

Proposed biology teaching unit using artificial intelligence for third-year secondary students and its impact on developing preventive medicine concepts

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ABSTRACT

This study investigated the effectiveness of an AI-supported Biology 3 unit on preventive medicine concepts among third-year secondary female students in Saudi Arabia, employing an experimental design that utilized virtual simulations, interactive activities, and project-based learning. Results indicated that the experimental group achieved significantly higher scores in health awareness and preventive knowledge with a strong effect size, suggesting that such AI tools effectively bolster student health literacy. While the study's focus on a single, female-only setting necessitates broader replication across different regions to ensure generalizability, it provides valuable experimental evidence for the originality of AI-supported instruction, advocating for the systematic integration of preventive medicine into biology curricula alongside expanded AI tools and continuous teacher development.

Keywords: Artificial intelligence, Biology education, Preventive medicine, Curriculum development, Health literacy, Saudi Arabia

1. Introduction

Curricular innovation is increasingly being perceived as a strategic process of enhancing the ability of learners and the well-being of the society especially in the context of sustainable development agendas that integrate education with the quality of life, productivity, and long term sustainability. In this transition, health education has stood out as a marginal theme to be a central area of integration and holistic student growth since it is largely linked to health literacy, health related behaviour and the general developmental outcomes of children and adolescents [1], [2]. Recent syntheses also show that health literacy is multidimensional and receptive to systematic educational assistance and support the validity of placing health education as a curriculum concern and an auxiliary activity [3]. Biology education, in particular, is particularly well placed to play a role in preventative health competence since it offers a basic scientific knowledge of the human body, disease processes and the interactions between the organism and the surroundings. Therefore, a quality biology study can be a path, by which scientific knowledge can be rendered into a responsible and health-aware citizenship, particularly when clear preventative health ideas are incorporated in the program, practiced and evaluated.

In Saudi Arabia, Vision 2030 has put on a fast track reforms in the education sector towards modernization, digitalization, and alignment of the outcomes of the curriculum with national development priorities. The academic work on educational change as a part of Vision 2030 points to the strategic anticipation of schools to support the provision of society with future-competency and societal development in terms of updating their curricula and enhancing learning outcomes [4]. Meanwhile, Vision 2030 has been linked to massive change in the entire health sector, preempting prevention, quality, and modernization of the system as national priorities



[5]. Collectively, these instructions make the argument of implementing prevention-based health education into the school curriculum (including secondary science education) more robust. In spite of this policy impetus, there is still an evident curricular constraint to Biology 3 and other secondary science courses: the coverage of content can be more theoretical than applied, there may be a lack of systematic attention to the preventive health concepts, which allow the student to understand health information, risk assessment and act as evidence-based practitioners of preventive behavior.

At the same time, the development of artificial intelligence (AI) in education is a rather rapid phenomenon that opens a possibility of enhancing the teaching of biology and obtaining the results of prevention-oriented learning. Willful reviews of AI and learning analytics note personnalistic strategies, which focus on significant learning assistance, including customization, prompt timely feedback, and adaptive instructions, instead of just having technology at its beck and call [6]. Complementary syntheses state that AI can be applied to designing personalized learning paths, and facilitate lifelong learning by designing instructionally adaptively and reactively to learner needs and responses to learning [7]. Reviews in the IEEE-indexed publications also define AI in education as a quickly evolving area where data-driven adaptation and intelligent assistance can be used to support learning processes when achieved in line with pedagogical objectives [8]. These affordances can be applied particularly to biology, where learners tend to explore abstract and dynamic processes, which can be visualized, explored with guided inquiry, and practised.

It is also practical in nature, as evidenced in local evidence. A survey of thirty randomly chosen biology teachers and supervisors teaching third-year secondary instruction at Riyadh explored the level of coverage of the concept of preventive medicine in the extant curriculum and what priority issues educators felt should be included in the curriculum [9]. The results showed that there was a unanimous opinion that the content of preventive medicine is inadequate in the current Biology 3 textbook. The majority of respondents highlighted the necessity of direct mention of healthy nutrition and lifestyle habits (87%), next in line is the content on chronic disease (especially diabetes, hypertension, and cardiovascular disease) (80%) [10]. Other issues that were mentioned by participants include infectious diseases, immunization, and immunity (75%) and emphasized environmental health problems including pollution and waste management (70%). Both these results indicate the underrepresentation of prevention-oriented health ideas in Biology 3 and justify the necessity of curriculum redesigning based on the priorities of stakeholders and consistent with the national health and sustainability objectives [11].

In biology education, in particular, there is empirical evidence that digitally enhanced and AI-supported methods can enhance engagement and learning outcomes upon the consideration of the implemented methods [12]. To illustrate, social contexts in secondary biology literature show that AI-based learning tools can have a positive impact on performance, engagement, and retention, which means that AI can be used as a pedagogical aid in learning complex sciences and not as a supplemental tool [13]. Immersive and simulation based experiences can also be used in biology learning. Data in virtual laboratories show that it has positive implications to the academic performance and attitude to the study of biology among students [14]. Associated literature proves the usefulness of virtual simulation in online laboratory training and active learning exercises, especially in cases where the hands-on practice is restricted by instructional limitations imposed on learners [15]. Conceptual learning through presence and interactive visualization have also been taught in using immersive technologies like virtual reality to teach difficult concepts in the molecular and biological field [16]. All of these strands support the offer that AI-guided and simulation-intensive teaching in biology can reinforce the conceptual understanding and long-term interest- so conditions favorable to prevention-based learning when preventive medicine ideas are formally aimed.

Notably, to make AI-based biology teaching in harmony with the notion of preventive medicine, there must be an educational goal and a justifiable assessment plan. The paper Work on AI in public health education explains the opportunities and obstacles of using AI to enhance the performance of health education, which suggests that AI can be used in preventive learning provided the design is created around real-life health situations and

responsible pedagogy [17], [18]. Nevertheless, methodological reviews include the fact that AI integration into science education has significant disparities in design rigor, implementation limitations, and reported findings, which should be taken into consideration when designing the instructional process and where empirical research on the implementation should be conducted in the real classroom environment [19]. Further, even though researchers record the advantages of AI-enhanced classes in generating awareness and prospective thinking in science-related subjects [20] and indicate that the attitudes of perceived usefulness and ease-of-use determine adoption intentions of AI-based applications in science classes [21], less literature has explicitly modeled and tested biology courses that aim to produce preventive medicine concepts as quantifiable learning outcomes in secondary schools.

Similar literature on curriculum content also suggests that the topics of preventive health are disproportionately covered in biology textbooks and through education systems. The comparative studies indicate that certain curricula have higher levels of disease and epidemic coverage and lesser systematic coverage on environmental health and nutrition, indicating that there is a need to establish deliberate balance and consistency in curriculum design on prevention related aspects [22]. This variability in the curriculum supports the importance of ensuring the development of a well-organized and prevention oriented unit on biology and testing its efficiency in an empirical manner instead of based on the descriptive assertions of its desired results.

It is against this backdrop that the current research fulfills three gaps that are interconnected: inadequate systemic incorporation of preventive medicine concepts into the Biology 3 courses, lack of empirically validated teaching materials and evaluations instruments that are consistent with the concepts, and a little explored role of AI in intensifying prevention-related learning outcomes in secondary biology instruction under Saudi reforming circumstances. This study will thus attempt to determine key preventive medicine concepts that can be included in Biology 3, examine how the concepts have been currently represented in the curriculum, design and implement an AI-based instructional unit that focuses on the concepts among female secondary students and evaluate the effectiveness of the unit in terms of outcomes between the experimental and control groups. The study aims to provide an evidence-based and context-sensitive framework that can be used to make an informed decision about curriculum development and pedagogical practice, both in line with the priorities of educational transformation in Vision 2030 and the overall sustainability and population health agenda.

2. Research Methodology and Procedures

The multi-methodological approach was chosen in order to respond to the research objectives and questions, as addressing the topic was complex and interdisciplinary. Relevant literature, world curriculums, and health education reports were reviewed using the descriptive-inductive approach that would bring out the concepts on preventive medicine that would be integrated into the third-year secondary textbook on biology. To measure the presence of these concepts in the existing textbook, the quantitative-analytical approach was chosen to investigate the content of the textbook through content analysis. At the same time, a descriptive-analytical approach was applied to evaluate what biology teachers and supervisors say by using a validated questionnaire to investigate the existing practice in teaching about health-related topics. Lastly, an experimental study design using control and experimental groups was used to test the effectiveness of a proposed unit of AI-based biology in improving the knowledge of students on preventive medicine.

The study sample consisted of an exploratory and experimental part. The sample size was 30 biology teachers and supervisors who were engaged in the evaluation of the current curriculum and provided information on the creation of the concept list. The target population was that of the female students in the third grade of the Al-Hamra Secondary School (School 122) in Riyadh who were chosen as a sample of the intervention group. The learning content consisted of the official third-year high school biology textbook (2022 edition), which is in line with the natural sciences track and is the foundation of the content analysis and redesign of the instruction. This two-sample design provided a triangulation of data and testing of instructional efficacy in a contextual environment of learning.

The research instruments were developed based on international standards in science education and included:

- A comprehensive list of preventive medicine concepts
- A structured content analysis card aligned with textbook chapters
- A proposed biology unit integrating AI-supported strategies and key health concepts
- A teacher's guide designed to facilitate instructional delivery
- A concept-mastery test to evaluate student learning outcomes

The process of the instrument development was based on a strict multi-stage strategy:

First, the rationale defining critical concepts of preventive medicine has been presented with respect to student health literacy and behavior change.

Second, literature data (e.g., past research, e.g., [23]), WHO reports, Vision 2030 reports, and state health statistics were consulted to identify the useful concepts.

Third, a preliminary list was developed, and it comprised four thematic dimensions, including chronic diseases, infectious diseases, healthy lifestyle, and environmental health.

Fourth, the experts considered this list due to the conceptual appropriateness, age-level appropriateness, and dimensional coherence.

Fifth, expert feedback was implemented to effect some changes, and a final list was come up with that can be integrated in instruction as shown in Table 1.

Table 1. Proposed List of Preventive Medicine Concepts

No.	Main Concept	Sub-concepts
1	Common chronic diseases	Diabetes, heart diseases, early screening
2	Infectious diseases & epidemics	Viral infections, bacterial diseases, vaccination & immunity
3	Nutrition & healthy lifestyle	Balanced diet, obesity, vitamin & mineral deficiency, physical activity, digestive diseases
4	Environmental health	Air pollution, water pollution

The researcher came up with a strict content analysis tool to guarantee the systematic fit between the concept list of preventive medicine ideas and the third-year secondary biology textbook. This tool is a structured tool that was aimed at gauging the presence and the depth of integration of each sub-concept of the four main domains, i.e., chronic diseases, infectious diseases, nutrition and healthy lifestyle, and environmental health. The process of writing the instrument started with a thorough examination of the textbook material, locating those paragraphs that seem to be related to the required concept and corresponding with the list of known concepts. All the identified sections were then recorded with the help of a standardized analysis card, which made the coding process consistent and traceable. Inter-rater reliability was also assessed by introducing a trained biology teacher to the test, and the findings provided a reliability coefficient of 0.93 with the use of the formula presented by Kober, which resulted in an excellent level of agreement and proved the applicability of the tool to the context of the research. This is a multi-step process that ensures the instrument is reliable in measuring the curricular coverage of the concepts of preventive medicine and facilitates rigorous measurement as outlined in the international standards of educational research.

To address the learning needs of the students presented by the curricular gaps observed after content analysis, the researcher developed a special unit of biology that aligns the concepts of preventive medicine in learning environments based on artificial intelligence. The unit objectives were constructed based on the triangulation, which used textbook analysis, the survey responses of biology teachers and supervisors, and subject-matter experts. The goals were stated at cognitive, psychomotor, and affective levels, which guaranteed the

measurability of learning outcomes and the situational relevance of the goals to the third-year secondary students. The general objectives focused on reinforcing the knowledge of students and their skills in using preventive health behaviors, whereas the specific ones were precise definitions of concepts, real-life applicability, and use of AI tools, including ChatGPT and digital disease modeling platforms, to simulate health situations [24]. This design model also guaranteed that the instructional unit will not simply gap the theoretical information with practical implementation but also instill digital literacy and future-readiness skills. The strategy is directly correlated with the modern educational innovation paradigms and national curriculum change goals.

The instructional unit was based on a combination of instructional methods that were carefully chosen to facilitate the intensive involvement and help learners obtain meaningful learning. Such approaches as project-based learning, simulation-based inquiry, cooperative learning, guided classroom discussions, and virtual laboratories powered by AI were combined to suit the needs of different learners. The package of learning tools consisted of adaptive AI platforms (e.g., Google Gemini, Microsoft Copilot), disease simulation software, AI-generated infographics, and interactive video modules illustrating in a visual way the mechanisms of disease transmission and prevention. A guide for the teacher and a student activity booklet were designed to assist in order to implement it in a structured manner and also to enable uniformity in instructional environments. The learning activities were specifically aimed at training students in critical thinking, solving real-life problems, and overall health literacy [7]. This is a multi-dimensional approach that can be used to guarantee that the instructional unit is not only technologically enhanced but also pedagogical to promote evidence-based approaches to the teaching of biology.

The proposed unit had a unique lesson structure that centered on the real health problems and contextual learning conditions with the help of artificial intelligence. The sequencing of the contents was done in a way that it comprised inquiry-based questions and case studies that promote higher-order thinking and that which connected the students' lived experiences to curriculum materials. The entire unit was also reviewed by the experts in curriculum design, biology delivery, and public health to ensure that the instructional materials were of good quality and suitable. Systematic revisions were done under the guidance of the expert feedback to increase conceptual coherence, developmental suitability, and instructional impact. The completed teaching package was created in the form of a ready-to-use student booklet presentation and an elaborated guide for instructors so that it would be easily accessible and applicable in the classroom environment. Notably, the design process was still grounded in the principles of 21st-century innovation in curriculum and strategic national goals like those expressed in Saudi Vision 2030.

These instruments were continuously tightened based on feedback from experts and in the field to be valid, reliable, and congruent with cognitive and affective domains of learning. The proposed unit relied heavily on the usage of AI applications to facilitate simulation-based interaction and individual feedback during health-related learning tasks as presented in following Table 2.

Table 2. Content of the Proposed Unit

Main Topic	Proposed Lessons/Concepts for Inclusion
Common Chronic Diseases	Diabetes: causes, symptoms, prevention.
	Heart and vascular diseases: risk factors, early prevention.
	Importance of early screening for disease and risk factors.
Infectious Diseases & Epidemics	Viral infections (influenza, COVID-19): transmission and prevention.
	Common bacterial diseases (measles, mumps, meningitis): role of vaccination.
	Vaccination and immunity: importance of national vaccination programs.
Nutrition & Healthy Lifestyle	Balanced diet and its effect on immunity.
	Obesity and malnutrition and their impact on general health.

Main Topic	Proposed Lessons/Concepts for Inclusion
	Digestive diseases due to poor nutrition and food poisoning: causes and prevention.
	Essential vitamins and minerals (Vitamin D, iron, calcium) and their preventive roles.
	Regular physical activity and its impact on general health.
Environmental Health	Air pollution (dust and sandstorms) and its effect on the respiratory system.
	Water pollution and resulting diseases.

The researcher came up with a teacher guide that will facilitate the implementation of the instructional unit that is being proposed to assist in teaching the concept of preventive medicine using artificial intelligence applications to female students in third grade at the secondary level of education. The guide encompasses an introduction, general and specific objectives, well-defined step-by-step instruction procedures, pedagogical strategies that should be followed, needed instructional tools, and diversified assessment procedures that should be undertaken in accordance with each lesson. The first edition of the guide was presented to a panel of subject-matter experts in science teaching and curriculum development, with their opinion used to implement systematic changes. The last and tested draft of the guide was made ready to be implemented in the classroom.

The evaluation scheme of the proposed unit also involved various modalities in order to provide a thorough evaluation of the cognitive and skill areas. The following types of the applied assessments were applied:

Pre-assessment: The purpose of the pre-assessment was to assess the baseline knowledge and prior knowledge of the students of the concepts of preventive medicine by the use of the Preventive Medicine Concepts Test.

Formative assessment: This is done during the unit implementation and is in the form of teacher-led questioning, classroom discussions, worksheet completion, short quizzes, and interactive AI-mediated activities.

Summative assessment: Given at the end of the intervention, it will help determine how well the students have mastered the target concepts and how effective the AI-enhanced instructional strategies are.

The instructional units in the proposed unit were placed based on an elaborate teaching plan that was equivalent to the scheduled instructional time of third-second-grade biology. The distribution was meant to deliver sufficient content coverage as well as to deliver the intended learning outcomes. Table 3 shows the time allocated to every lesson:

Table 3. Time Schedule for the Proposed Unit

Lesson No.	Main Topic	Number of Hours
1	Common chronic diseases: diabetes, heart diseases, importance of early screening	3
2	Infectious diseases and epidemics: viral and bacterial infections, importance of vaccination	3
3	Nutrition and healthy lifestyle: balanced diet, physical activity, obesity, vitamin and mineral deficiency, digestive diseases	4
4	Environmental health: air and water pollution and their impact on public health	2

In order to evaluate the learning of the concepts of preventive medicine by students, the researcher constructed a specialized test on the basis of the following steps. The main idea of the test was to assess the extent to which third-grade students in secondary schools were able to learn about preventive medicine concepts that were introduced in the proposed unit [25]. It was organized on the concept list of validated concepts that comprised

chronic diseases, infectious diseases, healthy lifestyle, and environmental health. The test was to be given a 45-minute duration, with 20 multiple-choice questions, each having four choices, and the time within which one point is given every time the question is answered correctly, making the highest score 20. Experts in the fields of biology education and science pedagogy reviewed it to establish its validity, and revisions were made to create a final version [26]. The reliability processes ensured the internal consistency and accuracy of the test using the relevant statistical methods, such as item difficulty and discrimination indices [27]. These findings provided justification for the test in the study due to its psychometric soundness of use [28].

Statistical methods were utilized in the analysis of quantitative data and the content-based inputs. The content of textbooks and the agreement on the concept list of experts were investigated using descriptive statistics (frequencies and percentages). The content analysis tool was measured using a formula that evaluated inter-rater reliability by Kober. The t-test was used in inferential analysis to compare the results of the pre-intervention and post-intervention in the experimental and the control groups. Cronbach's alpha was used to test the reliability of the achievement test as well as the item difficulty and discrimination indices. Lastly, eta squared (e^2) was used to find the effect size of the AI-based instructional intervention on student learning outcomes.

After formulating the research instruments and authenticating their psychometric characteristics, the instructional unit and guide for the teacher were finalized, and the research sample was chosen. The implementation process was conducted in four key steps, including (1) pre-test administration to the experimental and the control group in order to identify baseline knowledge of preventive medicine concepts; (2) the delivery of the proposed instructional unit to the experimental group with the help of artificial intelligence-based applications, strategies, and activities; (3) post-test administration to both groups; and (4) systematic data recording and statistical analysis.

In all the research procedures, complete adherence to ethical considerations in research in the educational environments was done. The approval of the institutional and school authorities was taken beforehand. The participants were provided with all the information on the goals of the research, methods, and voluntary participation. Informed consent was obtained, and the confidentiality and anonymity of the responses were ensured at all levels. No personal identifiers were gathered, and all data were utilized in the academic field.

3. Results and discussion

This section introduces and discusses the empirical results of the study based on the research questions that informed the study. The findings are summarized based on every key question, which gives a clear connection between the aims of the study, the methodological procedure, and the results of the study. It focuses on how the key concepts of preventive medicine are identified and how they are currently being provided to the students of the third grade of the Saudi Arabian secondary education, which is informed by the relevant literature and policy frameworks [29].

The initial research question aimed at establishing the most important preventive medicine concepts that are supposed to be taught in the third grade of the biology curriculum in Saudi Arabia. In an attempt to address this inquiry, the research conducted a systematic literature review of the earlier academic literature, authoritative guidelines, and other pertinent national policy reports [29]. It led to a comprehensive model that involved four broad areas and thirteen sub-concepts as described previously in the instrument development part.

The second research question was concerned with how far the concepts of preventive medicine exist in the biology curriculum at the third grade of secondary in the Kingdom of Saudi Arabia. To overcome this, a pilot study was undertaken on a representative sample of the biology teachers and supervisors, which brought out a major deficiency (see problem statement). A replication of the content analysis of the third second-grade biology text (Natural Sciences track, 1444H/2022 edition) with a validated content analysis card showed no preventive medicine content whatsoever in any of the chapters. Table 4 showed quantitative findings that showed the inclusion rate was 0%. In nine chapters and thirty-three of the main lessons, including enrichment and practical experiment materials.

This extreme gap depicts a significant mismatch between the articulated goals of Saudi Vision 2030, in particular those focused on developing proactive health education at the school level, and the real curricular provisions. These results suggest that systematic curricular change is urgently required to implement preventive medicine as a solid part of biology education that would provide students with fundamental health knowledge and skills. Such reforms are essential to the provision of prevention-based behavior, which is aligned with the international standards and contributes to maintaining sustainable changes in the quality of life of students [16].

Table 4. Extent of Inclusion of Preventive Medicine Concepts in the Biology Curriculum for Third Secondary Grade

Chapter No.	Chapter Title	Number of Lessons	Inclusion of Concepts	Percentage
1	Introduction to Plants	3+ enrichment & experiments	-	0%
2	Plant Structure and Functions	2+ enrichment & experiments	-	0%
3	Reproduction in Flowering Plants	2+ enrichment & experiments	-	0%
4	Cell Structure and Functions	3+ enrichment & experiments	-	0%
5	Cellular Energy	3+ enrichment & experiments	-	0%
6	Cellular Reproduction	3+ enrichment & experiments	-	0%
7	Sexual Reproduction and Genetics	3+ enrichment & experiments	-	0%
8	Complex and Human Genetics	3+ enrichment & experiments	-	0%
9	Molecular Genetics	4+ enrichment & experiments	-	0%

Table 4 demonstrates the content analysis of the general track curriculum, which is a biology textbook in the 3rd grade with nine units and thirty-three principal lessons that include enrichment and practical experiments, and thus the content of preventive medicine was entirely deficient. There was no inclusion rate of preventive medicine concepts in any of the chapters. This finding denotes that the textbook does not have information that should be used to connect biology to preventive healthcare services, including chronic and infectious disease prevention, immunization, diet and healthy eating habits, and environmental well-being. Although the text addresses other areas of biology, e.g., plants, genetics, and cellular biology, it fails to address these key points of health education.

This sharp contrast reminds us about an evident discrepancy between health education objectives identified in Saudi Vision 2030 and the up-to-date curriculum. The results have emphasized the urgent necessity to reform and restructure the curriculum to include preventive medicine as an intrinsic part of the biology training to increase the health awareness of the students and nurture preventive habits that can lead to better living.

The fourth research question analyzed whether the differences between the means of students of the experimental and control groups in the preventive medicine concepts test were statistically significant, which is attributed to the use of the proposed unit as a result of artificial intelligence applications. To make the groups equivalent, the preventive medicine concepts test was conducted on both groups before administering the

intervention. After the instructional unit was complete, a repeat of the test was done. An independent samples t-test was used to compare the means of the pre-test and the post-test stages.

The pre-test results given in Table 5 do not show any statistically significant difference between the experimental group (M = 13.34, SD = 2.3) and the control group (M = 12.4, SD = 2.1). The t-value that was obtained (1.6525) was less than the critical value (2.0) at 58 degrees of freedom and the level of significance (0.05), indicating that it was statistically non-significant.

Table 5. Results of the t-test for Differences in Mean Scores between the Two Research Groups in the Pre-test of the Preventive Medicine Concepts Test

Group	N	Mean	Standard Deviation	t-value		df	Significance Level	Statistical Significance
				Tableted	Calculated			
Experimental	30	13.34	2.3	2.0	1.6525	58	0.105	Not significant
Control	30	12.4	2.1					

This finding establishes the baseline of the early equivalence of the two groups, without which it is impossible to establish the validity of any further comparisons and attributions of effect to the inter-intervention. This kind of equivalence is generally acknowledged as a vital condition in experimental educational research because it eliminates the existence of differences prior to the experiment as a confounding factor. These results would justify the rigor of the methodology of the study and improve the validity of future analyses on the effects of artificial intelligence-based teaching interventions on health education. Table 6 shows that the results of the post-test of the preventive medicine concepts test are statistically significant and in favor of the experimental group, as the result is significantly higher in the experimental group (18.32) compared to the control group (14.06). The t-value (12.466) obtained is larger than the critical value (2.0) at 58 degrees of freedom and at the level of significance of 0.05, which means that the impact of intervention is significant.

Table 6. Post-test t-test Results for Mean Score Differences between Experimental and Control Groups

Group	N	Mean	Standard Deviation	t-value		df	Significance Level	Statistical Significance
				Tableted	Calculated			
Experimental	30	18.32	1.5	2.0	12.466	58	0.00	Significant
Control	30	14.06	1.12					

The fifth research question was the impact of using a proposed biology instruction unit in the third grade in the secondary level that is planned to use artificial intelligence applications towards the modelling of the concept of preventive medicine in students. In order to answer this question, the researcher obtained the effect size of independent groups by calculating Eta squared (e^2) using the following formula:

$$\eta^2 = \frac{t^2}{t^2 + df}$$

$$\eta^2 = \frac{12.466}{12.466 + 58} = 0.728$$

The value (0.728) is deemed to be very high, which suggests that the independent variable (i.e., the proposed instructional unit) explains the variance in the scores of students to the tune of 72.8%. According to the criteria provided by [30], the Eta squared value above 0.14 is the large effect size; hence, the value has a very large impact. This proves that the suggested AI-enhanced instructional unit was statistically significant and significant in the learning of preventative medicine ideas among the students.

This study provides strong empirical data on a significant gap in the content of preventive medicine among the existing Biology 3 courses in Saudi Arabia, as the main areas such as chronic disease prevention, vaccination, healthy lifestyle, and environmental health are not covered at all in the required textbook [25]. These omissions do not only limit the health literacy of the students but also limit the capacity of the curriculum to fulfill the full-

fledged educational reform and well-being goals of life as stated in the Saudi Vision 2030 [31], [32]. In the study, conducted after the introduction of the suggested AI-based instructional unit, statistically significant differences in the skills that students developed concerning the knowledge of preventive medicine concepts were identified, and the impact of the proposed intervention was much higher than the benchmarks of conventional educational interventions. Such an outcome highlights the radical potential of artificial intelligence in closing the gap between theoretical teaching and the creation of practical health behavior development in students.

The analysis of these findings reveals that the concept of an integrated approach to AI-based pedagogy (including virtual simulations and adaptive learning tools as well as interactive assessment tools) does not just correspond to the international standards but reflects the latest trends in science education. Individualized learning pathways, instant and formative feedback, and increased engagement were supported by the use of AI-driven practices and brought about measurable benefits in the conceptual learning and health-related skills [6]. These findings are in line with the successful experiences in other nations where the concept of preventative health has been successfully introduced into the science curriculum through digital innovation to produce measurable positive impacts on student learning and preparedness to face the common challenges of public health. The present research is not only comparable to but actually, in a number of aspects, superior to these foreign attainments, proving the versatility and the situational appropriateness of AI-enriched biology education in Saudi schools. When these results are compared to other efforts conducted in other countries, it is clear that the instructional design used in the present case corresponds to or exceeds international values on educational effectiveness. International frameworks are always emphasizing the incorporation of health literacy and digital technology as the only way to develop critical thinking, lifelong learning, and civic responsibility [33]. The significant effect sizes and knowledge gain in the present study pre-posed the proposed unit of instructions as a model of national curriculum reform, whereas the alignment with the agendas of digital transformation predetermines the sustainability and the further progress of the quality of education [34]. To apply these results, a systematic change in the organization of the biology curricula is necessary to introduce the concepts of preventive medicine and AI-assisted learning experiences into it. It is also important that the professional growth of educators should be sustained and should promote the mastery of digital tools and creative strategies, or institutional cooperation, to guarantee curricular relevance and international standards. Cultivating research and practice at the cross-section between preventive medicine and artificial intelligence is essential to empower students, especially female ones, and train them to form a digitally literate and health-conscious generation. Taken together, these suggestions offer an incremental roadmap to national objectives of educational innovation and of health promotion, which can be extended to a wider range of learning contexts [35-45].

4. Conclusion

The study concludes that the current Biology 3 curriculum taught to Saudi Grade 12 students is critically deficient in preventive medicine, as rigorous content analysis shows that essential themes—chronic disease prevention, vaccination, healthy lifestyle practices, and environmental health—are entirely absent, thereby limiting students' health literacy and undermining national educational priorities and international best-practice standards; however, the experimental implementation of an AI-based biology instructional unit produced statistically significant gains with a large effect size in students' knowledge of preventive medicine, confirming the pedagogical value of AI-enabled design in bridging theoretical biology content and practical health behaviors and supporting the systematic integration of such units to build actionable, future-oriented competencies aligned with Vision 2030 and the goal of a digitally empowered, health-conscious population; accordingly, the study recommends comprehensive curriculum reform to embed evidence-based preventive health frameworks across biology education, expand AI-supported instructional units using simulations, computer-based modeling, and educational robotics, and institutionalize continuous teacher professional development in both pedagogy and AI applications through adaptive policy and assessment structures; it further advocates sustained collaboration between schools and health institutions to enrich curricular content with

internationally standardized, current health topics and authentic joint projects, with targeted initiatives to empower female students through AI and preventive-health projects that strengthen critical thinking and problem-solving; finally, the findings imply that the demonstrated effectiveness of AI-assisted teaching warrants long-term curriculum change, supportive policymaking, and scalable national models of digital health education, while future research should replicate and extend the intervention across educational levels and science subjects (e.g., chemistry and physics), examine impacts on achievement, skills, and attitudes, and design structured training programs that build teachers' technical and pedagogical capacity to employ AI tools effectively for students' lifelong well-being and responsible citizenship. The given paper is uniquely novel, as it develops and empirically cohorts a specialized instructional unit, which is AI-enhanced, and specifically focused on the introduction of the concepts of preventive medicine to the learning of high school students of the field of biology. It is novel in the sense that it combines artificial intelligence applications, e.g. simulations, adaptive learning, and automated assessment with health-based curricular reform (a phenomenon virtually unknown in the literature). Beyond analyzes, the research also offers a viable framework of intervention which demonstrates how AI can contribute immensely to changing the biology education process and equip students with health literacy.

5. Limitations

Regardless of the strengths, the study has a number of limitations. The study is also restricted to female secondary school pupils in Riyadh and this might limit the extrapolation of the findings to other larger groups. The study took place in a single school, which may have been affected by the context, including the level of teacher competence or access to resources. Also, researcher developed some of the instruments, which, although validated, can create limitations to measurement. These are the limits that need to be put into consideration in the interpretation of the scope and transferability of the findings.

6. Future Projections

The findings of the analysis indicate that the opportunities of AI-based instructional design are high and may be applied to enhance preventive health education and scientific literacy. Practically, the findings indicate the need to implement AI applications in the national curriculum of biology and the need to constantly educate teachers on digital pedagogy. The concept of preventive medicine retention has to be tested in the long term in the future, and the unit should be tested in different regions, gender, and type of school. Addition of mixed-method tests and expansion of the framework on other courses in science will further benefit the learning concerning the overall impact of AI on education.

Declaration of Competing Interest

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Conflicts of interest

None of the aforementioned conflicts of interest, financial, institutional, or personal, have contributed to the research, authorship, and publication of this manuscript. The research was done on its own and with no external influence.

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