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PAPER

The Impact of Intelligent Adaptive Learning on Flexible Thinking and Academic Achievement for Undergraduate Students

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ABSTRACT

In the knowledge society, artificial intelligence (AI) forms a cornerstone of global education. This quasi-experimental study examines the impact of an Intelligent Adaptive Learning Strategy (IALS) on flexible thinking (FT) and academic achievement among 60 3rd-year undergraduate students at the College of Education/University of Baghdad (experimental n = 30; control n = 30). The IALS was implemented via an AI-supported educational platform, while the control group received conventional instruction. Post-test intervention assessments included an FT test (10 items, content validity = 0.89, Cronbach's $\alpha = 0.87$) and an achievement test (10 objective items, $\alpha = 0.85$). Results revealed statistically significant superiority of the experimental group in both FT ($p < 0.01$, $\eta^2 = 0.34$) and academic achievement ($p < 0.001$, $\eta^2 = 0.42$). Findings affirm IALS efficacy in personalized learning environments. Recommendations include adopting centralized adaptive learning (AL) platforms, faculty training in adaptive pathway design, and integration of IALS into mathematics, algorithms, and programming courses.

KEYWORDS

intelligent adaptive learning (IAL), flexible thinking (FT), academic achievement, artificial intelligence (AI) in education, personalized learning, undergraduate students, education college, quasi-experimental design, adaptive platforms

1 INTRODUCTION

UNESCO (2021) reports indicate that the traditional educational system is no longer able, on its own, to prepare students with the future skills they need, such as higher-order cognitive skills, self-directed learning, adaptability skills, and social and emotional skills. Studies indicate that 70% of global educational systems still do not utilize adaptive learning, despite its proven improvement in academic achievement

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by 30–50%. Therefore, it has become crucial to integrate new strategies such as adaptive learning (AL) and artificial intelligence (AI) to ensure the activation of all learners' capabilities from early stages. Accordingly, intelligent adaptive learning (IAL) represents a strategic direction for educational development toward achieving effective and inclusive personalized education, as it meets the individual needs of the learner, while AI provides flexible and customized mechanisms to support this learning.

The limited awareness of academic faculty members regarding recent developments in teaching methods and strategies may be a reason for the low level of student achievement and their inability to stimulate students' thinking. Traditional methods and approaches do not take into account individual differences among students nor meet their varying educational needs, despite the continuous advancement in the field of educational technology. Consequently, many educational systems remain outdated in providing flexible learning environments capable of delivering personalized learning experiences tailored to each student's individual needs, which may lead to weakened academic performance [1–3].

In this context, AI emerges as an innovative tool that enables educational institutions to improve learning methods and provide customized, flexible educational solutions. AI has become capable of offering AL strategies that empower teachers to design educational experiences suited to each student's level, thereby enhancing their opportunities to develop skills more efficiently—particularly those skills expected to foster critical thinking. With the increasing use of AI in education, there is a growing need to develop innovative teaching methods aligned with the rapid technological advancements in today's societies [4–6].

Given AI's proven capacity to deliver targeted, personalized learning solutions, this study seeks to guide educational policy toward more flexible, efficient systems that meet diverse student needs across traditional and technology-enhanced contexts [7].

Research Question: To what extent does the intelligent AL strategy (IALS) enhance flexible thinking (FT) and academic achievement among College of Education undergraduates?

1.1 The importance, goals, and limits of the study

Research adds a practical and applied framework for IAL systems, which are modern systems in teaching design and implementation. This opens new horizons for researchers to adopt and develop these systems in interactive educational environments, which is important from a theoretical standpoint. An examination of the theoretical underpinnings of AI-supported IAL sheds light on the ways in which these technological resources influence the enhancement of student learning through the comprehension of AI systems' reactions to specific learner requirements and difficulties. As an added bonus, it helps build a theoretical foundation for future AL applications by shedding light on the intricate relationship between AI and personalized education tools. The research contributes a qualitative viewpoint to current attempts to improve academic achievement by tailoring instruction to each student's unique requirements according to their current performance and learning speed via the use of IAL as a pedagogical approach. Integrating FT skills (such as the ability to change strategies, explore multiple perspectives, and adapt to new contexts) into learning environment design relies on an integrative approach

that combines technology, physical design, and instructional strategies. This integration fosters adaptive learning, particularly in the context of AI and personalized learning, as previously mentioned [8].

Its practical importance: Adaptive smart learning benefits faculty members in general education, especially in teaching mathematics or any other subject structurally dependent on mathematics. Teaching through adaptive smart learning leads to more enjoyable and interactive learning, resulting in better understanding and long-lasting learning effects, as it meets the individual needs of each learner. The academic library is enriched with an achievement test for third-year students in the Computer Science Department of the College of Education. This test is designed according to the standards of good test construction and was implemented technically via the educational platform used and supported by AI to achieve adaptive learning. The FT test helps teachers identify their students' skills and understand their levels and abilities. It also enriches the university library with an undergraduate test based on FT skills.

The research aims to determine the effect of the teaching strategy based on IAL on critical thinking and academic achievement among university students.

Its limitations: It is limited to 3rd-grade students/Computer Dep./College of Education, University of Baghdad, Academic Year 2025–2026.

2 LITERATURE REVIEW

2.1 AI and the future of education

AI ranks among the most significant technological innovations that have added a new dimension to e-learning, granting it roles and functionalities that did not previously exist. This has led to the emergence of new AI patterns, forming an integrated system through which the educational process is updated and developed. The shift toward utilizing AI applications in instructional design represents an urgent goal and necessity that educational institutions are striving to achieve, enabling them to keep pace with all the latest advancements in digital educational content development and teaching strategies [9].

AI contributes to the learning process by enabling the analysis of large volumes of data to better understand students' behaviors and needs. This helps improve curriculum design and deliver personalized educational materials that meet individual requirements [10]. It achieves this through teaching strategies based on AL systems, providing a personalized and optimized educational experience tailored to each student's specific needs [11].

Among the most prominent AI applications that can be employed in education, particularly e-learning, are intelligent chatbots, interactive augmented reality, virtual reality, voice synthesis, expert systems, educational robots, intelligent adaptive learning, intelligent educational games, intelligent assessment, letter reading recognition, and text summarization [12].

Based on the excellence of AI applications in e-learning environments, with their high capabilities in instructional design for digital content and assistance to academics in educational institutions, as well as educational technology and AI specialists in developing their various skills [13], the researchers were motivated—given all the aforementioned—to investigate the impact of using a modern instructional

strategy based on an AI-supported AL system in developing FT among students in scientific colleges.

AI is a key application of the modern era, coinciding with the information and communication technology revolution. It permeates many aspects of daily life [14–16], including intelligent learning systems, AL environments, predicting learner performance, intelligent virtual reality, smart content, educational robots, and automating administrative tasks [17]. This study will examine AI-enhanced AL as a teaching strategy, a first for researchers in Iraq, specifically at the university level.

2.2 IAL

Adaptive learning (AL) is the learning process in which the method of presenting content changes based on each student's individual responses. Digital learning systems are considered adaptive when they make real-time changes to the best learning alternatives. It is an innovation aimed at changing the rules in education, as it has been used historically in remedial education through highly advanced and integrated technological tools [18].

It's a system for teaching and learning that seeks to personalize lessons, readings, training activities, and assessments for each student individually based on their current skills and performance. Its AL software personalizes learning by using AI and machine learning techniques to "adapt" the learning path offered to an individual student in real time. Accordingly, later on, faculty members can analyze the data collected from AL software to review the needs of individual students or groups in a specific course, then adapt instruction according to those needs during the semester and revise the course between semesters. Likewise, students can use data about their skills and performance to adapt their own learning practices; i.e., records every decision made by the student and adjusts their learning path within lessons and between lessons, providing millions of individualized learning paths, each designed according to the student's unique needs in real time [19].

One of the key features of AL is achieving personalized learning by delivering content tailored to each learner's needs (with variable content). This makes e-learning environments more intelligent, as they rely on AI systems that determine the appropriate educational path for learners based on their varied responses to the system. Consequently, these environments become capable of understanding learners' styles and diverse patterns and providing the correct path for suitable educational content [20].

Utilizing technology in various forms to deliver content that suits the learner's unique internal learning style is what AL systems provide in education. This harnesses technology to serve learners in a qualitative manner, putting an end to the idea of presenting uniform electronic content to all students. Instead, each learner enters a learning environment that identifies their learning patterns and subsequently presents the content in the most suitable way for them [21].

Most AL environment systems contain the four elements as shown in Figure 1.

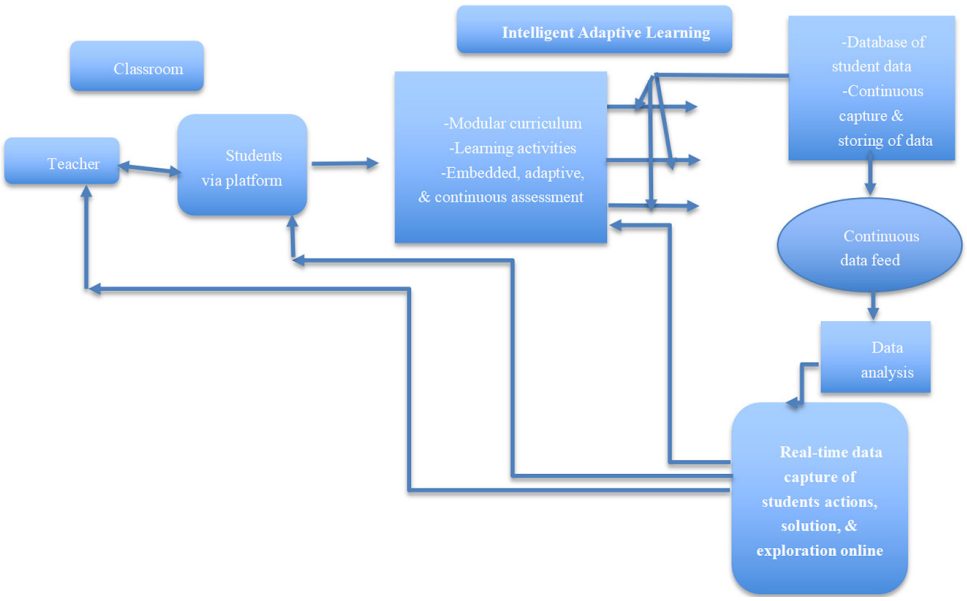

Fig. 1. Elements of AL environments [22]

2.3 Intelligence adaptive learning strategy

Intelligence Adaptive Learning Strategy (IALS) means solving problems and providing personalized and remedial forms of education, where remediation is important on a wide scale, especially for the diverse number of students with varying educational needs. It offers a convincing solution to disparities related to rising educational costs and the urgent need to produce more compelling and impactful educational experiences for new generations. AL provides asynchronous means of education, eliminating the need for scheduled courses or training sessions [23].

So, its procedural definition is a set of steps, procedures, and proposed activities according to AI-supported adaptive learning, implemented under the conditions and capabilities provided by the researcher (the academic instructor) to help their students (the experimental group) achieve the required educational objectives. The impact of this strategy is measured through the students' responses (research sample) to the items of the two instruments prepared to measure the dependent variables of this study.

Steps of the IALS. A teaching strategy based on the units of the AI-supported AL system (learner unit, teacher unit, content unit, and interface unit) can be designed practically as follows:

1. Preparing the learning environment and setting up technological tools and the intelligent system.
2. Assessing the learner and creating a dynamic profile that includes skills and learning styles.
3. Designing educational content in the form of small, flexible multimedia units suitable for customization.
4. Implementing AL by automatically adjusting content and activities based on student performance.
5. Supporting the teacher with intelligent reporting systems and continuous recommendations to help modify teaching plans, along with training on AI tools and effective communication channels with students.
6. Providing an easy-to-use interactive interface that includes instant feedback tools and smart support.

Conducting ongoing assessments and regularly surveying student performance, along with personalized feedback that contributes to improving learning and enhancing motivation.

Teacher and learner characteristics in the IALS:

1. Interacted assessment: combines classroom observation with digital tracking to create a dynamic profile reflecting students' interactions and cognitive abilities.
2. Appropriate content: small multimedia-rich units (texts, videos, interactive exercises) presented via the digital interface as the primary platform for adaptive personalization.
3. Automatic adaptation: AI algorithms modify content in real-time, supported by teacher intervention in the classroom setting.
4. Central teacher role: interpreting reports, adjusting lesson plans, and providing emotional and instructional support [24].
5. Training and collaboration: teacher self-training alongside continuous assessment blending automated (system) and human (teacher) elements [25].

2.4 Flexible thinking

One of the cornerstones of cognition is FT, which is the ability to come up with unique ideas after thoroughly investigating all the possible ways to accomplish a goal, including visualizing and fully understanding them through various responses, some of which might not be obvious at first. In order to choose the best solution at the right time, it uses a variety of FT techniques [26].

It comprises two components: thinking and flexibility. Thinking represents a critical factor in human life, as it enables individuals to confront problems and arrive at solutions for them. Flexibility, in turn, refers to the individual's capacity to generate a multitude of diverse ideas [27].

Flexible thinking ranks among the most crucial types of cognition, as it enables students to adapt to situations, devise creative solutions to problems, and effectively manage unanticipated changes. So, in the current study, FT represents students' ability to employ their acquired knowledge, skills, and experiences to view matters and life situations from diverse angles and perspectives, contemplate various types of ideas, transition from one idea to another, and thereby confront challenging situations while adapting to all that is novel [28].

Types of FT:

1. Spontaneous Flexibility: This represents the individual's capacity for spontaneous cognitive adaptation when confronting a specific problem, without adherence to rigid thinking patterns.
2. Adaptive Flexibility: This pertains to the individual's ability to shift from one idea to another, acclimating to the problem's conditions with the aim of finding a solution.

Characteristics of FT:

1. The adaptation to continuous variables and adjustment to new circumstances.
2. It strengthens creative capacity, as an individual's possession of mental flexibility renders the achievement of personal and collective goals successful and beneficial.

3. It equips the individual with the ability to adapt and evaluate appropriately, since a mind endowed with a high degree of flexibility possesses the capacity for accurate analysis and adaptation to diverse activities.
4. It enables the individual to avoid narrow thinking, as it shifts the individual away from constricted thinking patterns toward broader domains.

It is essential for accomplishing educational objectives efficiently [29].

FT components:

1. Acknowledgment of Technology in Daily Life: This pertains to a person's capacity to welcome technological progress and its contemporary uses, incorporating them into different areas of life, especially education. At its core, it's about being open to new technology, which demonstrates that you can learn to use advanced tools for intentional learning.
2. Having an Open Mind and Being Able to Learn from Other People's Experiences: This trait shows that you may improve yourself over time by being receptive to new ideas, respectful of different points of view, and willing to reflect on and incorporate feedback from others. Participating in the stories and perspectives of others helps one grow as a person and exposes oneself to new information.
3. Adaptation in life situations refers to an individual's capacity to respond flexibly to a variety of circumstances, including those encountered in educational settings. Specifically, it encompasses the learner's proficiency in generating multiple solutions, resolving unfamiliar problems, and transferring knowledge to novel situations [29].

2.5 Academic achievement

Academic achievement is considered an indicator that shows a level of learning in a student's academic life, as well as their ability to interact with and confront the educational environment [30].

3 METHODOLOGY

Researchers employed a quasi-experimental design with two groups (experimental n = 30, control n = 30) and pre-post testing, representing a true experimental approach targeting IAL (independent variable) effects on FT and achievement (dependent variables) [31].

The population comprised 3rd-year Computer students/College of Education, University of Baghdad. Class A was randomly assigned as the experimental group (n = 30), and Class C as the control group (n = 30). Internal validity (α = .89) and external validity (β = .11) were statistically verified.

3.1 The tools and technologies

1. The AI-supported Google Classroom platform was used (as the primary intervention tool):
   - Configured according to the (IALS) model as shown in Figure 2.
     * Platform Setup: Google Classroom (version 2025) was configured with AI extensions via Google Workspace for Education, including machine

learning plugins for adaptive content delivery (e.g., Google Cloud AI APIs for real-time performance analytics). The platform hosted four core units of IALS: learner profiles, teacher dashboard, multimedia content repository, and interactive interface.

- Implementation of AL steps: diagnosing student needs → providing a personalized learning pathway → instant evaluation with pathway adjustment from [Wisal Hashim Abdulsalam].
  * Adaptive Features Implementation: Initial diagnostic quizzes created dynamic learner profiles based on pre-test data (skills, pace, and learning styles). AI algorithms adjusted pathways automatically; e.g., if a student scored <70% on an exercise, the system delivered remedial multimedia (videos, interactive quizzes) before advancing. Real-time feedback loops used reinforcement learning to personalize paths for 30 experimental students.
  * Content Delivery: 10 modules aligned with course objectives (mathematics/algorithms), featuring variable difficulty levels, instant grading (KR-20 = 0.85), and branching logic. Teacher interventions included weekly analytics reports for hybrid adjustments.
  * Technical Specifications: Hosted on secure university servers (Baghdad University network); mobile/web access; data privacy compliant with GDPR-equivalent Iraqi regulations. Total implementation: 12 weeks, Academic Year 2025–2026 [Wisal Hashim Abdulsalam; Ban Hassan Majeed].

  Figure 2 illustrates the IALS design elements integrated into the platform.
- The teaching strategy derived from [Ban Hassan Majeed] with interactive digital content.

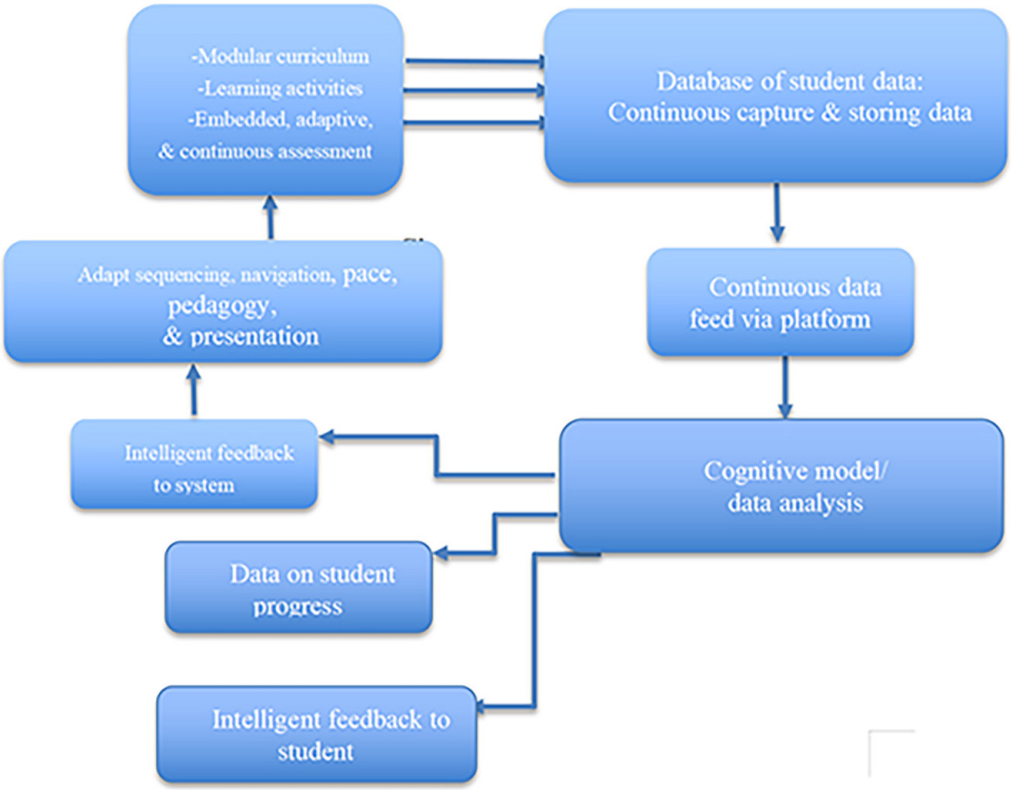

Fig. 2. Design elements of IALS [22]

2. FT Test

Following the delineation of the concept of FT based on the presented terminology and theoretical background, two primary types were identified: spontaneous flexibility, which involves generating the maximum possible number of diverse thought directions linked to a problem or provocative situation; and adaptive flexibility, which signifies the capacity to produce unfamiliar solutions to problems. Consequently, the test comprises 10 essay-type items.

To Verify Psychometric Properties:

A-Validity:

***Face Validity:** It refers to the general appearance of the test in regard to item type, content, clarity of wording, and structure that is held acceptable.

****Construct Validity:** It is the degree to which a test measures what it claims, as evidenced by empirical validation of the matches between test scores and the relevant concept. Invalidity is the lack of correspondence of the empirical test outcomes to the theoretical construct. The construct validity for the FT test was supported by: (a) obtaining a correlation between each item and total test scores and (b) having all items correlate with their corresponding domain [32].

B-Reliability: Reliability was assessed using the split-half method, in which the test was divided into two equivalent halves. Pearson's correlation coefficient for the halves was 0.50. After correction with the Spearman-Brown prophecy formula, the reliability coefficient increased to 0.70, indicating good reliability.

3. Academic Achievement Test

A 10-item multiple-choice test was constructed to assess learning of constructivist lesson complexity at the cognitive levels of Bloom. A table of specifications was created from the content that had been personally taught by one of the investigators to the study participants, considering the number and relative importance of behavioral objectives according to Bloom's taxonomy. The test's validity was verified through face validity to ensure the integrity of item wording and formulation, followed by confirmation of content validity [33].

Statistical Analysis: The test was administered to an exploratory sample outside the main research sample. After scoring responses, scores were arranged in descending order, and the upper and lower 27% groups were selected (yielding 27 students per group). The difficulty coefficient for each item was then calculated using the appropriate equation, ranging from (0.40 to 0.75)—indicating the test is valid and effective. Discrimination indices ranged from (0.60 to 0.80), confirming all items are suitable for application. The effectiveness of distractors was assessed, revealing all negative values, so they were retained without modification or deletion. Kuder-Richardson Formula 20 (KR-20) was applied to the objective items, yielding a reliability coefficient of 0.80, signifying good and acceptable test stability.

4 RESULTS

1. **1st HO.:** There is no statistically significant difference at the significance level (0.05) between the mean scores of the experimental group students who studied the assigned material using a teaching strategy based on IAL and the control group students who studied the same material using the conventional method in the FT test, as shown in Table 1 and Figure 3.

Table 1. FT test

Group	No.	Average	SD	Variance	DF	t Value		Signifier	η^2
						Calculated	Tabular		
Experimental	30	7.94	0.44	0.193	58	5.586	2.002	Sig.	0.34
Control	30	7.42	0.26	0.067					

Notes: $\alpha = 0.05$; p-value < 0.001.

2. **2nd HO:** There is no statistically significant difference at the level of significance (0.05) between the mean scores of students in the experimental group who studied according to the IALS and those in the control group who studied the same subject using the usual method in the achievement test. See Table 2 and Figure 3.

Table 2. Academic achievement test results

Group	Sample	Mean	S^2	s	df	t(Cal.)	t(Tab.)	α	Sig	η^2
Exp.	30	70.8	14.2	201.6	58	2.221	2.002	0.05	Sig.	0.42
Con.	30	62.8	13.7	187.6						

Note: p = 0.030.

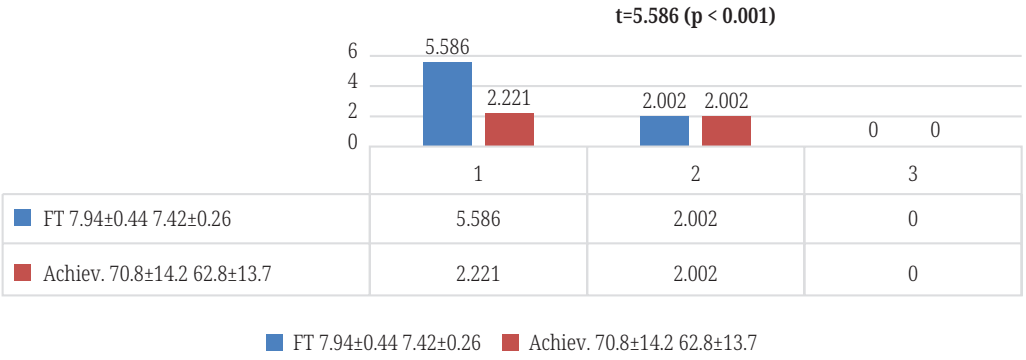

Fig. 3. Data comparison

Notes: Sig at 0.05; df = 58; $\alpha = 0.05$.

5 DISCUSSION AND CONCLUSIONS

The experimental group's superiority in FT ($t = 5.586$, $p < 0.001$, $\eta^2 = 0.34$) and achievement ($t = 2.221$, $p = 0.030$, $\eta^2 = 0.42$) strongly supports the hypotheses, aligning with prior findings on IALS efficacy. For instance, Rincon-Flores et al. [18] reported 30–50% achievement gains via adaptive systems, which our $\eta^2 = 0.42$ exceeds, particularly in higher-order skills such as FT as defined by Montanari [26] (spontaneous/adaptive types).

These results extend AI applications in e-learning [9–12], filling gaps in Iraqi higher education where 70% of systems lack adaptivity [1]. Unlike traditional methods' limitations on individual differences [1–3], IALS via Google Classroom provided personalized paths, enhancing cognitive flexibility (acceptance of tech, open-mindedness) [29] and Bloom-level mastery [33].

In line with UNESCO (2021) [1] and Wang et al. [4], AI fosters future skills (adaptability, self-directed learning). Our quasi-design [31] confirms hybrid teacher-AI roles [24–25], boosting motivation in math/algorithms courses.

Limitations: Small sample (n = 60) limits generalizability [31]; single-department focus (Computer Science); short-term (12 weeks)—longitudinal studies needed. No control for prior tech exposure, though pre-tests mitigated this.

Conclusions: IALS proves transformative for undergraduate FT and achievement, urging policy shifts. Recommendations build on [7–8]:

- Centralize adaptive platforms university-wide (resolve internet issues).
- Faculty training in AI pathway design [24].
- Integrate into STEM/humanities; special needs adaptations [23].

Future: Multi-institution trials; VR/robot extensions [12, 17].

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