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Personalized Learning Paths: The Impactsof Adaptive Learning Technologies (ALT)andArtificial Intelligence (AI) -Driven Analyticson Language Acquisition

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Abstract
Language learners often exhibit unique learning styles that shape how they acquire and understand a new language. Adaptive learning technologies (ALT), coupled with Artificial Intelligence (AI)-driven analytics, offer enhanced virtual platforms that support personalized learning experiences tailored to individual preferences and learning strategies. This study examines the effects of these adaptive learning tools and Artificial Intelligence (AI) analytics on the language acquisition of foreign language learners. Focusing specifically on the Duolingo learning application, the research investigates how its adaptive learning system and Artificial Intelligence (AI) components contribute to more effective language acquisition. A total of 32 English as a Foreign Language (EFL) learners/students were purposively selected to participate in the study. Utilizing a quasi-experimental design, the study found that the control group showed minimal improvement between their pre-test and post-test assessments. In contrast, the experimental group demonstrated a notable increase in performance, with mean scores rising from 19.03 in the pre-test to 23.82 in the post-test. These findings underscore the positive influence of adaptive learning technologies and Artificial Intelligence (AI-driven) analytics on the language learning process. The integration of such tools not only fosters personalized instruction but also enhances overall learning outcomes for foreign language learners.

Keywords: Adaptive learning technologies, AI-Driven analytics, Effective language acquisition, Personalized learning, Duolingo App, Control group, Experimental group

1.0 Introduction

The revolution brought by technology in language education has changed the learning approach of both language teachers and students. Nowadays, technology is integrated into the language learning system to cater for the needs of language students in such a way that their personal learning styles are considered for optimal learning experiences. Given the importance of learning styles in language learning, research on language acquisition has continued to emphasize understanding the learning styles of students to enable them to concentrate on improving on the areas they find difficult. This proposition, which reflects personalized learning, focuses more on a student-centered approach to language learning. According to Shemshack& Spector (2020), personalized learning is only centered on learners' learning needs, interests, motivation and engagement, readiness and ability to adapt to their learning progress.

Nevertheless, adaptive learning technologies have been developed to cater for this personalized learning path. First, adaptive learning technologies are the technological tools that support adaptive learning systems. In the words of Donevska-Todorova et al. (2022), adaptive learning is a system of learning that considers learners' strengths and weaknesses; incorporating technologies to regulate their learning process for better performance. In other words, adaptive learning can be considered a supplementary

learning approach. The difference this approach has with the traditional learning approach is the personalized aspect of it. Learners are taught based on their learning preferences and their learning curriculum is further customized to meet their learning needs.

The definition of Adaptive Learning Technologies (ALT) by Morze et al (2021) fully represents the main function of these digital tools. According to scholarly work, ALT integrates an Artificial Intelligence(AI)-driven algorithmic system that provides learners with appropriate learning methods and materials suiting each student's needs and learning styles. In essence, teachers are provided with basic information on learners' interests and needs. On the other hand, learners are also made to be aware of their learning styles, which also motivates them to improve in their learning process. Apart from motivation and personalized learning experience that caters for learners' needs, the adaptive learning feature found in this learning system encourages progressive learning, multiple pathways to learning outcomes and frequent evaluation, Morze et al. (2021).

2. Literature Review

2.1 Theoretical Basis of Personalized Learning

Many frameworks have been put forward to properly describe and understand the concept of personalized learning, especially in the context of language education. As maintained by Lokey-Vega & Stephens (2019), some of the definitions of personalized learning developed by many scholars are contradicting in nature. Meanwhile, the bone of contention in regard to the definition of personalized learning hinges on what should be the foundational components of personalized learning. While some scholars focused on the student-centered component, others focused on the technological aspect, Lokey-Vega & Stephens (2019).

Conceptualizing personalized learning based on a student-centered learning approach, the model known as Montessori was introduced by Maria Montessori(1912,1989). However, this model captures personalized learning because it considers learners' needs and provides a means to cater appropriately for them. Although this model was developed with a basic focus on child learning, Watson & Watson (2016) acknowledged the applicability of this learning method beyond the child learning strategy. Meanwhile, Winnefeld (2012) described this learning as an auto-education learning strategy, whereby the learning process of each learner is customized to suit their interest and needs. A study by Batubara et al. (2020) claimed that foreign language students taught with the Montessori Method participate actively during their English learning activities. Contrary to the student-centered learning approach, Bingham et al. (2018) conceptualized personalized learning in regard to the technological aspect. From the investigation conducted by the scholarly study, technology was prioritized as an indispensable component of personalized learning. Technological tools or resources are customized in a way that suits each learner who utilizes them. The background data of learners are first compiled to set up their profiles. Relevant learning materials are subsequently provided for each learner according to his/her learning needs.

Another theory put forward about personalized learning is constructivism. This theory emerged from other existing theories like Piaget's cognitive and developmental views and Bruner & Vygotsky's Zone of Proximal Development (ZPD) theory, Watson & Watson (2016). The theory of Piaget's cognitive and developmental views considers the basic role of learners and how they ought to fully own their learning. The theory further recommended discovery learning. On the other hand, Bruner & Vygotsky's theory focused on social interaction. Here, learners are made to understand their realistic environment, integrating social negotiation and self-awareness in their learning journey. The theory of constructivism about personalized learning highlights the importance of learners understanding and interacting with social and cultural elements in their learning. This, however, paves the way for an increase in mental processes,and constructing their own knowledge of the world, Watson & Watson (2016) .

Differentiated instruction is another theory which emphasizes personalized learning. This theory hinges on the readiness part of learners with regard to their learning process. Although this theory moves slightly away from focusing on learners' learning styles, it emphasizeson active participation of teachers. In this context, Pham (2012), maintained that the role of the teacher is to assess the learners' cognitive development and readiness level of the students. This is achieved by assessing students to ensure the curriculum aligns with their needs, followed by making necessary adjustments for learners who are found to be falling behind. Using Carol Ann's differentiated instruction model, Erickson (2010) investigated the impact of this method in teaching language and literacy at the primary level. The scholarly work claimed that the theory of differentiated instruction (DI) makes students feel valued and encourages them to believe in themselves. Connor et al. (2004) further explored the impact of DI on 108 first-grade students. The result of the investigation shows that variation in instruction strategies for learners and needs has a huge impact on their overall literacy development.

In general, many theories, including those reviewed in this study on personalized learning - emphasize the importance of addressing students' individual learning needs. Nevertheless, one can say that in terms of defining the basic concept of personalized learning, inclusion of learners' need should be of utmost priority. This inclusion is represented in the pictorial illustration below.

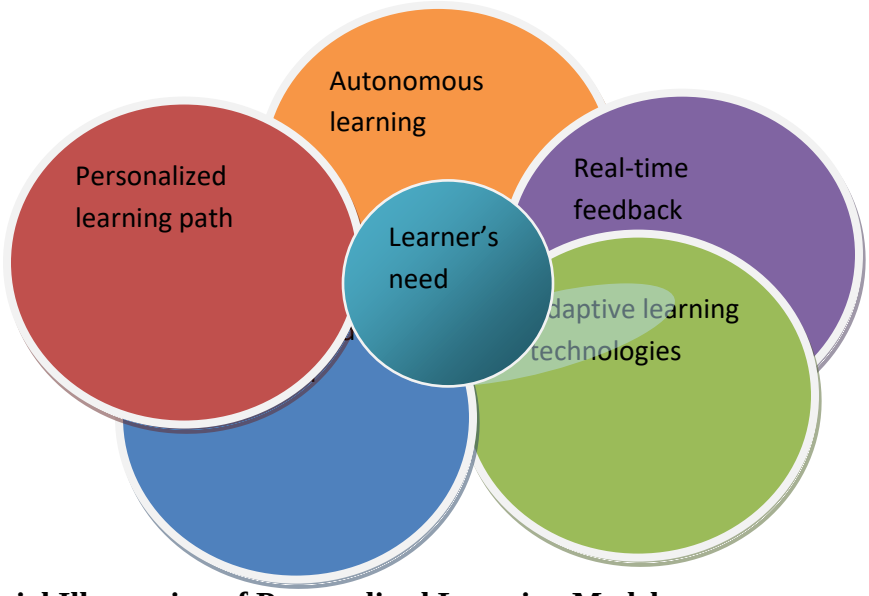

Fig:A Pictorial Illustration of Personalized Learning Model

The above represents what the model of personalized learning should include. The vital term known as 'learners' need' is at the core of other relevant features found in personalized learning. This prototypical model is assumed to be what the definition of personal learning should entail.

2.2 Exploring the Concept of Adaptive Learning Technology and its Roles in Language Education

Adaptive learning technology is associated with technology that supports adaptive learning. In adaptive learning, learners' interest is usually considered, allowing them to own their learning process. This is similar to the concept of personalized learning. The concept of adaptive learning is sometime interchangeable with other similar concepts such as personalized learning, individualized instruction, and self-paced instruction. According to Shemshack& Spector (2020), these similar words were used based on the need to include students' preference, learning styles and characteristics. For instance, in the work Yang et al. (2013), the concept of adaptive learning was used to describe as a system that represents all the features in personalized learning. Addressing the concept of adaptive learning, Koka et al. (2023) argued that the concept reflects a learning strategy that goes beyond enhancing learners'

learning ability to encourage learners to understand their learning needs and styles to be able to adapt easily in their learning process.

On the other hand, adaptive learning technology pavesthe way for the implementation of adaptive learning. With the use of technology, learning methods are customized to suit learners. Donevska-Todorova et al. (2022) noted that creation of learner model and multi-agent-system which can explore learners' performances is one way to implement adaptive learning system. The essence of the inclusion of technology in this learning approach is to properly and easily identify learners' strengths and weaknesses, motivating factors, needs and preferences. This is simply accomplished based on the algorithmic feature incorporated in the system which allows it to monitor each of the learner's learning background and performances. Several works such as, Shuai et al. (2020), Bhatti et al. (2020), Eugenia et al. (2021), andKatsaris&Vidakis (2021),have explored the integration of components of adaptive learning technology.

Meanwhile, the work of Katsaris&Vidakis (2021) categorized them as the Learning Management Systems (LMS), Adaptive Hypermedia Systems (AHS), and Intelligent Tutoring Systems (ITS). Kasim & Khalid (2016) identified LMS a web-based application that provides learners with several learning contents such as learning materials, assessment tools, reports on their learning progress and activities. A study by Adzharuddin& Ling (2013) emphasized the importance of this technology among e-learners since their learning is already situated online. While Adaptive Hypermedia System has the capability to offer experience unique to individual users, Intelligent Tutoring Systems leverage on user-generated data. This compilation of data aids in developing a system that will help guide the users towards optimal outcomes. Analyzing Intelligent Computer-Assisted Language Learning (ICALL); which is also a type of ITS in second language learning,Tafazoli et al. (2019) noted that this technology provides a personalized path to language learning. Hence, language learners are guided by this technology as if it is a language tutor.

To further explore the role of these adaptive technologies in language education, Ambele et al. (2022) examined different adaptive learning technologies. The study identifies some of these technologies which include adaptive educational media, personalized learning recommendation systems, personalized intelligent tutor system, and personalized mobile learning system amongst others. Findings from this study revealed that these technologies help students in building their learning styles and also help in students' participation during language learning activities. In this similar vein, Bourguet et al. (2006) noted that the virtual environment provided by these adaptive technologies helps learners to overcome cultural and language obstacles during language learning process. However, this finding implies that adaptive learning technology paves way for cross-cultural adaptation of learning technologies. Some of these technologies are equipped with AI-driven algorithms and data analytics to provide culturally sensitive learning contents to users.

2.3 An Overview of Artificial Intelligence (AI) Analytics in Duolingo App.

Duolingo App. is a popular mobile language learning application (App.) that has proven to enhance language learners' learning process. However, the App. is considered to provide a proper platform for language learning and practice. Past studies such as Hidayati& Diana (2019), Habibie (2020), Kessler (2023), and Loewen et al. (2019) have made claims on its effectiveness. The study by Hidayati& Diana (2019) investigated the integration of the mobile App. in second language learning. The findings from the scholarly work revealed that the activities found in the App. encourage motivation and engagement. The Study by Ajisoko (2020) asserted that the App. facilitates the improvement of various language skills such as reading, writing, listening and speaking skills.

As one of the most used language learning Apps., Duolingo is equipped with Artificial Intelligence (AI) analytics which enables the user to have a personalized learning experience. Vijayakumar &Chellapandiyan (2024) described Artificial Intelligence (AI) as the simulation of human intelligence

by a computer system. However, the AI aspect of the Duolingo App. simply monitors users just like human beings would. With this, it can be able to predict users' language proficiency and subsequently provide personalized learning paths for them. Duolingo App. goes beyond a language learning App. to an adaptive learning system that provides learners with appropriate information about their learning styles. However, this is made possible by the presence of the AI analytics integrated into the App. Meanwhile, the AI system in the App. is designed to first collate data from the App. users. Users' activities, both interaction and log-in sessions in the App, are constantly recorded. With this collated data, the system identifies the learning patterns and trends of individual users. The work of Vijayakumar &Chellapandiyan (2024) further revealed that from the identification of the trends and patterns in individuals' language learning process, AI analytics can now predict learners' strengths and weaknesses. A further adjustment is made by the App. regarding the instructional materials for users. Additionally, difficult exercises are also reduced to easier ones if the AI algorithm observes low proficiency in certain areas.

Apart from the creation of a personalized learning experience, AI analytics in DuolingoApp. provides instant feedback to users. According to Fitria (2021), the mobile App. provides a fast feedback system that allows users to receive feedback in real-time. The system instantly identifies and corrects learners' mistakes. This helps to reinforce their learning and encourages memory retention. Jiang et al. (2021), argued that the feedback feature in the Duolingo App.is beneficial for speaking and listening proficiency. With speech recognition aspect, the user's spoken responses are analyzed by the AI analytics and further provided with correct feedback pronunciation, if there is a need. Although the App. does not provide grammar explanations for learners, it further helps them to understand why and where they made mistakes. Hence, Vijayakumar &Chellapandiyan (2024) noted that users rather learn grammar rules through numerous trials and errors as they engage in the application.

Artificial Intelligence () analytics in DuolingoApp. also offers an assessment role to users. This is achieved through the use of tests and quizzes in the App. It is important to note that these tasks in the form of tests and quizzes in the App. are apportioned to the users based on their language proficiency level. For instance, tasks apportioned to beginners are easier compared to those at the intermediate level. The system further determines the proficiency level of users based on their performance in these tasks.

2.4 Gap in Literature

As one of the dominant topics in the field of language education, personalized learninghas attracted a lot of interest from several scholars, such that numerous investigations have been carried out in regard to it. Majority of these studies have explored several adaptive learning technologies, including Duolingo App., with the aim of revealing how these technologies can facilitate personalized learning. Nevertheless,Artificial Intelligence (AI)-driven analytics in Duolingo App. remains a critical aspect that has received less attention. As such, this research is aimed at bridging this identified gap in literature; thus, providing better insights on how this adaptive learning technology can aid in improving language acquisition process of language learners.

2.5. Research Hypothesis

Based on the identified research gap, the following hypotheses were developed to guide the objective of this research.

- Ha (Alternative Hypothesis): There is significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process
- Ho (Null Hypothesis): There is no significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process.

3. Research Methodology

A. Research Design

With a view to achieving the main objective of this study, a type of experimental research design known as quasi experiment was adopted. In this research design, alteration of treatment in the variables is used tocompare the effect of adaptive learning technologies and AI-driven analytics in Duolingo App. on language acquisition between two groups. It is important to note that these two groups; control and the experimental groups were evaluated using pre-test and post-test techniques. The pre-test was used to assess the participants' language proficiency level before the treatment. A standardized language proficiency test known as 'Test of English as a Foreign Language (TOEFL)' was used in the pre-test. The same test was also used after the treatment for the post-test.

B. Research Participants

Total number thirty-two (32) foreign language learners were included in this research. However, these participants were purposively selected to reflect appropriate participants for the research. Based on this sample selection technique, three criteria were put forward by this research in selectingthem, which include, being an intermediate EFL learner, being within the age range of 22-35 years, and being willing to participate in the research's experiment. These participants were further divided into the experimental group which consisted of fifteen students and the control group which consisted of seventeen students. Nevertheless, the basic information of the participants is summarized in the table below.

Table 1: Demographic Variables of the Participants

Variables	Categories	Frequency	Percentage
a. Gender	Male	15	46.9%
	Female	17	53.1%
b. Age.	22-25years old	16	50.0%
	26-30years old	11	34.4%
	30-35years old	5	15.6%
c. Language proficiency level	Beginner	2	6.25%
	Intermediate	30	93.75%
	Advanced	0	0%
d. Frequency in theof Duolingo App.	Frequently	20	62.%5
	Rarely	7	21.9%
	Occasionally	5	15.6%

C. Research Instruments and Procedure

The tool used for this research includes two basic tests (pre-test and post-test). The research experiment started with a pre-test to evaluate the initial language acquisition level of the participants. In the pre-test, the participants in the two groups were administered a Test of English as a Foreign Language through their various active emails. They subsequently forwarded the test after one week for assessment and

scoring. An intervention was used in the experimental group. This was achieved through the engagement of the participants in the group in language learning using the Duolingo App. for an extra week, whilst the conventional learning method was used by the control group for language improvement. Nevertheless, the same test was administered to the two groups in the post-test evaluation. This was to ascertain any observable difference in their language acquisition process. The results of these tests were further analyzed using SPSS program.

4. Data Presentation and Analysis

Table 2: Descriptive Statistic Result for the Pre-test

t-test

Group	***N***	***$\bar{x}$***	***sd***	***Df***	***t-value***	***p-value***
Experimental group	15	19.03	2.122	30	-0.43	0.68
Control group	17	18.61	2.358	30	-0.43	0.68

**Significance $\alpha \leq (0.05)$*

The result from the table showsthe language acquisition level of the research participants. As noted, before, the two groups were administered the pre-test. After data collation and scoring by the researchers, the findings reveal that the average scores of the two groups are 19.03 and 18.61 correspondingly. On the other hand, standard deviation shows the level of disparity that exists among the means of two groups. As seen in the table, the level of disparity in mean scores was low. It is important to note that t-test was further carried out to determine if there is anysignificant difference in the score. This is represented by the t-value and p-value. The t-value from the result is -0.43 which is almost close to zero and the p-value is 0.68 (which is greater than the significant level). The implication of this t-test reveals that there is no statistically significant difference between the two groups. Since the p-value is greater than the traditional significance threshold of 0.05, there is not enough evidence to reject the null hypothesis which states that there is no significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process. Nevertheless, the result simply implies that the participants exhibited the samelanguage acquisition level during the pre-test phase.

Table 3: Descriptive Statistic Result for the Post-test

t-test

Group	***N***	***$\bar{x}$***	***sd***	***Df***	***t-value***	***p-value***
Experimental group	15	23.82	1.63	30	-15.812	<0.000
Control group	17	18.70	2.93	30	-15.812	<0.000

**Significance $\alpha \leq (0.05)$*

The second experiment in this research, which was post-test, was conducted to ascertain if theadaptive learning technologies and AI-driven analytics were impactful on students' language acquisition process. First, an intervention was included in the experimental group (the participants used Duolingo App. in their language learning process). While the control group continued with the conventional language learning method. After the incorporation of this treatment, the post-test was administered to the two groups, and the table above represents the result gotten from the assessment, which also included t-test analysis. Nevertheless, the result from the post-test experiment showed obvious improvement among the

participants in the experimental group. Comparing the mean scores of the two groups in the post test, it can be observed that there was significant improvement in the language acquisition process of those in the experimental group. The mean score of the experimental group increased from 19.03 in the pre-test to 23.82 in the post test. While the mean score of those in the control group increased from 18.60 in the pre-test to 18.70 in the post-test. On the other hand, the t-value and the p-value which indicate the t-test carried out reveals that there is a statistically significant difference between the mean score of the two groups. The result of this post-test shows compelling evidence for the rejection of the null hypothesis of this research, and acceptance of the alternative hypothesis, which states that there is significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process. This finding emphasizes the effectiveness of the adaptive learning system and AI-driven analytic features in the Duolingo App.

Table 4: Paired Sample for the Pre-Test and Post-Test between the Two Groups

Sample	***N***	***x̄ (pre-test)***	***x̄ (post-test)***	***sd***	***Df***	***Sig.(tow-tailed)***	***f***	***Extent***
E.G	15	19.03	23.82	4.723	14	0.000	-5.452	High
C.G.	17	18.61	18.70	1.25	14	0.250	-1.347	Low

A paired sample test was further used in this research to analyze the differences between pre-test and post-test scores within both the experimental and control groups. This test was used to demonstrate the distinct changes that have occurred between the two groups during the experiments (from the pre-test to the post test). Nevertheless, based on the performances of the participants in the control group in the pre and post-tests, it can be said that there was little improvement in the students' language acquisition process. As indicated in table 2, the control group's mean score increased from 18.61 to 18.70, suggesting little or less improvement. However, the estimated significance (Sig.) value which is 0.185 is above the significance threshold of 0.05, indicating insufficient evidence to conclude that the observed change in mean score for the control group is statistically significant. Contrarily to what was obtained in the control group, there was an observed difference in the course of the researchers' experiment in the experimental group. Although the group showed almost the same level of proficiency as the control group during the pre-test phase, withthe presence of the intervention variable (use of the adaptive learning system and AI-driven analytics in the Duolingo App.) there was an increasein regard to the students' performances. The last finding in table 4 reveals the extent to which the adaptive learning system and AI-driven analytics in the Duolingo App. is impactful on the language acquisition process of students. The impact on the experimental group was high because the participants used the App. in their learning process. As such, there was observable progress in their learning process. Also, the impact they have on the control group was low since there was absence of the intervention in course of the researchers' experiment in the control group. This finding provides strong evidence to accept the hypothesis that there is significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process. Summarily, it can be asserted that adaptive learning technologies and AI-driven analytics are impactful on language acquisition of foreign language students.

4.0 Discussion

A basic feature of the Duolingo App. is the presence of adaptive learning system and AI-driven analytics. As an adaptive learning technology, Duolingo App. was used by this study to explore the impact of adaptive learning technologies and AI-driven analytics on the language acquisition of foreign language students. The research adopted a quasi-experiment to undertake an evaluation on the use of Duolingo App. in language acquisition. Nevertheless, a pre-test was first administered to the research participants who were earlier divided into experimental group and the control group. Using a standardized language proficiency test known as 'Test of English as a Foreign Language (TOEFL)', the research conducted assessment on the initial language acquisition proficiency of the respondents. This assessment was not only limited to one aspect of language proficiency, but overall aspect of it.

It is important to note that the two tests carried out in this research were anchored on the two proposed hypotheses by this research. These hypotheses include the alternative hypothesis (there is significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process) and the null hypothesis (there is no significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process). The pre-test conducted in this study showed that the participants in the two groups exhibited the same language acquisition level. This is seen from the t-test analysis, where the t-value was -0.43 which is almost close to zero and the p-value was also greater than the traditional significance threshold of 0.05; suggesting that there is no statistically significant difference between the two groups. This test provided a foundation to understand the level of impact the integration of the use of adaptive learning system and AI-driven analytics found in the Duolingo App. can have on the language acquisition of learners. It can be assumed that prior to this experiment, the respondents were used to the traditional methods of language learning, hence the level of their performances in the pre-test. As stated by Levenston (1979), the traditional language acquisition method often occurs in the classroom, wherein students are taught new language by teachers.

In the second phase of the research's experiment, the experimental group received treatment while the control group continued with the traditional learning method. Subsequently, the post-test was administered. The essence of this second phase is to trace any observable impact of the Duolingo App. This is achieved by monitoring the performances of the respondents. Nevertheless, the result from the post test showed progress in the language learning process of only the experimental group. Nevertheless, the t-test carried out revealed that there is a statistically significant difference between the mean score of the experimental group and the control group. Having analyzed the result of the post-test, it was concluded that t-test showed compelling evidence for the rejection of the null hypothesis of this research, and acceptance of the alternative hypothesis, which states that there is significant impact of adaptive learning technologies and AI-driven analytics on students' language acquisition process.

Meanwhile, a paired sample test was conducted to compare the differences between pre-test and post-test scores within both the experimental and control groups. Based on the performances of the participants in the control group in the pre and post-tests, it was observed that there was little improvement among the students in regard to their language acquisition process; contrary to the experimental group which showed immense progress. The findings in the last table showed that there was a high impact of the adaptive learning system and AI-driven analytics in the Duolingo App. among the students in the experimental group and the impact they have on the control group was low since there was absence of the intervention in course of the research experiment in the group.

Adaptive learning system and AI-driven analytics are the features found in some technology that support personalized learning. Duolingo App., which is equipped with these features, paves way for easy language acquisition process by personalizing the learning experience for users who are also language learners. According to Vijayakumar &Chellapandiyan (2024) instructional contents are organized and made available to aa users based on their language proficiency. Hence, an advanced learner using the App. gets sophisticated instructional content as compared to beginners in language learning. This makes

it easier for every user, even with his/her different language background to adapt to the learning system in the App. The findings of this study emphasize that the integration of adaptive learning technologies in language acquisition of foreign language students can help to create personal and improved learning experiences for language students.

5.0 Conclusion

The effectiveness of adaptive learning technologies in language acquisition process shows that it supports personalized learning. Personalized learning is associated with the type of learning that encourages and considers learners' needs and preferences. This type of learning is regarded asa student-centered approach to language learning. However, this type of learning method usually integrates adaptive learning technologiessuch as learningApps. (Duolingo, Babbel, Memrise, etc.).Based on the investigation carried out in this research, it wasfound that the adaptive learning system and AI-driven analytics in DuolingoApp. allows the implementation of personalized learning. From the experiment conducted using this App, it is revealed that the use of the adaptive learning system and AI-driven analytics in the Duolingo App. significantly impacts learners' language acquisition process. This research contributes to other existing research on the effectiveness of the use of Duolingo App. in language acquisition. Not only does the App. paves a way for personalized learning, but also serves as a languageteacher, offering students instant correction for progressive learning.

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