

Smart eLearning: A framework development of a web portal for data-driven assessment and module recommendation for senior high school students using backtracking algorithm

¹Ma. Glaizel R. Gajardo & ²Francis F. Balahadia

Abstract

The study reviewed challenges in student performance in the Philippines, particularly in reading, mathematics, and science, as reflected in international assessments such as PISA and the 2024 National Achievement Test (NAT). Despite various efforts, Filipino students continue to underperform in these core subjects, highlighting the need for more targeted and personalized learning interventions. Existing assessment methods often fail to accurately identify specific learning gaps, making it difficult to provide timely and appropriate academic support. In response, the proponents introduced the SMART eLearning framework a conceptual web-based model designed to enhance instruction through data-driven assessments and customized learning materials. It integrates diagnostic and achievement tests with a backtracking algorithm a method that systematically traces a student's incorrect answers to uncover underlying concepts they struggle with. Based on these results, the system recommends focused modules or exercises to help students improve in those specific areas. This approach aims to help senior high school students master essential competencies required for national standardized tests and college entrance exams. The framework promotes an adaptive learning environment using ICT tools such as automated quizzes, performance dashboards, and real-time progress tracking that provide immediate feedback to both learners and educators. It will guide system development through a developmental and descriptive research design, applying Agile principles to enable continuous refinement through classroom testing and user input. Ultimately, the SMART eLearning framework seeks to improve academic performance, reduce failure rates, and better prepare students for higher education and future careers, addressing persistent challenges in the Philippine education system.

Keywords: *learning materials recommendation, backtracking algorithm, diagnostic analytics, data-driven assessment, educational quality*

Article History:

Received: May 21, 2025

Accepted: June 29, 2025

Revised: June 25, 2025

Published online: August 2, 2025

Suggested Citation:

Gajardo, M.R. & Balahadia, F.F. (2025). Smart eLearning: A framework development of a web portal for data-driven assessment and module recommendation for senior high school students using backtracking algorithm. *International Journal of Science, Technology, Engineering and Mathematics*, 5(3), 22-39. <https://doi.org/10.53378/ijstem.353233>

About the authors:

¹Corresponding author. Bachelor of Science in Computer Science, Student, State Polytechnic University (Siniloan) Host Campus. Email: maglaizel.gajardo@lspu.edu.ph

²Doctor in Information Technology. Faculty, Laguna State Polytechnic University (Siniloan) Host Campus. Email: francis.balahadia@lspu.edu.ph

© The author (s). Published by Institute of Industry and Academic Research Incorporated.



This is an open-access article published under the Creative Commons Attribution (CC BY 4.0) license, which grants anyone to reproduce, redistribute and transform, commercially or non-commercially, with proper attribution. Read full license details here: <https://creativecommons.org/licenses/by/4.0/>.

1. Introduction

Assessment plays a crucial role in education, providing critical insights into student learning, informing instructional practices, and guiding policy reforms. Effective assessment systems are essential not only for evaluating academic achievement but also for identifying learning gaps and addressing systemic weaknesses. According to Jimenez and Modaffari (2021), large-scale assessments such as the Program for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS), and the Progress in International Reading Literacy Study (PIRLS) have been instrumental in benchmarking student performance and informing educational strategies. Reports from OECD (2023) and Mullis et al. (2020) likewise emphasize the importance of international benchmarking in improving educational quality.

Despite various initiatives to improve educational outcomes, the Philippines continues to face significant challenges. Filipino students have consistently ranked among the lowest performers in the 2018 and 2022 PISA cycles, particularly in reading, mathematics, and science, according to the OECD (2019, 2023). The Philippines ranked near the bottom, placing 78th out of 78 countries in 2018 and 77th out of 81 in 2022, with average scores well below the OECD averages—355 in mathematics, 347 in reading, and 356 in science in 2022, showing minimal improvement from 2018 (OECD, 2019; OECD, 2023; CPBRD, 2024). Recent national assessments further affirm these concerns. The 2024 National Achievement Test (NAT) results for Grade 12 students revealed generally low proficiency levels across all regions and senior high school tracks, with a national average score of 41.12. Only seven regions scored above this mark, with the National Capital Region (NCR) leading at 46.88, followed by the Cordillera Administrative Region (CAR) at 45.12 and Region VIII at 44.51. In contrast, the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM) posted the lowest score at 35.00, indicating significant regional disparities (Tolentino, 2025).

Performance across senior high school tracks also reflected worrying trends. Students struggled most in science, mathematics, language, and communication, key subjects essential for higher education and employment. While the Academic Track achieved a relatively higher score in Philosophy (55.14), it recorded low scores in Mathematics (35.34) and Science (37.92). Students in the Technical-Vocational-Livelihood (TVL) Track posted even lower scores in Mathematics (30.97) and Science (33.25), while those in the Sports Track registered the poorest outcomes, particularly in Mathematics (27.89) and Language and Communication

(28.30). Although the Arts and Design Track showed slightly better results, weaknesses remained evident in Mathematics (31.49) and Science (34.21) (Tolentino, 2025).

At the local level, schools continue to face inconsistent assessment practices, limited diagnostic tools, and insufficient access to instructional resources. These trends highlight critical gaps in the quality of assessments and in the effective use of assessment data to drive learning improvement (Gonzales et al., 2024). While national efforts, such as the Department of Education's Basic Education Development Plan (BEDP) 2030 and the adoption of Learning Management Systems (LMS), aim to strengthen assessment systems, many current initiatives fall short in systematically analyzing student performance and linking results to targeted instructional interventions. According to the Department of Education (DepEd, 2022) and Gonzales et al. (2024), a clear gap persists between assessment outcomes and actionable educational improvement.

To address these challenges, this study proposes the development of the framework architecture of SMART eLearning, a web portal for data-driven assessment and module recommendation across levels of learning for senior high school students using a backtracking algorithm. The system will leverage information and communication technology (ICT) tools, including assessment platforms, analytics dashboards, and module recommendation features enhanced by a backtracking algorithm, to evaluate prior knowledge, assess current competencies, and recommend appropriate learning modules. The integration of a backtracking algorithm will allow the system to dynamically trace students' learning paths, ensuring that module recommendations are closely aligned with identified competency gaps. By combining assessment and instructional support in a single, data-driven platform, the system aims to foster more effective and individualized learning trajectories.

The primary goal of this project is to bridge foundational learning gaps among senior high school students and to enhance performance in key subject areas such as reading, mathematics, and science. Through a technology-enabled, data-driven approach, SMART eLearning seeks to contribute meaningfully to national efforts to raise educational quality and better prepare students for success in both national and international assessments. Specifically, this study aims to design a conceptual system framework that outlines the structural layout of the SMART eLearning platform, including key components such as the user interface, assessment module, module recommendation engine, data analytics dashboard, and student performance database. It also aims to define the role of the backtracking algorithm in

identifying specific learning gaps based on assessment results and generating targeted module recommendations aligned with individual student needs, and to develop a data flow model that describes how learner data is collected, processed, and utilized to generate individualized learning recommendations.

2. Literature Review

2.1 Pre-Assessments / Diagnostic Testing

Pre-assessments and diagnostic testing represent a critical juncture in the educational process, shifting the focus toward proactive insight into students' learning landscapes before the onset of formal instruction. Shepard (2019) emphasizes the crucial role of classroom assessment, including pre-assessments, in informing instructional decisions and supporting learning. Wiggins and McTighe (2005) advocate for "backward design," where understanding students' prior knowledge, often revealed through pre-assessments, forms a foundational step in effective curriculum planning. Administered before a specific learning unit or course, pre-assessments serve to illuminate students' existing knowledge base, prior experiences, and initial understanding of key concepts. Heritage (2020) identifies various formative strategies that uncover students' starting points, allowing instruction to be adjusted accordingly. McMillan (2023) stresses the value of assessing prior knowledge to tailor learning experiences, while Schachter and Piasta (2022) highlights how early insights into content understanding can prevent unnecessary repetition and promote more targeted instruction.

Building on the foundation established by pre-assessments, diagnostic testing provides a more detailed and individualized exploration of student learning profiles. Esomonu and Eleje (2020) underscore the role of diagnostic tests in identifying specific needs and informing targeted interventions. The National Research Council (2022) further emphasizes the importance of understanding how students think and reason, a key focus of diagnostic assessment practices. Berkeley and Riccomini (2017) offer practical guidance on curriculum-based measurement as a means of monitoring progress and identifying skill deficits, while Rababah and Alghazo (2016) examine the use of diagnostic tools in recognizing learning disabilities in mathematics. Hosp et al. (2023) also provide comprehensive strategies for using curriculum-based assessments to support individualized instruction.

The strategic integration of pre-assessments and diagnostic testing offers significant advantages within the educational sphere. Gaining a clear understanding of students' entry

points enables educators to tailor their approaches with precision, building on existing strengths while addressing areas of weakness from the outset. Tomlinson and Moon (2024) advocate for differentiated instruction grounded in such assessment data, making learning experiences more engaging and relevant. Darling-Hammond and Oakes (2021) stress the need for educators to be skilled in using assessment outcomes to guide instruction, a practice equally important for general education and specialized settings. Nanyinza et al. (2024) highlight the critical role of authentic assessment in supporting English language learners. Stiggins et al. (2020) reinforce the idea that effective assessment practices are inseparable from meaningful student learning.

The data provided by diagnostic assessments enables educators to implement targeted interventions and differentiated support, creating a more equitable and inclusive environment where diverse learning needs are recognized and addressed. Stapleton-Corcoran (2022) outlines the principles of Universal Design for Learning, emphasizing the value of assessments in informing accessible instructional strategies. Rose et al. (2023) further elaborate on UDL's application in creating responsive learning environments, while Kholid et al. (2024) highlights that diagnostic assessments enable teachers to identify learners' strengths and weaknesses. These can guide targeted strategies, aligning with evidence-based practices for responsive and equitable learning. Pre-assessments and diagnostic testing, therefore, stand as indispensable tools for fostering a more responsive, personalized, and effective educational experience where instructional design is anchored in a deep understanding of student needs.

2.2 Achievement Tests and Performance Evaluation

Achievement tests are fundamental instruments designed to measure the extent of students' acquired knowledge and skills within defined instructional domains. McTighe and Ferrara (2021) explain that achievement tests aim to assess what students have learned following a specific period of instruction. Gronlund (2021) describe how these assessments often employ selected-response formats to efficiently evaluate a broad range of content understanding. Attakumah (2020) emphasize that well-constructed achievement tests provide a standardized measure of student learning relative to specific criteria. These assessments offer educators a valuable snapshot of content mastery at a particular point in time. Performance evaluation, by contrast, provides an alternative perspective for examining student learning, emphasizing the application of knowledge and skills in authentic contexts. Wiggins and

McTighe (2005) champion performance assessment as a critical means of evaluating students' ability to utilize their learning in real-world scenarios. Darling-Hammond and Oakes (2021) stress the role of performance tasks in assessing complex, 21st-century competencies that go beyond factual recall. Brookhart (2018) highlights the effective use of rubrics to provide clear and transparent criteria for judging student work. This approach moves beyond assessing discrete knowledge points to evaluate depth of understanding and the capacity for practical application.

The integration of both achievement tests and performance evaluation offers a more comprehensive view of student learning. Brookhart and Nitko (2019) advocate for a multifaceted assessment system that strategically incorporates both types of measures to capture a holistic picture of student progress. Stiggins et al. (2020) support the use of varied assessment methods, including performance tasks, to inform instructional practices and deliver meaningful feedback. Hattie and Zierer (2018) further note the impact of rich, specific feedback, particularly from performance-based assessments, on enhancing student learning outcomes and self-regulation. This balanced approach provides essential information about both the acquisition of content knowledge and the ability to apply that knowledge in complex situations.

Strategically implementing both achievement tests and performance evaluations not only informs instruction and ensures accountability but also empowers students to demonstrate their learning in diverse ways. McTighe and Ferrara (2021) point out that thoughtfully designed assessments, including performance tasks, offer students clear targets and actionable feedback for improvement. Wiggins and McTighe (2005) maintain that engaging students in meaningful performance tasks fosters deeper learning and a stronger sense of ownership over their educational journey. By using both assessment methods wisely, educators can cultivate a richer and more accurate understanding of student achievement, supporting both knowledge acquisition and practical application beyond the classroom.

2.3 Existing Learning Management Systems

LMS have come a long way in recent years, especially with the growing integration of adaptive features. What once delivered the same experience to every student now strives to personalize learning, adjusting to individual needs. Fahimirad and Kotamjani (2018) note that LMS platforms are becoming increasingly sophisticated, capable of tailoring learning paths to

better support each student. These developments move education further away from a one-size-fits-all model, using technology to build more responsive and meaningful learning environments.

Today, many well-known LMS platforms offer adaptive functionalities. Moodle, for example, uses plugins and conditional activities that let educators create customized learning pathways based on how students perform on earlier tasks. Blackboard Learn supports adaptive release and personalized learning paths, helping instructors deliver content step-by-step as students demonstrate mastery. Canvas by Instructure provides mastery paths and differentiated assignments, giving students a more individualized experience based on their progress. Across the board, these platforms reflect a shared understanding: adaptation is key to making learning more effective. For both educators and learners, adaptive features bring clear advantages. Teachers can more easily differentiate instruction, reaching a wider range of abilities within one classroom (Becker et al., 2018). The data generated along the way offers valuable insights into how students are learning and where they might be struggling (Mayer, 2021). From the student's side, learning becomes more engaging and efficient. When the content matches a learner's needs and pace, motivation often increases, along with a stronger sense of ownership over the learning process (Means et al., 2020).

The path to fully adaptive learning comes with challenges. Setting up adaptive pathways can be time-consuming and often requires a good deal of technical know-how, which can be a barrier for some educators (Khalil Awan et al., 2021). Even the smartest algorithms do not always match perfectly with every student's learning style or preference (Popenici & Kerr, 2017). Another major challenge involves making full use of the data these systems collect. While LMS platforms gather large amounts of information, automatically transforming diagnostic and achievement test results into truly personalized learning experiences remains a difficult task (Tatineni, 2020; Khalil Awan et al., 2021). In many cases, teachers must manually set rules and conditions, a process that becomes increasingly complex with larger groups of students (Becker et al., 2018). The real-time analytics available often miss the mark when it comes to tracking mastery of specific competencies or offering actionable feedback for improving instruction (Mayer, 2021). Beyond individual classrooms, many LMS platforms also struggle to provide schools with easy-to-use data for broader decision-making. While reports on student progress exist, tools that help educators spot trends across subjects, evaluate the success of teaching strategies, or align instruction with national standards are often lacking

(Tatineni, S., 2020; Means et al., 2020). The ability to pull together insights from a variety of assessments and activities, to truly inform both classroom practice and institutional strategy, remains an area needing further innovation (Fahimirad & Kotamjani, 2018).

Adaptive LMS represent a strong step toward a more personalized educational future. However, realizing their full potential requires thoughtful implementation, continuous reflection, and a clear understanding of both the technology and the teaching practices behind them. There is much more to explore, particularly in creating smarter, data-driven systems that genuinely meet the needs of every learner.

2.4 Backtracking Algorithm

Backtracking algorithms are a powerful tool for solving complex problems, especially in educational systems (Russell & Norvig, 2020). These algorithms work by systematically exploring possible solutions, much like navigating a maze. As decisions are made along the way, backtracking steps in when a path leads to a dead end or violates certain rules. Instead of blindly searching, the algorithm retraces its steps and tries a new direction (Marino et al., 2016). This process ensures that all potential solutions are considered, without wasting time on dead ends.

The backbone of a backtracking algorithm is often a recursive structure (Cormen et al., 2022). It begins by defining base cases, which might represent a solution or an impasse. The algorithm then goes through available choices, adding to a partial solution with each decision, before recursively calling itself to explore further. When a recursive call returns, it undoes the most recent decision, moving on to the next possible path. This iterative “try and adjust” approach is the essence of backtracking. To understand backtracking better, think of it as a state-space tree (Russell & Norvig, 2020). Each node represents a partial solution, and the edges represent the decisions made along the way. The algorithm follows a depth-first approach, exploring each path thoroughly. If a dead end is reached, it backtracks to the last decision point and tries other options. This method of pruning the search space, based on constraints, helps backtracking solve problems more efficiently than brute-force methods (Marino et al. 2016).

Although backtracking is guaranteed to find a solution if one exists, its efficiency often depends on applying optimization techniques. For example, constraint propagation checks for invalid solutions early on, allowing the algorithm to discard unproductive paths (Izadkhah,

2022). Heuristics can also help guide the algorithm toward the solution faster (Pearl, 2018). In cases where overlapping subproblems arise, memoization can be used to store and reuse results, further improving efficiency (Cormen et al., 2022). By understanding and applying these strategies, backtracking algorithms can tackle complex problems in education, such as personalized learning (Manouselis et al., 2012), automated assessment creation (Cohen, 2019), and intelligent tutoring systems (VanLehn, 2023).

Based on the literature, there has been increasing recognition of the importance of personalized learning and data-driven approaches in enhancing educational outcomes. Several studies have demonstrated the effectiveness of pre-assessments and diagnostic testing in identifying students' strengths and weaknesses, which helps tailor instructional strategies to individual needs (Shepard, 2019; Wiggins & McTighe, 2005). Additionally, LMS with adaptive features have shown potential in offering personalized learning pathways based on student progress, fostering greater engagement and motivation (Fahimirad & Kotamjani, 2018; Means et al., 2020). However, challenges remain in maximizing the benefits of these systems, particularly in terms of real-time feedback and content alignment with diverse learning styles (Mayer, 2021; Tatineni, 2020).

The integration of backtracking algorithms into educational technology has also garnered attention to optimize personalized learning by exploring multiple potential solutions and providing tailored learning pathways (Russell & Norvig, 2020; Manouselis et al., 2012). These algorithms can enhance intelligent tutoring systems and improve the adaptability of learning tools, offering a more efficient and comprehensive approach to addressing students' unique learning needs (Cormen et al., 2022).

To address these gaps, this study aimed to develop a Smart eLearning system that combines data-driven assessments, personalized learning modules, and backtracking algorithms to improve the academic performance of high school students. By utilizing diagnostic and achievement tests, the system will identify students' competencies and provide customized learning pathways, ensuring that students receive targeted interventions to bridge learning gaps. The integration of backtracking algorithms will further optimize the learning process by continuously adapting to individual student progress.

The relevance of this study lies in its potential contribution to the growing body of research on personalized, data-driven education systems. By providing real-time analytics and tailored learning experiences, this system could empower educators to make more informed

decisions, improve instructional strategies, and foster deeper learning outcomes. Ultimately, the proposed Smart eLearning system aims to enhance student success in core subjects, offering a scalable model for future educational innovations.

3. Methodology

3.1. Research Design

This study employed a descriptive research design to gain a clear understanding of high school students' current competencies, learning gaps, and readiness to engage with digital learning platforms in key subjects such as reading, mathematics, and science. By collecting and analyzing data from diagnostic tests and surveys, the research was able to pinpoint specific areas where students require additional support. These insights are crucial for designing the SMART eLearning system to align with national standardized assessments like the National Achievement Test (NAT), ensuring that the learning interventions are relevant and targeted.

3.2. Instrumentation and Data Gathering Process

Interview. The researcher conducted structured interviews with selected Grade 12 teachers and school administrators to gather crucial information about current teaching practices, assessment methods, and the integration of digital learning tools. Teachers provided insights into instructional strategies and challenges in using technology for assessments and module delivery, while administrators discussed policies, available resources, and the practicality of implementing a web-based learning portal. The data collected directly informed the design of the Smart eLearning framework, ensuring that the system's data-driven assessments and module recommendations, powered by the backtracking algorithm, aligned with real classroom needs and administrative support.

Internet research. The researcher conducted extensive Internet research to review existing literature, digital learning platforms, and technological tools related to data-driven assessment and personalized module recommendation systems. This research provided a theoretical foundation and best practices for the development of the Smart eLearning framework. Insights gained from relevant studies and online resources helped shape the system's design, particularly in integrating the backtracking algorithm to optimize module recommendations for senior high school students. The Internet research ensured that the

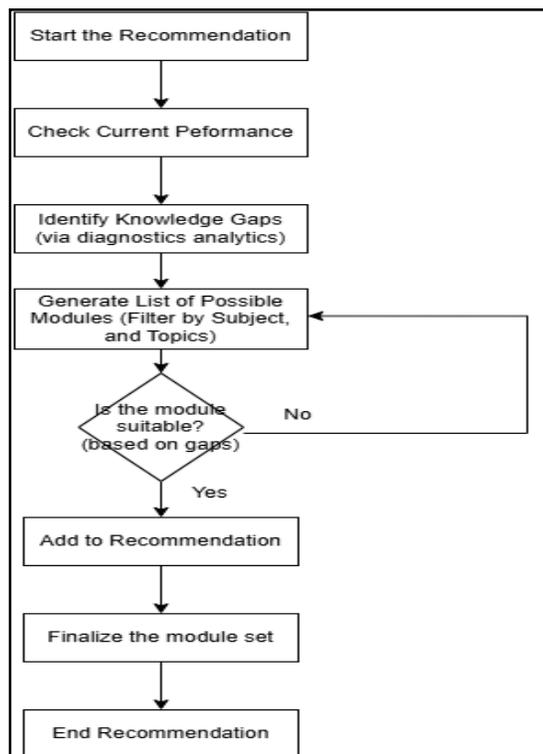
framework was grounded in current educational technology trends and aligned with effective eLearning strategies.

3.3. Backtracking Algorithm

The SMART eLearning framework integrates a backtracking algorithm as a key component of its module recommendation design. As shown in Figure 1, the structured process begins with the analysis of diagnostic assessment results to identify student-specific learning gaps. These gaps inform the recommendation logic, where the framework generates a filtered list of potential learning modules based on subject and topic relevance.

Figure 1

Backtracking algorithm process in the system



At the core of this process is the backtracking mechanism, which is embedded within the decision logic of the framework. For each learning gap, the framework evaluates whether a selected module is suitable, meaning it addresses the identified gap and aligns with any required prerequisites. If the module fails to meet these conditions, the backtracking algorithm

discards it and returns to the list to assess the next option. This iterative trial-and-error process continues until the framework identifies modules that meet all necessary criteria.

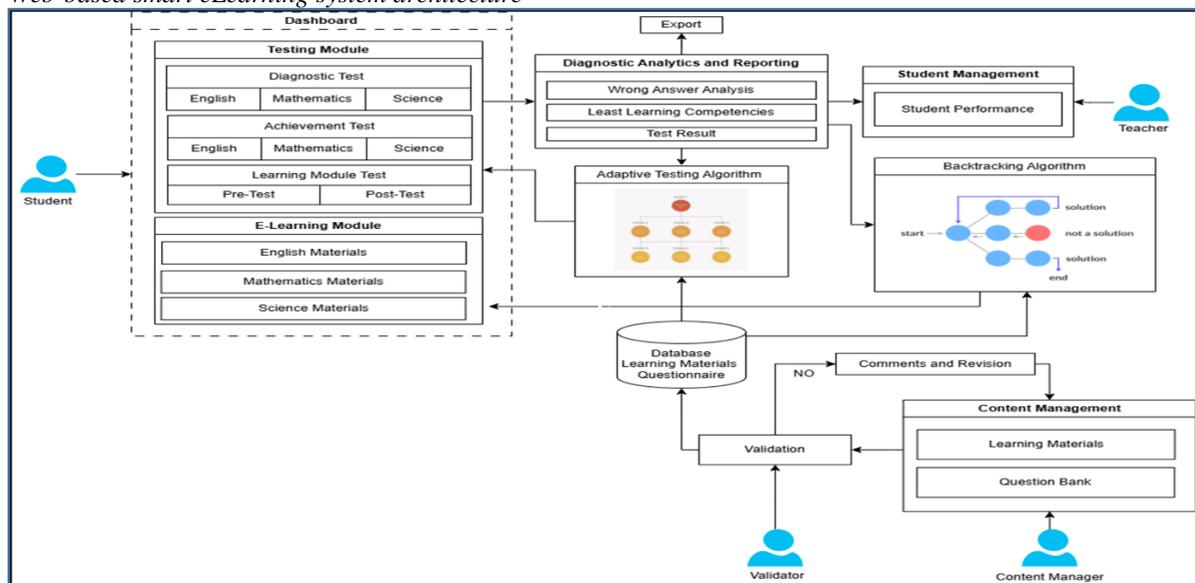
Once suitable modules are found, they are compiled into a final recommendation set, forming a personalized learning path. The integration of the backtracking algorithm within the SMART eLearning framework ensures that module selection is dynamic, constraint-based, and responsive to individual learner profiles. This architecture supports the framework's goal of delivering adaptive, data-informed learning recommendations that directly address student needs and competency gaps.

4. Findings and Discussion

The system design as a web-based application will provide high school students with personalized and adaptive learning experiences, addressing the growing need for individualized education in preparing learners for standardized assessments. By making the platform accessible online, students will be able to engage with learning materials anytime and anywhere, promoting flexibility and continuous learning beyond the traditional classroom setting. To illustrate this framework, Figure 1 shows the Smart eLearning architecture, which will integrate the key stakeholders, students, teachers, and content managers, with adaptive algorithms that will tailor the learning journey. This interconnected design ensures that each component works collaboratively to support student progress.

Figure 1

Web-based smart eLearning system architecture



At the heart of the system is the student dashboard, which will serve as a centralized hub for accessing various learning activities. Through this interface, students will take different types of assessments such as diagnostic tests, achievement tests, and learning module tests. These assessments not only measure current knowledge but also help identify specific areas where students may struggle.

The system's intelligence is driven by two main algorithms. The Adaptive Testing Algorithm will dynamically adjust question difficulty based on student responses during the diagnostic phase. This personalization will help maintain student engagement by providing appropriately challenging tasks while accurately identifying learning gaps. The Backtracking Algorithm will then use the diagnostic results to recommend personalized learning modules, adjusting the suggested materials as the student progresses to maximize learning efficiency.

Teachers play a crucial role through the Student Management module, which will provide detailed performance data. This enables educators to monitor individual and class-wide progress, allowing them to intervene early with targeted support for students who need it. The content management process ensures the quality and relevance of learning materials. A Content Manager will upload educational resources, which a Validator will review for accuracy before approval. This quality control step will maintain the integrity of the system's content, ensuring students receive reliable and effective learning materials. Finally, the system supports exporting data for further analysis or reporting, which can inform curriculum adjustments and broader educational strategies.

The Smart eLearning system represents a comprehensive, adaptive approach to learning that will combine assessment, personalized content delivery, and performance monitoring. This cycle will not only support students in overcoming learning challenges but also equip teachers with the insights needed to enhance instruction, ultimately fostering a more effective and responsive educational environment.

5. Conclusion

This study presents a proposed framework designed to support high school students in preparing for standardized assessments such as the National Achievement Test. The SMART eLearning framework outlines a system for delivering personalized learning pathways through pre-assessments, targeted learning modules, and achievement tests. By structuring learning around real-time progress tracking and adaptive algorithms, the framework is intended to help

address individual learning needs and strengthen foundational skills relevant to academic readiness.

In addition to supporting students, the framework also incorporates a performance dashboard for teachers, allowing for insights into class-wide trends that can guide instructional adjustments. While the framework is conceptual at this stage, it offers a flexible design that could be adapted for integration into existing digital education initiatives or national curriculum reforms. Its scalable and modular nature suggests potential for broader adoption, especially in contexts where personalized learning is a growing priority. However, one limitation of this study is that it is confined to the conceptual development of the Smarts eLearning framework and does not extend to the actual design and implementation of the system. As such, the technical feasibility, user experience, and system performance remain untested. It is recommended that future research focus on the full system development guided by this framework, including prototyping, user testing, and iterative refinement. Further studies should also examine the system's effectiveness in improving student outcomes and its alignment with national education policies and digital learning environments.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was not supported by any funding.

AI Declaration

The author declares the use of Artificial Intelligence (AI) in writing this paper. In particular, the author used ChatGpt in checking and refining the grammar. The author takes full responsibility in ensuring proper review and editing of content generated using AI.

References

- Attakumah, D. (2020). Achievement tests as a universal measure of school success across nations: A theoretical perspective. *International Journal of Research and Review*, 7(4).
- Becker, S. A., Brown, M., Dahlstrom, E., Davis, A., DePaul, K., Diaz, V., & Pomerantz, J. (2018). *NMC horizon report: 2018 higher education edition*. Educause.
- Berkeley, S., & Riccomini, P. J. (2017). Academic progress monitoring. In *Handbook of special education* (pp. 218–232). Routledge.
- Brookhart, S. M. (2018). Appropriate criteria: Key to effective rubrics. *Frontiers in Education*, 3, 22. <https://doi.org/10.3389/feduc.2018.00022>
- Brookhart, S. M., & Nitko, A. J. (2019). *Educational assessment of students* (8th ed.). Pearson.
- Cohen, Y. (2019). The handbook of cognition and assessment: Frameworks, methodologies, and applications. *Assessment in Education: Principles, Policy & Practice*, 26(5), 630–635. <https://doi.org/10.1080/0969594X.2019.1597679>
- Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). *Introduction to algorithms* (4th ed.). MIT Press.
- Darling-Hammond, L., & Oakes, J. (2021). *Preparing teachers for deeper learning*. Harvard Education Press.
- Department of Education (DepEd). (2022). *Basic education development plan 2030*. <https://www.deped.gov.ph/wp-content/uploads/2022/07/BEDP-2030-Photo-Documentation.pdf>
- Gronlunds, N. E. (2021). Measurement and assessment in teaching. *Pakistan Journal of Educational Research and Evaluation (PJERE)*, 5(2).
- Esomonu, N. P.-M., & Eleje, L. I. (2020). Effect of diagnostic testing on students' achievement in secondary school quantitative economics. *World Journal of Education*, 10(3), 178–188. <https://doi.org/10.5430/wje.v10n3p178>
- Fahimirad, M., & Kotamjani, S. S. (2018). A review on application of artificial intelligence in teaching and learning in educational contexts. *International Journal of Learning and Development*, 8(4), 106–118.
- Gonzales, R., Tamayao, A., Vecaldo, R., Balagtas, M., Balagan, M. B., Lapinid, M. R., Rungduin, T., & Medula, C. (2024). Alignment of policies, standards, and guidelines for teacher education programs with the K to 12 program. *DLSU-AKI Policy Brief*, 2024-05-030.

- Hattie, J., & Zierer, K. (2018). *10 mindframes for visible learning: Teaching for success*. Routledge.
- Heritage, M. (2020). *Formative assessment: Making it happen in the classroom* (2nd ed.). Corwin Press.
- Hosp, M. K., Hosp, J. L., & Howell, K. W. (2023). *The ABCs of CBM: A practical guide to curriculum-based measurement* (3rd ed.). Guilford Publications.
- Izadkhah, H. (2022). Backtracking algorithms. In *Problems on algorithms*. Springer. https://doi.org/10.1007/978-3-031-17043-0_14
- Jimenez, L., & Modaffari, J. (2021). Effective and equitable assessment systems. *Future of Testing in Education*. ERIC. <https://eric.ed.gov/?id=ED617053>
- Johnson, B., & Christensen, L. (2013). *Educational research: Quantitative, qualitative, and mixed approaches* (5th ed.). SAGE Publications.
- Khalil Awan, R., Afshan, G., & Bano Memon, A. (2021). Adoption of e-learning at higher education institutions: A systematic literature review. *Multidisciplinary Journal for Education, Social and Technological Sciences*, 8(2), 74–91. <https://doi.org/10.4995/muse.2021.15813>
- Kholid, B., Rahman, A., & Irawan, L. A. (2024). Implementing diagnostic assessment in designing differentiated learning for English language learning at the junior high schools. *Journal of Language and Literature Studies*, 4(2), 445–458. <https://doi.org/10.36312/jolls.v4i2.1934>
- Manouselis, N., Drachsler, H., Verbert, K., & Duval, E. (2012). *Recommender systems for learning*. Springer Science & Business Media.
- Mayer, R. E. (2021). *Applying the science of learning to online teaching: Guidelines and checklists for educators*. Routledge.
- Marino, R., Parisi, G., & Ricci-Tersenghi, F. (2016). The backtracking survey propagation algorithm for solving random K-SAT problems. *Nature Communications*, 7, 12996. <https://doi.org/10.1038/ncomms12996>
- McMillan, J. H. (2023). *Classroom assessment: What teachers need to know* (9th ed.). Pearson.
- McTighe, J., & Ferrara, S. (2021). *Assessing student learning by design: Principles and practices for teachers and school leaders* (ERIC No. ED611531). Teachers College Press.

- Means, B., Bakia, M., & Murphy, R. (2020). *Learning online: What research tells us about whether, when and how*. Routledge.
- Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2020). *TIMSS 2019: International results in mathematics and science*. International Association for the Evaluation of Educational Achievement. https://www.erc.ie/wp-content/uploads/2021/01/03-ERC-TIMSS-2019-Report_A4_Online.pdf
- Nanyinza, E., Munsaka, E., & Chiziwa, W. (2024). Pre-service teachers' use of authentic assessment to assess secondary school English grammar. *International Journal of Arts and Social Science*, 7(5), 303–312.
- National Research Council. (2022). *Science literacy: Concepts, contexts, and consequences*. National Academies Press.
- OECD. (2023). *Education at a glance 2023: OECD indicators*. OECD Publishing. https://www.oecd.org/en/publications/education-at-a-glance-2023_e13bef63-en/full-report.html
- Pearl, J., & Mackenzie, D. (2018). *The book of why: The new science of cause and effect*. Basic Books.
- Popenici, S. A. D., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning*, 12(1), Article 22. <https://doi.org/10.1186/s41039-017-0062-8>
- Rababah, A., & Alghazo, Y. (2016). Diagnostic assessment and mathematical difficulties: An experimental study of dyscalculia. *Open Journal of Social Sciences*, 4(6), 91–102. <https://doi.org/10.4236/jss.2016.46005>
- Rose, D. H., Gravel, J. W., & Gordon, T. (2023). *Universal design for learning: Theory and practice*. CAST Publishing.
- Russell, S., & Norvig, P. (2020). *Artificial intelligence: A modern approach* (4th ed.). Pearson.
- Schachter, R. E., & Piasta, S. B. (2022). Doing assessment: A multicase study of preschool teachers' language and literacy data practices. *Reading Research Quarterly*, 57(2), 515–535.
- Shepard, L. (2019). Classroom assessment to support teaching and learning. *The Annals of the American Academy of Political and Social Science*. <https://doi.org/10.1177/0002716219843818>

- Stapleton-Corcoran, E. (2022, February 12). Universal design for learning (UDL) introduction. *Center for the Advancement of Teaching Excellence, University of Illinois Chicago*. <https://teaching.uic.edu/cate-teaching-guides/inclusive-equity-minded-teaching-practices/universal-design-for-learning-udl/>
- Stiggins, R. J., Arter, J. A., Chappuis, J., & Chappuis, S. (2020). *An introduction to student-involved assessment for learning* (7th ed.). Pearson.
- Tatineni, S. (2020). Recommendation systems for personalized learning: A data-driven approach in education. *Journal of Computer Engineering and Technology*, 4(2), 18–31.
- Tolentino, A.J. (2025). *NAT 2024 results show 'low proficiency' among Grade 12 students across all regions*. ExplainedPH. <https://www.explained.ph/2025/03/nat-2024-results-show-low-proficiency-among-grade-12-students-across-all-regions.html>
- Tomlinson, C. A., & Moon, T. S. (2024). *Assessment and student success in a differentiated classroom: A practical guide for K-12 educators* (2nd ed.). ASCD.
- VanLehn, K. (2023). Intelligent tutoring systems. In R. Luckin, W. McCalla, J. Greer, & S. Ainsworth (Eds.), *Handbook of artificial intelligence in education* (pp. 237–263). Routledge.
- Wiggins, G. P., & McTighe, J. (2005). *Understanding by design* (2nd ed.). ASCD.