforms such as mobile, etc. More lessons should be added. These lessons should not be restrained to the courses already introduced in the web application.

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