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Active learning strategies as a mediator between educational components and knowledge retention in Science at LSPU-System

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ABSTRACT

Strategies for active learning were examined as a mediator between educational components (curriculum, instruction, and assessment) and knowledge retention in Science Education. The researcher implemented a descriptive-correlation study that also used Structural Equation Modelling. The research utilized a simple random sample procedure and achieved an 81.52% response rate with 300 respondents. Students have experienced a curriculum emphasizing critical thinking, creativity, and problem-solving, prioritizing comprehension over rote memorization. In terms of Instruction, dynamic teaching methods and cooperative learning help them foster real-world problem-solving and student-centered learning. Effective assessment practices enhance their self-awareness and autonomy. Finally, they found active learning strategies (ALS) and real-world problem-solving increase engagement and self-reliance. Knowledge retention in science was moderate overall (31.16; 38.95%). This finding supports that knowledge retention over time. In addition, HOTS concepts are complex to learn and thus pose a challenge to retain. While effective curriculum, instruction, and assessment are crucial, the study underscores that active learning strategies are the linchpin in fully mediating the relationship between assessment and knowledge retention. The study's findings emphasize the importance of science education, ensuring students are given opportunities to learn and develop thinking and questioning skills beyond mere information retention. To facilitate this, the study advocates implementing active learning strategies to bridge this gap, especially between assessment and knowledge retention. The study suggests that these strategies can significantly enhance student engagement and knowledge retention, with a focus on learning higher-order thinking skills (HOTS).

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INTRODUCTION

Knowledge retention in science education faces significant challenges. Students have problems recalling prior learning, which becomes even worse during the shift to online learning. The extra cognitive load and lack of focus could hinder memory recall (Ismail & Sabrina, 2023). The pandemic has further disrupted education by rising workloads and dissatisfaction with distance learning, thus decreasing students' responsibility for knowledge acquisition (Vinichenko et al., 2021).

Although independent learning and self-organization are promoted in the curriculum in Senior High School, students rely on rote learning to get high scores for high-stakes examinations, which is counterproductive to genuine learning and knowledge acquisition (Cherrier et al., 2020; Learned et al., 2020). It has been observed that learners tend to forget the knowledge imparted to them in the classroom. Therefore, courses are reiterated. It limits the possibilities of extending the range of topics studied and deepens understanding of the need for proper teaching methods and curriculum planning (Deng, 2022; Karwasz & Wybroska, 2023).

Theoretical methods such as the Zone of Proximal Development and the Cognitive Load Theory provide views on the retention of information. ZPD embraces facilitated, scaffolded instruction consistently optimized to enhance the learner's elaborate realization of a skill or subject matter concept (Breive, 2020). CLT stresses working on the tip of the cognitive load by improving pedagogical content features and reducing irrelevant and unrelated features (Paas & Merriënboer, 2020; Clark & Kimmons, 2023). However, knowledge acquisition and application by the students do not seem to have improved.

Given the development of curriculum, especially the K-12 in the Philippines, the aim of preparing the students with the right skills and competencies is desired. Still, there are specific issues that must, however, be faced to ensure proficiency (Rogayan & Dollete, 2019). Specifically, using Active Learning strategies has been identified as one of the techniques that can improve knowledge acquisition and students' attendance. Some activities like group discussions, problem-solving sessions, or even application of knowledge advance critical thinking, hence helping in improved understanding and, therefore, increasing the knowledge content as advanced by science (Flax, 2023). Bouwmeester et al. (2019) and Darling-Hammond et al. (2020) found that one of the two purposes of active learning was to decrease the load on the learner's working memory that was already present and increase the learner's motivation and performance. However, applying these techniques to practical and effective curriculum, instruction, and evaluation focused on finding practical answers to the recurring problem of knowledge acquisition and retention.

Integrating active learning strategies with well-designed curricula and assessments can significantly enhance knowledge retention. When these learning strategies are part of a well-articulated curriculum that maps with intended learning outcomes and assessment, the students are more likely to appreciate their learning, remain focused, and have long-term retention of knowledge /skills. Furthermore, assessments emphasizing critical thinking and application rather than rote memorization encourage students to engage more deeply with the material, thereby enhancing long-term retention. In addition, these strategies improve immediate academic performance and prepare students for lifelong learning and professional success (Alsaleh, 2020; Assaly & Jabarin, 2021; Deng, 2022).

OBJECTIVES OF THE STUDY

This study sought to establish whether active learning strategies could mediate the connection between educational components focusing on curriculum, instruction, and assessment and students' knowledge retention in science.

MATERIALS AND METHODS

The study used a descriptive-correlation design to explore how curriculum, instruction, and assessment influence science knowledge retention, with active learning strategies as a potential mediator. The method used in selecting the respondents was simple random sampling, whereby all the respondents had an equal chance to participate in the study. In addition, assumptions on the homogeneity of the respondents were assumed to be similar to those in research conducted in the field of education (Bhardwaj, 2019; Thomas, 2020). Based on the sample size formula, the researcher determined that 368 respondents included in the study came from the four Campuses of Laguna State Polytechnic University (San Pablo, Los Baños, Sta. Cruz, and Siniloan) as granted permission from the University President. However, only 300 responses (over 80% response rate) through Google Forms were retrieved from March to April.

The researcher adopted and contextualized questionnaires as the research instrument to gather data on respondents' profiles, level of agreement on curriculum (Aslan & Gunay, 2016), instruction (Suratmi & Sopandi, 2022), assessments (Pat-el et al., 2013), and practice of active learning strategies of students (Shroff et al., 2020). Moreover, the knowledge retention utilized a researcher-made multiple-choice test, which collated questions requiring HOTS from various trustworthy sources. The research instrument was initially assessed by three (3) experienced teachers - a master teacher, a science coordinator, and a school principal—all critiques, suggestions, and recommendations for improving the research instrument. In the preliminary data gathering, instruments demonstrated strong internal consistency (Cronbach $\alpha = 0.776 – 0.936$), and the knowledge retention test had high reliability (KR-20 = 0.90; 0.66). This showed that the final research instrument used in the study is valid and has strong internal validity and reliability.

Frequency distribution tables summarized respondents' characteristics (age, gender, academic strand, grade, and campus). Data on students' perceptions of curriculum, instruction, and assessment and the extent of active learning strategies were analyzed using weighted means.

Descriptive statistics (mean, standard deviation) characterized science knowledge retention. Correlations (Spearman and Chi-Square) among independent (curriculum, instruction, assessment), dependent (knowledge retention), and meditating (active learning strategies) variables were tested, followed by regression analyses and structural equation modeling (SEM). SEM was used to determine the mediation effect of active learning strategies on the relationship between educational components and knowledge retention.

RESULTS AND DISCUSSION

Profile of the Respondents (Age & Grades in Science)

First-year college students have a mean age of 19.43. This phenomenon is parallel to the idea of Reyes (2023), which entails that most college students are in the starts around 18, and there is a recent flux of older students approaching the age of 30. In addition, they performed at a "Very Satisfactory" level in their previous science subjects in SHS (See Table 2). This implies that students have developed high scientific reasoning skills and critical thinking while attaining specific learning competencies mandated by the Department of Education. Those students can perform well in science subjects, no matter their academic strand or track. In the study of Farillon (2023), most students in various strands (including STEM, GAS, ABM, HE, and ICT) have a very satisfactory performance in science, which mirrors the current study's findings.

Table 1. Profile of 1st-Year College Students in Terms of Age and Grades in Science

`Profile	Category	$\bar{x}$	SD	Meaning
Age	–	19.43	1.57	–
Grade in Science	Earth and Life Science	89.80	3.80	Very Satisfactory

Physical Science	89.82	3.95	Very Satisfactory

Regarding gender, more female respondents were involved in the online survey. This result implies that females are more empathic and participative in online surveys. Females were more likely to participate in responding to research surveys compared to males due to their desire to have their opinions on a specific topic (in this case, their perception of research trends in education) heard (McMahon et al., 2023).

Many first-year college students attracted to LSPU were in academic strands (Gonzales & Digo, 2024), mostly HUMSS. HUMSS strand covers both the Humanities and Social Sciences disciplines, which prepares the students to pursue related college programs, yet some pursue other fields of specialization. Thus, Santiago (2022) advised that students must cross-check the "fit" based on their academic performance to prepare for tertiary education. This means that the student's inclinations can be checked based on their academic performance, which can help them decide which specialization they want to pursue in college.

Table 2. Profile of 1st-Year College Students in Terms of Gender and Academic Strand/ Track

Profile	Category	n=300	%
Gender	Female	171	57.00
	Male	121	40.33
	Prefer not to say	8	2.67
Academic Strand/ Track	ABM	39	13.00
	GAS	56	18.67
	HUMSS	105	35.00
	STEM	27	9.00
	TVL	73	24.33

The results implied that science education must adapt to the diverse profiles of the students. When implemented correctly, inclusive strategies and interdisciplinary approaches can enhance students' engagement and accessibility to knowledge from basic to complex. It is also essential to consider the alignment of interests and abilities to appropriate specializations to support success across all backgrounds.

Level of Agreement of Students in Educational Components: Curriculum, Instruction, and Assessment

The students perceived the curriculum and all its aspects, such as the attainment of objectives, content elements, educational context, and evaluation elements.

Integrating critical thinking (CT) into the curriculum content and instructional methodologies is essential for developing proficient critical thinkers. This integration, along with appropriate sequencing across all grade levels, is a crucial measure of the quality of student learning (Ansaleh, 2020). A curriculum based on student perspectives and integrating real-life knowledge and skills fosters enhanced comprehension, analysis, synthesis, and evaluation. Such a curriculum is necessary for meaningful learning and engagement (States et al., 2023). Different strategies and techniques must be integrated into the curriculum to cater to various types of learners, addressing cognitive, affective, and psychomotor development to create well-rounded individuals (Miqawati, 2022; Naro et al., 2023). Cooperative learning methods, emphasizing knowledge and skill sharing, significantly increase students' self-esteem and engagement and promote problem-solving skills. In higher education, effective collaboration involves converting classical teacher–student teaching into active/participatory/student-centered learning, emphasizing critical thinking, cooperation, and teamwork rather than learning by rote (Fragouli, 2023). Evaluation in the curriculum is not only concerned with knowledge retention but also with cognitive, affective, and kinesthetic development. The differentiated performance tasks and appropriate evaluation tools help to achieve learning outcomes by bridging gaps between students and teachers (Naro et al., 2023; Luu & Phan, 2020).

Table 3. Level of Agreement of Students in Curriculum Constructs

Curriculum	$\bar{x}$	Meaning
Attainment of Objectives	4.18	Agree
Content Elements	4.10	Agree
Educational Contexts	4.12	Agree
Evaluation Elements	4.07	Agree
Overall	4.12	Agree

Educators enhance their knowledge and teaching skills by engaging in problem-solving activities and observing students closely in action-based learning scenarios that encourage thinking development and promote dialogue with students to shape their perspectives positively and foster introspection (Faravani & Talebi, 2020). According to Lubis (2020), problem-based learning models can increase problem-solving ability more effectively than conventional models. Expert teachers employ questions at the higher-order thinking level to improve students' listening comprehension and critical thinking skills. Gochitashvili and Bashvili (2021) emphasize the importance of specific activities and questions to develop critical thinking, focus on crucial issues, and incorporate these skills into assignments and activities. Students believe teachers excel in helping them evaluate material critically and connect experimental results to real-world applications.

Students have a positive perception of teachers' efforts to promote critical thinking. The encouragement to conduct critical analysis is precious for deepening learning. Teachers' commitment to enhancing critical thinking abilities is highly esteemed. A constructive classroom environment and collaborative partnerships in online courses foster active, participatory learning (Fan et al., 2020). This environment, coupled with a focus on in-depth comprehension, aligns well with students' learning objectives and supports the development of critical thinking. Teachers are appreciated for administering tests that measure the kinds of critical thinking that students will find helpful. Students like being tested that way because it helps them develop the thinking they need. (Butcher et al., 2023).

Table 4. Level of Agreement of Students in Instruction Constructs

Instruction	$\bar{x}$	Meaning
Knowledge	4.21	Very Knowledgeable
Skills	4.16	Skilled
Attitudes	4.20	Positive
Overall	4.19	Great Instruction

As for Monitoring, students assume that their teachers encourage people’s performance reflection and focus on personal growth. Lazar (2022) states that teachers must encourage students to reflect on performance to facilitate their development and evaluate the approaches' success. When the students are taken through discussions on their results, they are in a better position to appreciate the results and some of their flaws. This approach fosters self-awareness and self-regulated learning necessary for improving motivation and academic achievement (Bonem et al., 2020).

In addition, instructional strategies like defining content at various difficulty levels and asking practical questions positively affect students’ understanding and learning processes (Dung & Trang, 2020). Such practices foster an effective classroom climate that enhances the students’ perceived membership and, therefore, positive engagement (Wulan & Sanjaya, 2022).

Table 5. Level of Agreement of Students in Assessment Constructs

Assessment	$\bar{x}$	Meaning
Monitoring	3.92	Implemented
Scaffolding	4.12	Implemented
Overall	4.02	Implemented

Hence, the study shows that improving science learning calls for infusing thinking skills into the curriculum and using learner-involvement techniques like cooperative and problem-based learning. Scaffolding and multiple formative and summative assessments, such as performance tasks and reflective assessments, enhance students' ability to analyze and solve problems. It should be noted that teachers should act as enablers instead of instructing the learners, and any professional development should be ongoing to help implement these approaches. Related to the topics of students' affairs, creating a positive learning climate in class and cooperation with students, connecting the materials shared with students to practical experience, promoting students' interest and learning relevance, engaging students in self-assessments and other forms of evaluations to help them better understand the content taught and improve better thinking abilities.

Level of Students' Active Learning Strategies

Students considered the activities useful, stimulating, practical, discussion-based, and related to some world events. Indeed, this active participation significantly predicted the learning acquired (Ginting, 2021). It allowed for enhanced explanations, thus a better understanding of the concepts, and increased interrelation between theory and practice. They also sponsored collective and invitational designs that systematically made the participants think critically about problems (Muvid et al., 2022).

Additionally, the activities helped the students identify their learning orientations, connect belief patterns and practical circumstances, and be open to further educational opportunities. Students showed preparedness to take responsibility for their learning process, flexibility to learning demands, and interest in experiential learning (Collins & Redden, 2020). The motivation to learn was further complemented by activities that enhanced their interest and curiosity in several topics, attesting to their freedom to make appropriate decisions (Wenning & Vieyra, 2020).

Table 6. Level of Students' Active Learning Strategies

Active Learning Strategies	$\bar{x}$	Meaning
Engagement	4.10	High
Cognitive Processing	4.07	High
Orientation to Learn	4.17	High
Readiness to Learn	4.21	Very High
Motivation to Learn	4.17	High
Overall	4.14	High

Incorporating motivating problem-solving experiences within the science curriculum improves students' interactions and performance by relating ideas to practical cases. This approach promotes the actual involvement of students, their analysis, and their logical and thorough approach to the problems. These positive attitudes require the students' beliefs to be aligned with real-life experiences to foster independent learning and motivation. Tasks that spark interest and exploration enhance the function of the individual and foster a more efficient and activating learning process. Applying these techniques can go a long way toward enhancing academic achievement and increasing students' interest.

Knowledge Retention in Science

Table 7 reveals that students retain moderate knowledge retention in Earth and life science while performing poorly in Physical Science. From their performance, it can be inferred that they moderately understand the concepts learned in the two subjects.

The study also shows that while some learners perform better, many require assistance reinforcing scientific concepts brought about by poor comprehension of essential concepts. Since the test targets HOTS, it is not easy even when the students have prior knowledge of the content being tested. Research conducted about the learning of science subjects seeks to explain the role of prior learning, stressing a firm foundation. Some teachers tend to direct their questions to lower levels of questioning, thereby, might not encourage students to employ the top-level questioning skills needed when answering HOTS questions. This puts much pressure on the students because they must overturn these odds and get better retention. Arifin and Arifin (2019) conducted a study that explores the rates of retention on a long-term basis in medical education, ranging up to only 50%, and this shows the problem of knowledge retention in science education.

Table 7. Level of Knowledge Retention in Science of 1st Year College Students

Knowledge Retention in Science	Mean	%	SD	Meaning
ELS	21.5	41.35	9.16	Moderate Knowledge Retention
PhySci	9.66	34.5	4.58	Low Knowledge Retention
Overall	31.16	38.95	12.72	Moderate Knowledge Retention

Therefore, assessing higher-order thinking skills should not be separate. Embracing active learning approaches and offering specific professional development can enhance critical thinking and educational performance. Knowledge-checking is continuous, so any gaps in knowledge can be identified and potentially rectified depending on the feedback; another technique found to aid long-term retention is spacing. Strengthening these areas may help students obtain a more profound and long-lasting understanding of the matter from a scientific viewpoint.

Relationship between Profile and Perception on Curriculum, Instruction, and Assessment

Spearman correlation analysis was implemented to establish a connection between the students' profiles (Age & Academic Strand/Track) with Curriculum, Instruction, and Assessment. Age had very weak correlations with Curriculum, Instruction, and Assessment facets. Thus, age does not seem to influence how students perceive the quality of their learning experiences. However, science grades had weak yet statistically significant correlations with Curriculum, Instruction, and Assessment facets. This implies that the higher the students' science grades, the better they perceive their curriculum, instruction, and assessment. Similarly, college student samples have also shown that student's course grade is related to their perception of course quality (Sakiz et al., 2021; Okun et al., 2022; Schultz-Jones & Ledbetter, 2021). Students' perception of the quality of their learning journey in education seems to be shaped by their academic performance.

Table 8. Relationship between Profile (Age and Grade in Science) and Curriculum, Instruction, and Assessment

Profile	CIA	r	Strength	P-Value
Age	Curriculum	-0.007	Negligible	0.899
	Instruction	-0.067	Negligible	0.245
	Assessment	-0.060	Negligible	0.299
Grade in Science	Curriculum	0.150	Weak	0.012*
	Instruction	0.196	Weak	0.001**
	Assessment	0.133	Weak	0.026*

Gender was significantly associated with the curriculum and instruction, indicating that gender may influence these aspects. Based on the contingency table, all gender categories likely agreed strongly with curriculum and instruction. This contrasts with Darkwa et al. (2020), who mentioned gender differences in students' perceptions of curriculum and their educators' classroom management strategies in science classes. However, no significant association was found between gender and assessment. For academic track/strand, no significant associations were observed with any aspects examined—curriculum, instruction, or assessment—suggesting that the choice of track/strand may not significantly affect these educational components.

Table 9. Relationship between Profile (Gender & Academic Strand/ Track) and Educational Components

Profile	CIA	X^2	df	P-Value
Gender	Curriculum	10.87	4	0.028*
	Instruction	12.55	4	0.014*
	Assessment	4.453	4	0.348
Track/ Strand	Curriculum	7.810	8	0.452
	Instruction	11.12	8	0.195
	Assessment	5.707	8	0.680

The analysis shows that higher science grades improve perceptions of curriculum, instruction, and assessment, emphasizing the role of academic performance. Gender significantly affects views on curriculum and instruction, suggesting the need for gender-sensitive approaches. Academic track/strand does not impact these perceptions, highlighting the importance of consistent quality across tracks. Thus, improvements should focus on enhancing academic performance and addressing gender-specific needs while maintaining high standards across educational tracks.

Relationship of Profile and Knowledge Retention in Science

It is found that there is a negligible correlation between Age and Knowledge Retention, implying that age alone does not significantly correlate with knowledge retention in science. Science grades negatively correlate with knowledge retention. Higher grades showed that students have learned from basic to complex science concepts, but there was a significant decay of knowledge considering knowledge retention. Binder et al. (2019) stressed that prior knowledge of principles and concepts predicts significantly higher academic achievement early in biology and physics courses. Moreover, Daniel's (2023) study showed that students suffered a substantial loss of knowledge over the curriculum period when they studied interrelated subjects, followed by a year.

Table 10. Relationship between Profile (Age & Grade in Science) and Knowledge Retention in Science

Profile		r	Strength	P-Value
Age	Knowledge Retention	-0.055	Negligible	0.338
Grade in Science		-0.209	Weak	<0.001**

From the table, we can infer that sex (gender) is not a discriminator of knowledge retention, similar to the findings of Ani et al. (2021). On the other hand, academic strand/ track has a significant relationship with the knowledge retention of 1st-year college students. Every academic strand has more students with low knowledge retention being pulled by several students with moderate knowledge retention, as supported in the contingency table. GAS, HUMSS, TVL, ABM, and STEM have more students with low knowledge retention. This finding parallels Rubas (2023), where strands in senior high school should be considered and must undergo a short-bridging program, especially those with strands that must be aligned with their chosen program.

Table 11. Relationship between Profile (Gender & Academic Strand/ Track) and Knowledge Retention in Science

Profile		X^2	df	P-Value
Gender	Knowledge Retention	5.883	4	0.208
Track/ Strand		27.59	8	<0.001**

Prior knowledge significantly influences academic success, suggesting curricula should focus on fundamental concepts. Variations in retention across academic strands highlight the need for tailored curricula and bridging programs. Gender does not impact retention, shifting focus to other factors. Continuous assessment is crucial for addressing learning gaps and enhancing science education effectiveness.

Influence of Curriculum, Instruction, and Assessment on Knowledge Retention in Science

Curriculum design plays a pivotal role, emphasizing the importance of how scientific content is structured and presented. A well-organized curriculum aligned with educational standards enhances students' understanding and long-term retention of scientific concepts (Yanti et al., 2023). Instructional methods significantly impact retention. Techniques such as interactive lessons, hands-on experiments, and multimedia resources are crucial for effective learning. These approaches foster active engagement and critical thinking, essential for better comprehension and retention of scientific information (Pillado et al., 2020).

Assessments also play a critical role. Effective assessment tools, including formative assessments and project-based evaluations, provide valuable feedback that guides instructional adjustments and reinforces learning outcomes. This highlights the importance of using assessments to evaluate, support, and enhance learning processes (Gamo, 2022). Active engagement during learning significantly enhances knowledge retention compared to passive approaches (Krishnan, 2019). Teachers' proactive feedback and scaffolding techniques improve students' understanding and responsiveness in science education. Thus, a comprehensive approach integrating well-designed curricula, effective instructional strategies, and meaningful assessments is crucial for optimizing knowledge retention and fostering deeper scientific understanding among students.

Table 12. Influence of Curriculum, Instruction, and Assessment Dimensions on Knowledge Retention in Science

Variables		Model Summary		ANOVA	
		R	R^2	F	P-Value
Curriculum	Knowledge Retention	0.184	0.034	2.59	0.037*
Instruction		0.203	0.031	4.24	0.006**
Assessment		0.206	0.036	6.6	0.002*

Effective science education requires a well-structured curriculum aligned with educational standards, diverse instructional methods (interactive lessons, hands-on experiments, multimedia resources), and varied assessment tools (formative and project-based). Active learning strategies like collaborative problem-solving and discussions facilitate deeper comprehension and retention. Teachers' targeted feedback and scaffolding techniques support student understanding and address learning challenges. Integrating these elements optimizes science education by improving student understanding and long-term retention of scientific concepts.

Active Learning Strategies as Mediator in the Influence of Educational Components on Knowledge Retention

Initially, curriculum, instruction, and assessment were hypothesized to correlate directly with knowledge retention, but the indirect effects indicate otherwise (Deslauriers et al., 2019). Effective knowledge retention in science hinges on several key factors. Relevance and engagement are crucial; irrelevant material and passive instructional methods can impede retention. Additionally, inadequate assessment practices and a lack of feedback hinder effective learning outcomes.

Active learning strategies related to curriculum, instruction, and assessment promote interactive and student-centered learning environments (Bassachs et al., 2020). An adaptable, interdisciplinary curriculum with clear objectives supports such strategies. Diverse teaching methods, teacher professional development, and conducive learning environments further enhance educational effectiveness. Formative assessments provide immediate feedback, while summative assessments incorporating projects and performance activities demonstrate active learning outcomes. Despite the benefits of active learning strategies, their direct impact on knowledge retention in science appears insignificant (Torralba & Do, 2020). Poor execution, student resistance, and the complexity of science topics can diminish their effectiveness. Moreover, traditional assessment methods may only partially capture the deeper understanding fostered by active learning approaches.

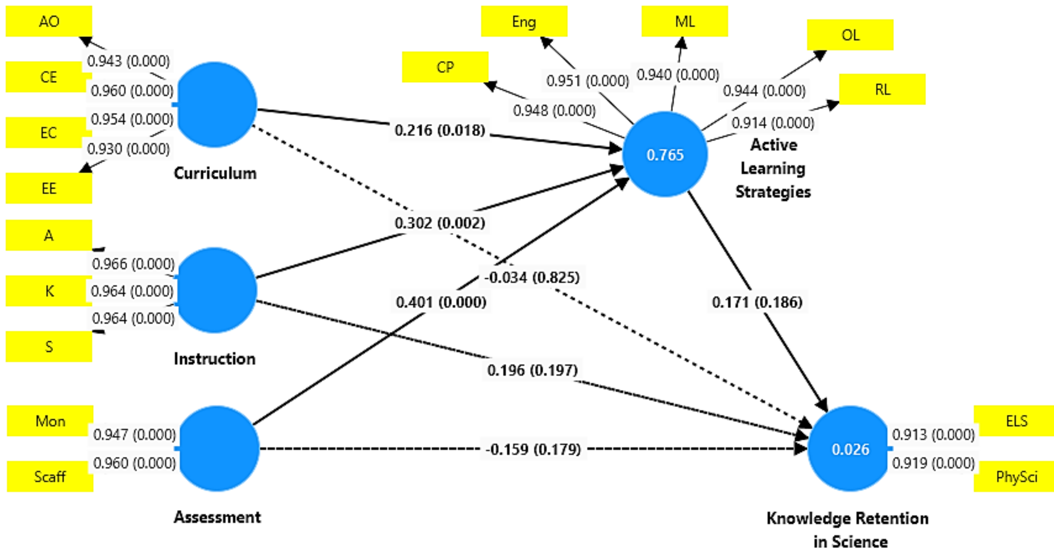

Figure 1. Hypothesized Structural Model Showing the Relationship between Curriculum, Instruction, and Assessment and Knowledge Retention in Science Mediated by Active Learning Strategies

Active Learning Strategies do not mediate Curriculum and Instruction but fully mediate Assessment and Knowledge Retention. Assessment methods like Monitoring, characterized by passive evaluation through exams and observations, could lead to superficial knowledge retention (Vlasblom et al., 2020). In contrast, scaffolding is an active technique involving teacher support through learning challenges, enhanced comprehension, and retention (Ouyang et al., 2021). Active Learning Strategies, encompassing interactive problem-solving, group discussions, and practical exercises, facilitate more profound understanding and retention by engaging students actively in learning. This integration transforms passive monitoring into a dynamic, continuous application and evaluation of knowledge, aligning with cognitive learning theories emphasizing active involvement for enhanced encoding and retrieval (Coker et al., 2018). Thus, while Active Learning Strategies do not mediate Curriculum and Instruction, they significantly enhance Assessment's impact on Knowledge Retention.

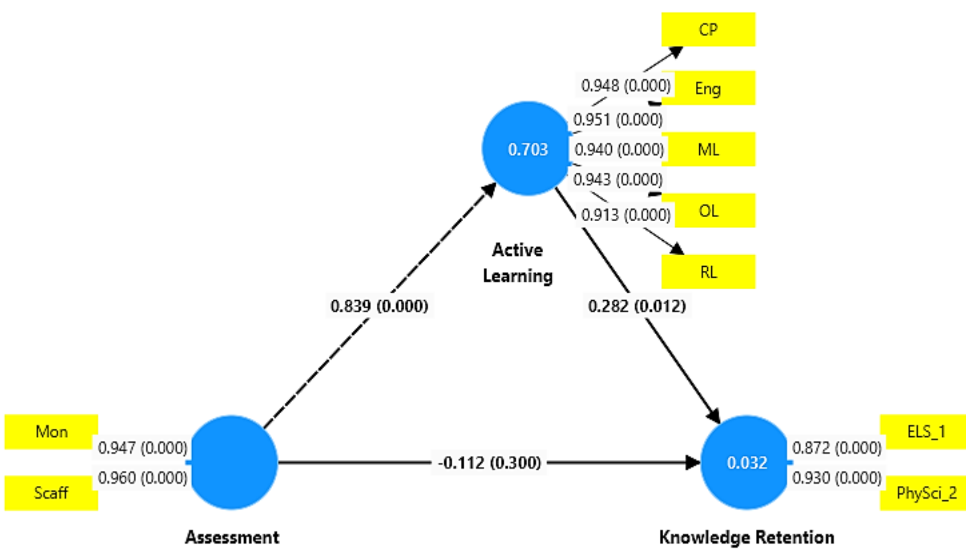

Figure 2. Modified Structural Model Showing a Full Mediation of Active Learning Strategies in the Relationship Between Assessment and Knowledge Retention in Science

Table 13 reveals that in the modified model, there are significant relationships between various factors that affect learning effectiveness. Firstly, active learning strategies demonstrate a significant impact on knowledge retention. Furthermore, assessment methods exhibit an even stronger correlation with active learning strategies. Additionally, the assessment methods employed also significantly influence knowledge retention levels.

The findings stress the pivotal role of active learning strategies and assessment methods in education. Their significant relationships with knowledge retention highlight their importance in fostering meaningful learning. Active learning promotes student engagement, participation, critical thinking skills, and increased motivation, leading to better knowledge retention and improved academic performance (Dogani, 2023). Then, teachers need to focus on group discussions and problem-solving activities, which drive student engagement. Tasks must also correlate with objectives and deliver feedback by incorporating assessments into instruction and professional development; students will thrive.

Table 13. Testing of Variables for the Modified Model

Variables	O	$\bar{x}$	SD	T statistics	P values
Active Learning Strategies → Knowledge Retention	0.282	0.295	0.113	2.503	0.012*
Assessment → Active Learning Strategies	0.839	0.839	0.031	26.721	0.000**
Assessment → Knowledge Retention	0.124	0.126	0.051	2.416	0.016*
Assessment → Active Learning Strategies→ Knowledge Retention	0.236	0.249	0.098	2.408	0.016*

This illustrates how important an active learning approach and more subtle and nuanced assessment methods are in maintaining student understanding, particularly within science. Educators are urged to use interactive, student-centered methods like problem-based learning, facilitated discussions, and experiential exercises as much as feasible. These instructional tools provide a more severe cognitive engagement and lead to the same sense of knowledge that the traditional educational methods have been taught in.

Moreover, assessment practices require systematic re-evaluation to align with active learning principles. Conventional assessment methods, including standardized exams and observational evaluations, may need to be revised to measure the depth and complexity of knowledge fostered by active learning environments. In contrast, formative assessments, project-based learning, and performance tasks are more congruent with these pedagogical approaches. These assessment methods promote continuous learning and provide actionable insights into student progress. The timely provision of constructive feedback is also essential, as it reinforces learning outcomes and supports student development.

Additionally, the professional development of educators is pivotal for effectively integrating these strategies into teaching practices. Teachers require targeted training in active learning methodologies, scaffolding techniques, and innovative assessment practices. This ongoing professional development should be complemented by a flexible and interdisciplinary curriculum design, emphasizing relevance and student engagement, thereby supporting the successful implementation of active learning frameworks.

CONCLUSION AND RECOMMENDATION

The study concludes that the active participation on the part of the learner is consistent with assessments for highly focused interventions in areas that the learner finds difficult. A final set of principles involves cognitive load theory's role in augmenting effective resource management, reducing extraneous load, and providing concise, clear information in a controlled way to avoid overload. This is supplemented by activities that promote active learning skills, such as problem-solving and group discussions, which deepen understanding and boost motivation, thereby stressing the relevance of practical appraisals in the learning continuum. In addition, it highlights the significant contributions of aligning teaching practices with cognitive development theories, advocating for an evidence-based approach to curriculum design and instructional strategies. This alignment is crucial for creating supportive learning environments that promote critical thinking and skill mastery, guiding students toward greater independence in learning and problem-solving. The findings are highly relevant to educational policy and practice, suggesting that adopting these approaches can lead to improved academic outcomes and more effective teaching methods.

Other recommendations include refining the curriculum to promote essential abilities; formulating quality control procedures for teaching methods and research grants to promote teaching excellence and retention in science education; stimulating the discussions on diverse real-world problems to sharpen critical thinking and understanding; emphasizing these abilities in the last two high school years; raise these abilities in college student through challenging activities; and lastly, refine the curriculum to encourage critical thinking and lend understanding. Nonetheless, the study has several limitations, such as overall generalizability and the lack of longitudinal data to evaluate long-term effects. To overcome these limitations, future research must address whether ZPD and cognitive load theory can be unified, how effective this unification is across various educational settings, and whether specific active learning strategies are effective for various disciplines and levels of education.

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