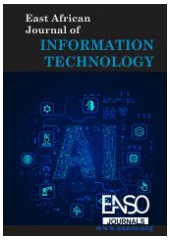

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Original Article

Development of Biology Virtual Laboratory

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ABSTRACT

This paper describes the application of the development of a biology virtual laboratory which will enable students to conduct practicals as many times as they can with no cost in terms of laboratory apparatus and chemicals required for conducting their biology experiments. The development of science and technology, which is increasing fast, requires the world of education to improve the quality of education. Visualization and the conduct of laboratory experiments are the most effective ways to simplify and clarify the comprehension of complex theories. Virtual learning environments provide students with the opportunity to get a better understanding. The intention of this project is to develop a biology virtual laboratory for ordinary-level students that improves the learning achievements of students resulting in better performance, especially in many of the government schools where there is inadequate quality biology laboratories. The project aimed at eliminating constraints on traditional laboratories by coming up with a gaming-like android-based application system with visualization of biology practical for ordinary-level secondary schools mainly in food tests and classifications. Students are able to reconduct the experiments until they catch up with no cost of laboratory apparatus by using the game-like developed application.

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INTRODUCTION

The development of a virtual biology lab is a thematic approach to the development of science education. Integration of several disciplines into one comprehensive subject is hoped to help build not only a knowledgeable but also a competent student who is able to implement the concepts in everyday life.[1] [2]. The learning itself is hoped to bring deeper meaning to students, provide a better learning condition through experiments, and help student generates a comprehensive understanding of important issues.[3]; [4]; [5] Biology virtual lab will help the students with analytical and problem-solving aptitudes to prepare them for real-life working environments. Knowledge with applicable implementation on solving problems is the definition of scientific literacy.[6] Scientific literacy is defined as the knowledge and skills required to identify problems, acquire new knowledge, explain natural phenomena, and draw conclusions based on presenting evidence. [7]–[9] Biology virtual lab increases the extent to which a student, teacher, or institution attains their educational goals, learning that goes beyond the memorization and recall of information and facts and the ability to store new information in one's long-term memory, so a person can easily recall it and put the knowledge to use in the future [10]

Many Tanzania government schools face problems in getting good achievements in students' understanding of biology practicals due to lack of quality laboratories. The presence of 3D software that gives science teachers and students complete access to a fully equipped laboratory that teaches biology concepts and techniques through a fun, engaging and highly immersive learning experience will automatically improve the academic achievements of many students including slow learners as they can repeat the experiments as much as they can until they catch up with no costs.[11] [12]

VIRTUAL LABORATORY DEVELOPMENT STAGES AND METHODS

This study uses the four stages educational research and development model with the define, design, develop, and disseminate phase.[2]

Defining

In the define phase, problems from Lupeta secondary school were analysed to identify content and context which will be built into the virtual lab. Analysis from Lupeta Secondary then triangulated with curriculum analysis, in this case, is the 2023 curriculum [13]. The next step was to do literature research in order to define the concept of a Biology virtual lab. In this step, I realized that many works already done favoured a lot of private schools where there are enough learning resources compared to the government schools where there is a scarcity of learning resources.

Designing

The design phase consists of making a flowchart, storyboard, and user interface of the program. The biology virtual lab is designed using an object-oriented approach, where real-world objects and their functionalities are translated into corresponding digital representations within the software. Modular design principles will be followed to create reusable components and facilitate future modifications and expansions [1],[16]. The biology virtual laboratory is designed using an object-oriented approach, where real-world objects and their functionalities are translated into corresponding digital representations within the software. Modular design principles will be followed to create reusable components and facilitate future modifications and expansions.

Development

This involved the development of a biology virtual laboratory that is robust and performant to

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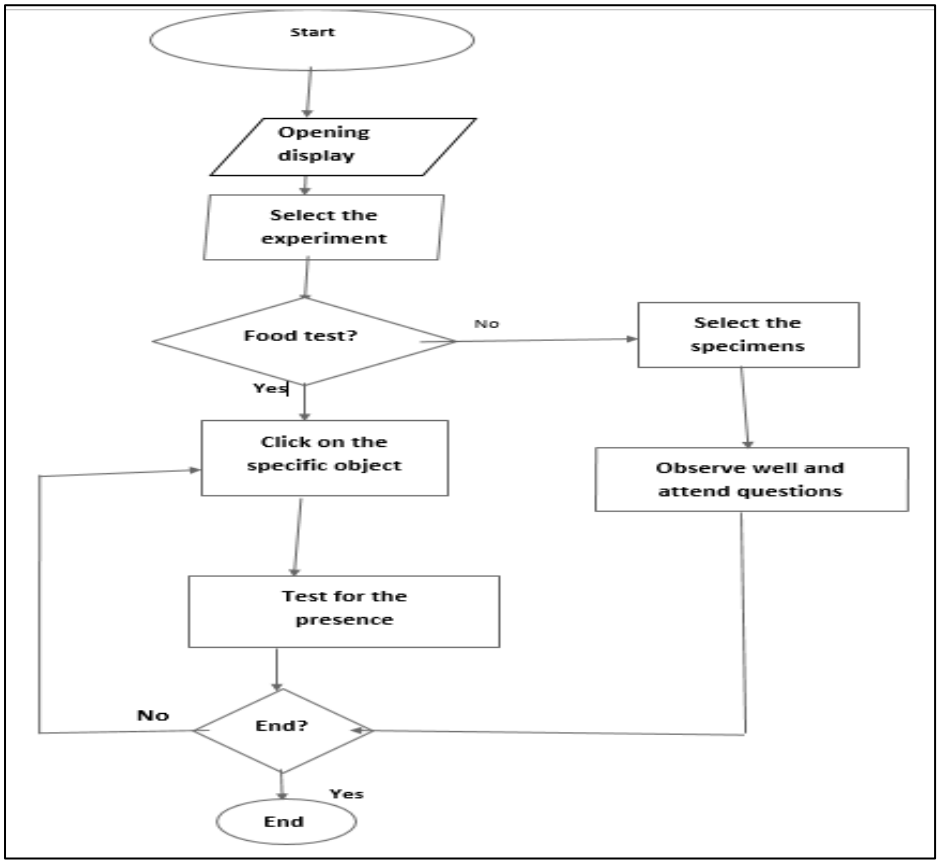
allow students to perform experiments in a distance environment without the existence of a physical laboratory. The flow of information on the developed game-like application is shown below in the flow chart.

Figure 1: Flow chart



This is where the biology virtual lab was made by using the most popular and strong 3D software and texture mixtures such as Unreal Engine, Unity, Quixel Mixer, and 3D Max.

Plate 1: Unreal engine logo.

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The Unreal engine is the primary software in the development of virtual biology laboratories due to the following reasons:

- Real-time rendering capabilities for creating visually appealing and interactive environments.
- Support for various programming languages, including C++, for scripting functionalities and logic within the biology virtual laboratory.
- Support virtual scripting language which is known as blueprint.

The biology virtual laboratory provides visual and auditory outputs, including:

- 3D visualizations**:** Realistic simulations of laboratory equipment, chemicals, and reactions.
- Audio effects**:** Sounds associated with virtual experiments and processes.
- Textual information**:** Displaying instructions, data, and feedback within the interface.

Disseminating

The dissemination phase saw the distribution of the virtual to end users to be implemented and tested [14]. The trial was done using a smartphone to examine the practicality of the virtual lab developed. [15]. The developed application increased the extent to which students attained their educational goals, learning that goes beyond the memorization and recall of information and facts and the ability to store new information in one's long-term memory, so a person can easily recall it and put the knowledge to use in the future [17].

RESULT AND DISCUSSION

Early work by [18] demonstrated the life sciences, in particular molecular genetics, have become a pivotal area of research and innovation, and at the same time are amongst the most controversially discussed in today's society. Despite this discussion, the demand for life science expertise increases rapidly, creating a growing need for life science education in particular and for science education in general, given that progress in this area depends on progress in biology, chemistry, computer science, and some others. In this article, an approach to science education is suggested that combines guided knowledge acquisition with hands-on experience in a computer-based learning environment. But still is a problem for many government schools to have access to computers enough for all students.

The traditional laboratories follow a traditional wet lab format (a teacher/technician and students physically meet together). They follow instructions from a written lab manual or on their blackboard and manipulated materials are provided for each group. They recorded their observations and answered questions, turning in their lab assignment at the end of the period.[19] [20] Furthermore, other virtual labs also exist but they are more costly in terms of required items since many of them involve the use of Augmented Virtual Reality (AVR) glasses or the need for a tool kit that government scholars cannot afford.[21] [22] The Biology virtual lab was designed and developed based on the existing format of ordinary-level biology practicals mainly on three food tests and nutrition classifications. The theme covered was food tests (starch, protein, and reducing sugar) and classification. By using the developed application, cost and time management will be very easy as no more needs of apparatus and chemicals for more practices. Pictures below is the user interface of Biology virtual lab developed.

CONCLUSION

As with any educational tool, teaching goals must govern the use of virtual labs. Many different types of Internet-delivered digital tools are used in developmental biology classes, and these tools fulfill a great range of teaching goals. Simplicity and the physical experience of the student should be balanced with the appeal and convenience of digital sources including the use of a biology virtual lab application where the user will be able to conduct experiments as per requirements and

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have the ability to answer the handled questions. As with many balanced solutions, both/and solution gives the most satisfying results. The study recommended hybrid approaches to the tools of developmental biology so that the benefits of both digital tools and lab bench exercises are used along with the careful analysis of the goals of different exercises. Most importantly, children of the digital game generation must understand that the study of biology always refers back to living organisms and the earthiness that entails. These issues are not new to the digital age. Analogue tools such as films have clearly been misused in the past in the same way digital simulations might be misused today. We recommend further improvements to the application in order to allow users to tackle the questions within the application.

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