Abstract—Research works have shown that students have negative attitudes toward learning algebra. These negative attitudes are due to the inability of the teachers to use an appropriate teaching approach that will encourage students’ active participation in the learning process. One of the ways to capture their interests to learn algebra is to use the different teaching modes which are reflected in Bruner’s EIS theory. This study developed a Learning Management System (LMS) for Nigerian secondary school students. This was done using WordPress. The LMS was used to teach the basics of algebra using the three modes of knowledge representation as stipulated by Bruner. Questions designed based on the Technology Acceptance Model (TAM) relating to perceived usefulness (PU) and perceived ease of use (PEOU) were asked to obtain students’ opinions on the LMS. From the results, 71% of the students found the LMS useful for learning; 86% affirmed that they could easily interact with the LMS and 85% submitted that they will easily become skillful at using the LMS. The results of the data analysis are an indicator of their satisfaction with the Bruner EIS-Based LMS. The study provides support for teaching and learning functions by spurring the interests of students in the learning of algebra.


I. INTRODUCTION

Algebra is an integral part of mathematics and holds a pivotal role in numerous fields of study. As important as algebra is to building students’ algebraic problem-solving skills, most students have negative attitudes towards learning it. Reference [1] in their study discovered that Nigerian secondary school students do not have positive attitudes towards learning algebra. They posited that the students’ negative attitudes towards solving algebraic problems are due to heavy reliance on teachers on every concept they learn and difficulty in connecting past experiences with present situations. They further suggested that the teachers’ inability to use the appropriate teaching approach that will encourage students’ active participation in solving problems themselves also contributes to the negative attitudes. The studies of [2]-[4] submit that most students find algebra very difficult to understand due to the following reasons (i) the students’ perception that algebra is very difficult, uninteresting, and is founded on symbolic manipulations that are meaningless and irrelevant to day to day living and (ii) the students’ misconception of the use of algebraic symbols.

Several schools have attempted integrating technology into their teaching system. One such attempt is the use of the learning management system (LMS). References [5], [6] defined a Learning Management System as an online learning technology for creating, managing, and delivering course materials. In present-day learning, this web-based information system typically plays a major role in providing an instructor/teacher with tools for the administration, documentation, tracking, reporting, delivery of e-learning education courses or training programs, and performance assessment. The other key features are video conferencing to provide synchronous learning; threaded discussion and discussion forums to aid asynchronous learning.

In this study, the authors are interested in finding a solution to students’ negative attitudes towards learning algebra through a virtual learning environment. This interest triggered the development of an LMS for learning the basics of algebra (expressions, equations, variables, coefficients, and literals). An LMS describes the incorporation of computer systems and web technologies into instruction provision, management of resources, and tracks the achievement of both students and institutions. It helps the instructors to deliver material to the students, administer the test and other assignments, track student progress, and manage record-keeping regardless of time or place provided Internet access and appropriate technologies are available [7]-[9]. The utilization of LMS for students can support
learning and save resources such as time and money [10]-[14].

Furthermore, LMS is normally used to supplement and complement the traditional teaching method i.e. the face-to-face conventional way of imparting knowledge to students. LMS has been used widely in citadels of learning and much of the research about it has been focused on technology or studies adoption [15], but very few on learning theories to back the curriculum design for the courses being offered. To overcome students’ negative attitudes towards learning algebra, this study developed a Bruner EIS-based LMS for Nigerian secondary school students to help to spur their interests in learning algebra. To this end, the study tried to find out whether, with the use of Bruner EIS-based LMS, students would become more interested in algebra.

II. LITERATURE REVIEW

A. Overcoming the Difficulties in Learning Algebra

Several authors have looked at ways to overcome the difficulties students face in learning algebra. The study of [16] investigated the challenges faced by some Zambian secondary school students in learning algebraic linear equations. The study concluded that the students’ failure to correctly solve linear equations is attributed to their inadequate pre-requisite knowledge. The authors suggested that students should first be equipped with the necessary background knowledge upon which new knowledge can be built. Reference [17] determined the difficulties of the algebraic thinking ability of a group of secondary school students and proffered the Math-Talk Learning Community concept as a way to improve the students’ algebraic thinking ability. In the study of [4], a diagnostic teaching approach was employed as a possible solution to students’ difficulties and misconceptions on several aspects of algebra.

B. Studies on Learning Management Systems

The traditional form of classroom teaching has recently been enhanced for effective learning using LMS [18]. A study on factors influencing LMS usage by teachers and students conducted by [19] identified six factors (students, teachers, technology, resources, pedagogy, and curriculum) that influence the use of LMS in education. The authors combined the six factors to develop a model which was called Holistic Information Communication Technology Adoption Model (HICTAM) to be incorporated into the curriculum to increase the efficiency and effectiveness of the teaching-learning processes. The study of [20] posited that required tools be built into LMS to enhance ease of educational task performance. The study of [21] investigated learning via mobile applications by comparing students’ LMS usage before and after its introduction. The major achievement of this study is the provision of examples for developers of mobile learning platforms for tertiary institutions.

Some studies have looked into the effect of blended learning in higher institutions using LMS. The research conducted by [22] was carried out among students of the Technological Educational Institution in Ionian Island, Greece. The researchers utilized the Open eClass platform to improve lecture materials. They found out that despite worries on students’ truancy and non-participation in physical classes when exposed to online educational materials including videos, students did not reduce their presence in classes; rather it served an additional means in assisting them to learn more.

Reference [23] study shows that students’ ideas and attitudes toward learning and education contribute to their perception of the usefulness of LMS. In Nigeria, there is a paucity of studies on the adoption of LMS in educational institutions. One of the very recent studies on LMS was conducted by [24]. The work investigated LMS adoption sampling students from four universities in Nigeria. Results from the study revealed that the study variables determine the student’s intention to use LMS which in turn determines LMS actual usage.

This present study fosters incorporating Bruner’s EIS constructivism learning theory into an LMS as a way to enforce meaningful learning in the teaching of algebra and also provides a solution to students’ negative attitudes towards the learning of algebra.

III. THEORETICAL FRAMEWORK

A. Learning Theories

Learning design should be based on learning theories because they help the teacher make more informed decisions around the design, development, and delivery of learning. Learning theories are combinations of principles, rules, and techniques that have been formed through speculation, research, and hypothetical testing on how knowledge acquisition occurs. This study embraces the constructivism learning theory emphasized in Bruner Jerome’s EIS theory which presents three modes of representations [25]. Constructivism is a learning theory that concerns the process of how humans come to know new knowledge based on their previous knowledge and experiences from the things around them [26]. The role of teachers/instructors in this process is to facilitate the construction of knowledge and ensure students make sense of the knowledge acquired.

B. Bruner Jerome’s EIS Theory

Jerome Seymour Bruner was a cognitive psychologist who believed that education is about discovery and making the learner independent. He created a theory of development based upon the idea that the goal of education should be intellectual development. His focus was on children as he studied the way they learn and came to the agreement that children are born as ready active learners [27].

Bruner suggested that students may experience, or represent tasks in three modes: Enactive representation (action-based) which refers to learning through actions, Iconic representation (image-based) which refers to the learner’s use of pictures or models, and Symbolic representation (language-based) which refers to the development of the ability to think in abstract terms. Each mode is a way in which information or knowledge is stored and encoded in the memory. The modes of
representation are not delineated into stages but are integrated and loosely sequential [28]. Bruner’s EIS theory suggests that it is efficacious to follow a progression from enactive to iconic to symbolic representation when faced with new materials. He believed that the learning theory can be applied to any student of any age and can be used to teach any subject provided the learning instructions are organized appropriately [28]. His work further suggests that tests or punishments do not spur the learner to learn. One learns best when one finds the acquired knowledge appealing so, organizing appropriately the learning materials will spur the learner’s interest.

IV. A 3-TIER ARCHITECTURE OF THE LEARNING MANAGEMENT SYSTEM

This study developed a learning management system in which a three-layered conceptual framework was used.

A. Presentation Layer

In this tier the user interface had been built to display data to the student or accept input from the user. It contains controls like textboxes, dropdown lists, grid views, labels, etc. The graphical user interface is used for the presentation layer to enable users to operate the LMS by moving a mouse pointer or other pointing devices onto Windows, icons, or buttons. Users can learn online by logging on to the website. The LMS can support using desktop computers and mobile devices such as smartphones.

B. Business Layer

This tier serves as an intermediary for data exchange between the presentation layer and the data access layer. This layer includes the following modules:

1) Teaching management agent: This agent is responsible for the presentation of learning materials.

2) Quiz/test/examination agent: This agent is responsible for the quizzes/tests/examinations that are taken after completing the course.

3) Question & answer agent: This agent is responsible for the discussions that the students initiate to ask the teacher some questions about what he/she has learned and also to receive answers from the instructor/teacher.

4) Discussion forum agent: This agent is responsible for the discussion boards opened by each student.

C. Data Layer

This tier stores information. The layer contains the following databases:

1) Content database: This database stores basic teaching materials which include images, texts, and videos.

2) User database: This database stores users’ logging information such as their personal information, to verify whether they have the right to view the course content and learn. It also maintains records related to students’ quiz processes, and discussion boards opened by each user.

V. THE LEARNING MANAGEMENT SYSTEM DESIGN

Fig. 1 is the Use Case diagram for the learning management system. The Use Case diagram represents the users’ interactions with the system. It shows the relationship between the users, also known as the actors, and the different use cases, usually represented by either circles or ellipses, in which the users are involved.

Instructor, student, administrator and database are identified as the main actors in the Use Case diagram in Fig. 1. The instructor generates events, courses or lessons. The student accesses and interacts with a specific event and participates in the lesson. The administrator manages the whole environment. The architecture supports both contact and distance learning modes. The student can create an account or login in to his/her account, enroll in a course, take lessons at his/her own pace till completion, take quiz or examination, and view his/her performance on his/her dashboard. The student can further engage the instructor (who may also be an administrator) in a question
and answer section to clarify doubts on the course taught. The discussion forum is an avenue for the student to engage other students on the platform by exchanging ideas on the course learned. The performance record is stored and maybe used for counseling them on the course studied.

VI. SYSTEM DEVELOPMENT

The LMS was developed using WordPress - a content management system (CMS). A CMS is software specifically built for web content that provides website authoring, collaboration, and administration tools that help users create and manage website contents. WordPress is open source publishing software that can be installed locally on a web server and viewed on a proprietary website or hosted in the cloud and viewed on the WordPress website. It was coded with PHP (Hypertext Preprocessor) and uses MySQL (My Structured Query Language) database engine. It is used with a combination of themes, plugins and page builders to create and launch LMSs which were programmed with HTML (Hyper Text Markup Language), CSS (Cascading Style Sheets), PHP, JavaScript, and Ajax languages. Themes define the interface for the LMS. The plugin extends the functionalities of WordPress by combining a wide range of features to present a class setting without having the students come into a physical classroom. It allows one to create classes, share coursework, enrol students, and evaluate the students with quizzes and dashboard in the shortest possible time. Using WordPress to develop the LMS was a good choice due to the reduced development time it avails its users.

Some of the basic requirements of the LMS are explained below:

- **Course builder** with tools for uploading different file types like videos, Portable Document Format (pdfs), links and other contents.
- **Course progress information** is used to show to the students how well they are performing.
- **Student enrolment and management** enables the instructor or administrator to see how many people are undertaking the courses.
- **Quizzes and tests** for students to evaluate how much they have absorbed the material. Quizzes can be used as a way to determine who is qualified for a class.
- **Chats and forums integrations** for users to generate student profiles and interact with other students and teachers.
- **Homework options** allow the students to submit homework for grading.

VII. COURSE DESIGN—THE APPLICATION OF BRUNER’S EIS THEORY IN THE LMS

Bruner had influenced education greatly; his EIS theory has been most noticeable in mathematical education. The theory is useful in teaching mathematics which is primarily conceptual, as it begins with a concrete representation and progresses to a more abstract one. Bruner’s learning theory has direct implications on the teaching practices. The course lessons were organized according to enactive, iconic, and symbolic modes specified in Bruner’s theory and are presented in this section.

A. Enactive Representation of Knowledge

This is the first mode of knowledge representation and involves hands-on method of learning. Bruner believed that learning should begin with an action for instance, touching, feeling and manipulating. In mathematics education, manipulative are the concrete objects or anything tangible with which the actions are performed. In classroom learning, examples of manipulative used in this mode are algebra tiles, paper, coins, and scales. This mode has been represented in the LMS through written information and directly involving the students by asking them to perform some actions based on the knowledge acquired on what they have been shown. The use of scale in the enactive stage is a great way to “hook” students, who may not be particularly interested in the topic taught. (See Fig. 2).

![Fig. 2. Screenshot of the LMS showing lessons represented in Enactive mode](https://www.youtube.com/watch?v=z0OIXIZKfo0)

B. Iconic Representation of Knowledge

This is the second mode of knowledge representation and involves using images or other visuals to represent the concrete situation enacted in the first stage. Bruner believed that learning should scaffold from action-based to image-based. In classroom learning, images are drawn on boards or on papers. This allows the students to picture the concrete situations in their heads in the form of visual illustrations. This mode has been represented in the LMS with videos demonstrating the knowledge through diagrams, charts, graphs, and colors. (See Fig. 3).

![Fig. 3. Screenshot of the LMS showing lessons represented in Iconic mode](https://aeuso.org/resources/lessons/math/algebra/equation-basics)

C. Symbolic Representation of Knowledge

This is the third mode of knowledge representation and involves using words and symbols to represent the images...
from the second stage. Bruner believed that learning should scaffold from image-based to language-based. With the use of words and symbols, the student can organize information in his/her mind by relating concepts together. The symbolic representation is likely to be useful for learning something new in a familiar topic. Furthermore, by having all students go through each of the modes, it builds a foundation for which the students can fall back on if they forget or as they encounter increasingly difficult problems. This mode has been represented in the LMS through videos putting the whole knowledge together as would be done in the conventional teaching. (See Fig. 4).

![Fig. 4. Screenshot of the LMS showing lessons represented in Symbolic mode (Source of video: Adopted from https://www.youtube.com/watch?v=NybHckSEQBI)](https://www.youtube.com/watch?v=NybHckSEQBI)

**VIII. DATA COLLECTION METHOD**

The participants for this study were chosen based on a convenience sampling technique. This technique was chosen for two reasons: 1) The Higher National Diploma (HND) final year students of the Federal Polytechnic, Idah were readily available for us to use as they were concluding their project works. 2) The said students had already passed through the secondary school level. It is our belief that they can easily access if the LMS will be good for secondary school students and if they will use it. The study adopted a quantitative approach to examine students’ level of acceptance of the LMS based on the two main factors – perceived usefulness and perceived ease of use. Questionnaires were administered to the 7 Computer Science students of The Federal Polytechnic, Idah, Nigeria, who volunteered to use the LMS to learn “The Basics of Algebra”. All the 7 respondents completed and returned the questionnaire. Questions designed based on Technology Acceptance Model (TAM) which relates to perceived usefulness and perceived ease of use were asked in the questionnaire. All the questions were rated on a five-point Likert scale ranging from “strongly agree” to “strongly disagree”. Cronbach’s alpha on the full scale is 0.75 which demonstrates a reliable internal consistency of the questionnaire.

**IX. DATA ANALYSIS AND RESULTS**

The data from the questionnaire were analyzed as presented in Table I. The results showing the level of satisfaction is given in Table II.

**X. DISCUSSION**

**A. Perceived Usefulness**

Perceived usefulness is the degree to which a person believes that using a particular system would enhance his or her job performance [22]. All the students in the study found the LMS helpful in understanding algebraic basics more quickly and also agreed that the LMS increased their learning abilities. 71% of the students found the system useful for learning. (See Table II).

**B. Perceived Ease of Use**

Perceived ease of use is the degree to which a person believes that using a particular system would be free from effort [22]. All the students in the study submitted that they will use the LMS again to learn other topics in algebra and would recommend the system to other students. 86% affirmed that they could easily interact and understand the LMS and further found the system flexible to interact with. Furthermore, 85% of the students submitted that it will be easy for them to become skilful at using the system. (See Table II). The sample size was small but it was enough to gain some insights into the students’ perception and usage of the LMS. The success and adoption of a LMS in any institution starts by its acceptance. Findings from this study suggest that with the adoption of Bruner EIS-based LMS, students would become more interested in learning algebra.

**TABLE I. TECHNOLOGY ACCEPTANCE MODEL QUESTIONS SHOWING THE FIVE-POINT LIKERT SCALE RANGING FROM “STRONGLY AGREE” TO “STRONGLY DISAGREE”, THE FREQUENCY OF THEIR RESPONSES AND THEIR PERCENTAGES**

<table>
<thead>
<tr>
<th>Questions</th>
<th>TAM Questions and their Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students’ Responses to PU</strong></td>
<td><strong>Strongly Agree f(%)</strong></td>
</tr>
<tr>
<td>PU1 Using the LMS enables me to understand algebraic basics more quickly</td>
<td>4 (57)</td>
</tr>
<tr>
<td>PU2 Using the LMS increases my learning ability.</td>
<td>4 (57)</td>
</tr>
<tr>
<td>PU3 I find the LMS useful for learning.</td>
<td>4 (57)</td>
</tr>
<tr>
<td><strong>Scale for Perceived Ease of Use (PEOU)</strong></td>
<td><strong>Strongly Agree f(%)</strong></td>
</tr>
<tr>
<td>PE1 Interaction with the LMS is easy and understandable.</td>
<td>4 (57)</td>
</tr>
<tr>
<td>PE2 I find the LMS flexible to interact with.</td>
<td>4 (57)</td>
</tr>
<tr>
<td>PE3 It would be easy for me to become skilful at using the LMS.</td>
<td>5 (71)</td>
</tr>
<tr>
<td>PE4 I would use this LMS again to learn other topics in algebra.</td>
<td>4 (57)</td>
</tr>
<tr>
<td>PE5 I would recommend the LMS to other students.</td>
<td>4 (57)</td>
</tr>
</tbody>
</table>

* Percentages were rounded up to the nearest whole numbers.
XI. CONCLUSION AND SUGGESTIONS FOR FURTHER STUDIES

This study presents a solution to overcome students’ negative attitudes toward learning algebra. To achieve this, it developed an LMS for learning the basics of algebra by representing the learning materials in three ways: enactive representation (E), iconic representation (I), and symbolic representation (S) as suggested by Bruner. The use of scale in the enactive mode is a great way to “hook” students to be interested in the topic taught. The iconic mode allows the students to picture the concrete situations in their heads in the form of visual illustrations. The use of words and symbols in the symbolic mode allows a student to organize information in the mind by relating concepts together. This study submits that by having all students go through each of the modes, it builds a foundation for which the students can fall back on if they forget or as they encounter increasingly difficult problems.

The whole essence of utilizing Bruner’s EIS theory in the teaching of algebra is to allow teachers/instructors to be able to involve all the students in the learning process. This approach of learning provides the necessary background knowledge upon which new knowledge can be built. More so, the chat and forum features were integrated into the LMS as a way to improve the students’ understanding of the concept being taught through community learning.

Although the sample size used for this study is too small to generalize the findings, the students’ responses show some degrees of their acceptance of the LMS and also suggest their willingness to use the LMS to their advantage. Notwithstanding, further studies would cover larger sample sizes and stringent measures that will ensure that the students learn with the system would be put in place. Future studies would also empirically validate this present study by evaluating the LMS to test for significance on students’ learning ability.

Conclusively, the study found out that the use of Bruner EIS-based LMS would make Nigerian secondary students more interested in learning algebra. This study would be a major endeavor in promoting effective teaching and learning processes by motivating students to learn algebra. Specifically, this study would serve as a future reference for curriculum creators. The contributions of this study are not exclusive to only secondary school students but would be valuable to all students at all levels of education.

XII. RECOMMENDATIONS

It was evident from the findings that students’ acceptance of the LMS is a precursor to its adoption. Hence, it is recommended as follows that:

1) Nigerian government should approve and adopt this method for teaching mathematics, not just algebra in our schools.
2) Mathematics curriculum creators and instructors/teachers should be well equipped in the application of the Bruner’s EIS theory to the mathematics curriculum.
3) Nigerian government should expedite actions to provide the necessary infrastructural facilities to enable the use of LMS such as computer systems, broadband networks, and improved electricity supply.
4) Instructors/teachers should promote the use of LMS by complementing it with conventional teaching and learning processes.

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