An error-based learning strategy compared with the traditional system in medical students.

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Abstract

Introduction: Error-based learning encompasses various studies that range from general to specific, placing greater emphasis on understanding and addressing errors in medical training. Objective: To evaluate obstetric students' curricular experiences and satisfaction with error-based learning compared to the traditional system.

Method: This study was conducted at the University of Guayaquil. Two groups were established, one using a traditional system and the other employing error-based learning. The accuracy of each group was assessed.

Results: A total of 160 students participated. This strategy encouraged students to explore the identified errors and enhance the knowledge gained during the investigation. The knowledge questions sparked interest, reflecting a high percentage of correct answers compared to the traditional system. Moreover, the surveys conducted at the end of the classes revealed an 80% satisfaction rate with this strategy.

Conclusions: The learning methodology allowed the students in the obstetrics department to participate more actively, cooperatively, and critically in the research. The research was focused on the student, who demonstrated better knowledge and satisfaction with the teacher's support for the difficulties presented.

Keywords:

Medical training, Learning, Medicine, Competences, Diagnostic errors, Error.

Abbreviations

ABE: Learning based on error.
AST: Learning with the traditional system.

Supplementary information

No supplementary materials are declared.

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Authors' contributions

VVRM: Work with conceptualization.
FMGX: Data processing, formal analysis and methodology.
PIMV: Original writing of the draft, revision and editing.
MGPG: Contributed to the conceptualization and research.
MBLS: Original writing of the draft.
VSKS: Review and Editing.

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Availability of data and materials

The datasets used and analyzed during the present study are available from the corresponding author upon reasonable request.

Introduction

Medical careers use various strategies to develop effective teaching methodologies to have a solid base of scientific knowledge and skills in students to analyze problems or cases [1,2] that respond to the high demand in recent years, improving the gap in medical training. The term "learning" refers to acquiring knowledge through experience and research and is also related to remembering. Learning is understood as an innate set of own and inherited skills that are influenced by what has been learned in individual and collective experiences. The neural system participates in this process along with specialized areas of the central nervous system, such as the limbic system, which analyzes signals from the body and provides responses based on various factors, such as security, socioeconomic status, and socialization [3]. Guaranteeing the reactions between the individual and the social environment to which they belong. Rewards, sanctions, complicity, companionship, solidarity, guarantees, etc, integrate this learning. The traditional system of teaching has been the method of learning that medical teaching has adopted [4]. Master classes have been a popular way of teaching due to their effectiveness in transmitting knowledge, particularly by the large number of students; however, the investigative production presented by the lectures is ineffective for learning the skills and critical tendencies needed. In higher education, such as medicine [5], the traditional method is focused on teachers, who passively transmit knowledge to students [6].

The teaching system establishes various learning styles for multiple subjects, which are directed by the master class and supported by individual works and visual resources [7]. In medicine, methods are being implemented to improve student–teacher interaction, which implies a change in the traditional educational paradigm using novel didactic methodologies. Error-based learning is a teaching approach in which mistakes are used as a learning platform; it is a methodology where the teacher includes errors to motivate students to find the correct answer and solve a problem [8]; and it develops self-appreciation and the benefit of identifying mistakes when obtaining collaborative communication between individuals, promoting group work, increasing academic performance, dedication and companionship. For various subjects, the teaching system uses multiple learning styles directed in the classroom and supported by individual assignments and visual resources. This learning strategy has been motivated by gamification [9], with experience applied at the Complutense University of Madrid, allowing many students to increase their evaluation scores. Likewise, it is related to the metacognitive and constructivist system in the written communication of high school students [10]. Mistakes by teachers help retain students' knowledge during the learning process [11]. The beneficial effects of error could lie in implicit cognitive processes [12]. Although mistakes are the first source of learning, deficiencies in the organization that need to be improved are frequent [13]. Errors with the impulse technique in children aged 10--12 years have been essential for improving the self-efficacy and motivation of students [14].

In medicine, various teaching methods, such as clinical case analysis, seminars, simulations, and information and communication technologies, are usually different from those applied by students in clinical practice. In general, it is not known whether these approaches meet students' needs when they seek teacher strategies. The University of Guayaquil, sensitive to this need, has proposed using more effective and active methodological techniques. This work aimed to compare the differences between the error-based learning strategy and the traditional system for teaching obstetrics to medical students.

Materials and methods

Study design

The present study is quasiexperimental. The source is prospective.

Stage

The study was developed at the University Hospital of Guayaquil, in the chair of gynecology/obstetrics of the Faculty of Medicine. The field phase lasted from May 1, 2023, to August 31, 2024, and the analysis period lasted from September 1, 2023, to November 30, 2024.

Participants

Students who took a course on gynecology or obstetrics and were regularly enrolled in all semesters of their medical career were included. Students with repeats of the year or with transfer from another university were excluded. Two research groups were formed. The first group comprises learning based on errors (ABE), and the second group includes learning with traditional systems (ASTs).

Variables

The variables were knowledge about hypertensive disorders during pregnancy and student satisfaction.

Data sources/measurements

The source was direct; an electronic form was filled out from a knowledge questionnaire and a satisfaction survey of the

students in each group. The approach included learning spaces for the ABE group, with groups of 12 to 15 students, raising the issue to discuss with errors imposed by the teacher, opting for observation in different degrees of participation with the hypotheses and resolution of errors through an investigation on site, looking for the right thing. For the traditional system, seminars are organized by the teacher or by the students. A knowledge assessment and a survey were subsequently carried out to measure the level of satisfaction using the techniques and instruments for collecting the primary and secondary information listed below:

Primary information. Information given by the teacher with errors in topics, for example, which of the following entities is associated with multiple pregnancies more frequently? What is the site of action of furosemide? Complications of preeclampsia. Clinical picture of preeclampsia; Treatment of preeclampsia.

Secondary information: search for errors individually and analyze documents. This consists of collecting existing information about the errors that are the focus of the study from books, theses, web pages, or general documents. This information is necessary to relate the past with the current situation to interpret, understand, and explain the essence of the studies presented by the teacher.

Tertiary information. The content was evaluated through a questionnaire in the classroom and, later, the survey: Qualitative-descriptive type, which is corroborated by 10 multiple-choice questions when comparing natural phenomena in the teaching-learning process via 5-point scales, 5 = always; 4 = almost always; 3 = sometimes; 2 = rarely; and 1 = never.

Biases

Applying the participant selection criteria avoided observation and selection bias. To prevent possible interviewer, information, and memory biases, the principal investigator maintained the data at all times with a guide and records approved in the research protocol. Two researchers independently analyzed each record in duplicate, and the variables were recorded in the database once their agreement was verified.

Study size

The study sample included 500 students registered in the institutional system. The population size had a 95% confidence interval, an acceptable error of 5%, an expected frequency of 50%, and a sample size of 160 students, with 80 in each group.

Assignment to each group

The assignment to each group was simple randomized, using a table of numbers generated via a computerized sequence.

Blinding

The maneuver could not be blinded due to the apparent differences in the learning methods, which is why the study was quasiexperimental.

Quantitative variables

Descriptive statistics were used. The results are expressed as frequencies and percentages. The categorical variables were not converted into quantitative variables.

Statistical analysis

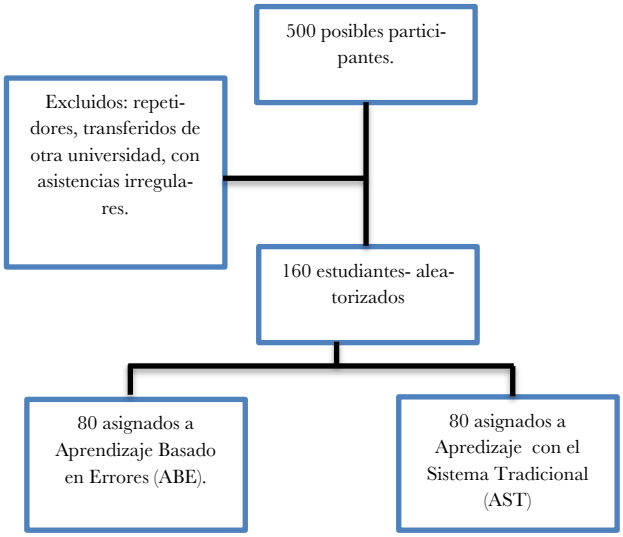
The qualitative variables were analyzed using frequencies and percentages. A 95% confidence interval is presented for a proportion of the relevant prevalences. The proportions are compared with the chi-square test. The statistical package used was IBM Corp. (released from 2018). IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.

Results

Participants

Eighty students were assigned to each group, and 10 were excluded out of 500 students (Figure 1).

Figure 1. Study participants.



Main characteristics of the study group

The average age of the students was 22.5 ± 1.4 years. In terms of gender, 80 students were women (50%). Table 1 compares the initial characteristics of the students in the ABE system and the traditional system (Table 1).

There were no significant differences between the two systems regarding sex, age or grade ($P > 0.05$). In addition, the demographic characteristics of the students in the traditional system were not significantly different from those in the ABE system. The average time dedicated to a class is shown in the ABE and conventional systems, which are significantly different (Table 1).

Scores

A comparison of test scores between the ABE and the traditional system before and after the class revealed that the average scores of the preclass tests and the scores of essential knowledge and case analysis were 70.43 ± 12.23, 45.23 ± 15.32, and 23.34 ± 12.4, respectively. However, for the traditional system, the values were 75.34 ± 12.3, 68.35 ± 13.3, and 35.43 ± 13.2, respectively. Notably, the preclass test scores for the conventional system were significantly higher than those for the ABE system ($P < 0.05$).

After class, the total mean score of the postclass tests and the basic knowledge scores for the ABE group increased significantly, from 72.23 ± 12.5 and 48.25 ± 13.23, respectively ($P < 0.05$), except the case analysis score after the class, which did not significantly differ in its means, 31.23 ± 14.2 and 30.24 ± 13.4 ($P < 0.05$) (Table 2).

Table 1. Descriptive characteristics of the group.

	ABE n=80	AST n=80	*P*
Women	40 (50%)	40 (50%)	1.00
Schooling			
Tenth semester	80 (100%)	80 (100%)	1.00
Age			
Age (Years)	22.5±1.4	22.5±1.4	0.396
Time spent			
Class time (minutes)	107.23±14.51	95.6.0±15.63	<0.001

ABE: Learning based on errors. AST: Learning with Traditional System.

Intragroup delta difference analysis

Similarly, in the traditional system, the mean total score decreased significantly from 75.34 ± 12.3 to 68.51 ± 11.32 (P = 6.39x10 ^ (- 5) < 0.05). In addition, the scores for bare knowledge and case analysis decreased significantly from 68.35 ± 13.3 to 39.51 ± 13.3 and from 35.43 ± 13.2 to 30.24 ± 13.4, respectively (P < 0.05). Moreover, the average total score and the basic knowledge scores in the ABE system were not significantly different from their means (70.43 ± 12.23 to 72.23 ± 12.5 and 45.23 ± 15.32 to 48.25 ± 13.23). In contrast, for the analysis of the cases, the scores increased significantly from 23.34 ± 12.4 to 31.23 ± 14.2 ($P = 4.31x10 ^ (- 5)$ $P < 0.05$) (Table 3).

Table 2. Pretest and posttest scores of the study groups.

	ABE n=80	AST n=80	*P*
Preclass score			
Total score.	70.43 + 12.23	75.34 + 12.3	0.0051
Basic knowledge score.	45.23 + 15.32	68.35 + 13.3	<0.0001
Case analysis score.	23.34 + 12.4	35.43 + 13.2	<0.0001
Postclass evaluation score			
Total score.	72.23 + 12.5	68.51 + 11.32	0.028
Basic knowledge score.	48.25 + 13.23	39.51 + 13.3	<0.0001
Case analysis score.	31.23 + 14.2	30.24 + 13.4	0.612

ABE: Learning based on errors. AST: Learning with Traditional System.

Table 3. Intragroup Delta Differences.

	Delta n=80	T	*P*
ABE group score			
Total score.	-6.83 ± 0.98	4.08	$6.39x10^{-5}$
Basic knowledge score.	-28.84 ± 0.01	15.33	$1.70x10^{-35}$
Case analysis score.	-5.19 ± 0.200	2.75	0.006
AST group score			
Total score.	+1.8 ± 0.27	-1.02	-1.02
Basic knowledge score.	+3.02 ± 2.09	-1.49	-1.49
Case analysis score.	+7.89 ± 1.8	-4.18	-4.18

ABE: Learning based on errors. AST: Learning with Traditional System

Discussion

The traditional educational system is adequate for imparting theoretical education [15 -17]. However, this system is unsuitable for advanced medical students to develop clinical reasoning and communication skills. With the advent of the internet, information has grown rapidly, and personal computers and mobile devices have made e-learning a tool in higher education, allowing medical students to obtain helpful information quickly. Consider and ask questions; obtaining new information is essential in education [18,19]. In this process, ABE teaching strategies, which differ from traditional teaching methods, aim to facilitate health and encourage students to actively move from "what I learned" to "what I want to learn" [20].

Some studies have focused on ABE [21 -27] rather than traditional education systems and shown the advantages of EBA. For example, the ABE emphasizes that staff prepare clinical case reports and documentation to help students develop comprehensive and practical clinical skills. Students also learn theoretical techniques [28]. Considering these individual strengths, this study focused on the ABE to understand the problems associated with errors.

It is a strategy through which the teacher includes errors to motivate the student to find and solve an evaluation [8,29]. Historically, teachers were the only ones who mediated knowledge [7,30 31]. With the advancement of technology, new strategies and teaching systems are being promoted, which allow students to participate more in teaching and interact more with teachers. However, the student is still responsible for their learning [32]. These results are related to the experience applied in five subjects with practical methodology at the Complutense University of Madrid, which allowed many students to obtain high marks [9,33]. This learning strategy encourages searching for information and resolving errors presented by the teacher in the classroom. The Applied Dietetics program, which included texts and practical seminars with errors using Kahoot! as an alternative to overcome students' fear of public speaking, was similar to the clinical review of error resolution [34,35].

Even in areas where no errors have been reported, collaborative teaching methods are more effective than traditional methods, similar to evaluating errors with the impulse technique in children aged 10-12 [36]. Thus, physical education teachers must practice to improve their methods and effectiveness. This procedure is crucial for increasing student self-efficacy and motivation [37].

The students learned clinical, self-learning, and teamwork skills and effectively solved clinical errors [38]. As a result of this experience, teachers and tutors of different roles promoted the necessary practice to develop this methodology, contributing to an organizational education that fosters the principles of responsibility, innovation, help, participation, and individual and collective reflection [39].

Teachers may encounter some difficulties due to cohesion, communication, and competency interaction deficiencies. Still, these difficulties can be overcome over time [40], which is related to the high academic performance of students who depend on resources to obtain information. Therefore, academic performance is influenced by various factors that interact during the learning process [41]. This research is fascinating because teachers and students build knowledge based on the space of action established by medical action [42].

Examining the efficacy and acceptability of the ABE teaching method in obstetrics and gynecology compared to conventional teaching methods. We acknowledge that OB/GYN courses still lack ABE training. In our study, students in the traditional educational system memorized fundamental knowledge from textbooks. Consequently, the overall scores of the case analysis and the pretest of the conventional system were significantly higher than those of the ABE system (75.3 compared to 70.4 and 35.4 compared to 23.3, respectively). This highlights the advantage of the pretest in the traditional educational system.

The students of the ABE system reviewed material throughout the course without case analysis or discussion topics. A comparison of the total scores of the course and the analysis of the cases revealed that the ABE group achieved significantly better results than the traditional group (72.2 vs. 68.5 and 31.2 vs. 30.2, respectively). This explains why the ABE training model is adequate. The mean total and essential knowledge scores were not significantly different on average between the two systems (P <0.05). Compared with the traditional system, the ABE teaching system helps reduce students' free time, indicating its effectiveness in applying medical chairs.

Our study had several limitations. First, we analyzed the results of a specific semester, which may vary across facilities. Second, there was no blinding procedure in this study, so some bias in the analysis was unavoidable, preventing teachers from observing students impartially in terms of their leadership qualities, which are influenced by self-efficacy and the development of students' interpersonal relationships. Third, our study was based on a gynecology course. In the future, we plan to conduct multicenter randomized trials with large sample sizes, different curricula, and long-term follow-up periods.

Conclusions

This teaching strategy enabled active and cooperative learning centered around the students. In this experience, a group of obstetric students expressed satisfaction and support regarding the instructor's errors in applying his teaching method and diagnosing and treating these errors. This enabled each student to personalize their learning and explore their areas of interest, facilitating the implementation of this teaching strategy in other subjects of medical education.

References

1. Gil YM, Hong JS, Ban JL, Kwon J-S, Lee J-I. Dental students' perception of their educational environment about their satisfaction with dentistry major: a cross-sectional study. BMC Med Educ 2023; 23:508. doi: 10.1186/s12909-023-04485-w.

2. Schlegel EFM, Cassara M, Olvet D, Fornari A. Developing Clinician-Educators: A Qualitative Analysis of Structured Reflections from Participatory Teaching in the Final Year in an Integrated Medical School Program. Med Sci Educ 2023; 33:107–17. doi: 10.1007/s40670-022-01712-9..

3. Pellón R. Psicología del aprendizaje. ISBN: 9788436267273 UNED. Madrid: 2014. dialnet/567566

4. Dietrich H, Evans T. Traditional lectures versus active learning – a false dichotomy? STEM Education, 2 (4): 275–292. 2022. doi: 10.3934/steme.2022017.

5. Wilson JA, Pegram AH, Battise DM, Robinson AM. Traditional lecture versus jigsaw learning method for teaching Medication Therapy Management (MTM) core elements. Curr Pharm Teach Learn 2017;9:1151–9. doi: 10.1016/j.cptl.2017.07.028.

6. Naing C, Whittaker MA, Aung HH, Chellappan DK, Riegelman A. The effects of flipped classrooms to improve learning outcomes in undergraduate health professional education: A systematic review. Campbell Systematic Reviews 2023;19. doi:10.1002/cl2.1339.

7. Cyr AA, Anderson ND. Learning from our mistakes. Effects of learning errors on memory in healthy younger and older adults. 1st. Edition. Routledge. p. 151–63. ISBN 9781315660738. London 2018. doi: 10.4324/9781315660738

8. Guerrero Benavides JI, Castillo Molina EJS, Chamorro Quiroz HG, Isaza de Gil G. El error como oportunidad de aprendizaje desde la diversidad en las prácticas evaluativas. Plumilla Educativa 2013; 12:361–81. doi: 10.30554/plumillaedu.12.388.2013.

9. Macho-González A, Bastida S, Sarriá Ruiz B, Sánchez Muniz FJ. Aprendizaje basado en errores. Una propuesta como nueva estrategia didáctica. JONNPR 2020; 6:1049–63. doi: https://doi.org/10.19230/jonnpr.4146

10. Vinces Mieles VA, Delgado Cedeño LA. Aprendizaje basado en errores: una propuesta didáctica para mejorar el proceso de la comunicación escrita en los estudiantes del Bachillerato. Revista Cognosis 2022; 7:95–110. doi: https://doi.org/10.33936/cognosis.v6i0.3622.

11. Molina-Montes ME. Aprendizaje basado en errores en materias de la nutrición: validación de una estrategia docente en un contexto interuniversitario. Universidad de Granadas 2020. doi: http://hdl.handle.net/10481/75110

12. Mera Equiza Yeray. Condiciones de aparición del Aprendizaje Basado en Errores: Relación semántica del material y recuperación del error. Tesis facultad de Psicología UPV/EHU 2018. Doi: 10810/45466.

13. Vázquez-Suárez L, Sánchez-Gómez R. Los 100 errores en el desarrollo de habilidades de gestión. Editorial Esic Primera edición. ISBN: 978841791414 Madrid: 2019.

14. Souissi MA, Elghoul Y, Souissi H, Masmoudi L, Ammar A, Chtourou H, et al. The Effects of Three Correction Strategies of Errors on the Snatch Technique in 10-12-Year-Old Children: A Randomized Controlled Trial. J Strength Cond Res 2023; 37:1218–24. doi: 10.1519/JSC.0000000000003707

15. Castellano, R., Rodríguez, J., & Ortiz, A. M. (2020). ¿Validación de un cuestionario de ABP en Educación Secundaria?: análisis de la formación e implementación en el aula. Espacios, 41(39), 212–230. URL: 20v41n39

16. Cantillon P. ABC of learning and teaching in medicine: Teaching large groups. BMJ 2003; 326:437–437. doi: 10.1136/bmj.326.7386.437.

17. Zhan H-Q, Zhang X-X, Qin R, Fei J, Dong G-Y, Hao J-H. Application of integrated problem-based learning combined with lecture-based classroom teaching in undergraduate medical education: An effective teaching model in a Medical School in

China. Medicine 2023;102: e34792. doi: 10.1097/MD.0000000000034792.

18. Goh CE, Lim LZ, Müller AM, Wong ML, Gao X. When e-learning takes center stage amid COVID-19: Dental educators' perspectives and their future impacts. European Journal of Dental Education 2022; 26:506–15. doi: 10.1111/eje.12727.

19. Hendricson WD. Changes in educational methodologies in predoctoral dental education: finding the perfect intersection. J Dent Educ 2012; 76:118–41. PMID: 22262556.

20. Schaefer S, Dominguez M, Moeller J. The Future of the Lecture in Neurology Education. Semin Neurol 2018; 38:418–27. doi: 10.1055/s-0038-1667042.

21. Burgess A, Bleasel J, Hickson J, Guler C, Kalman E, Haq I. Team-based learning replaces problem-based learning at a large medical school. BMC Med Educ 2020; 20:492. doi: 10.1186/s12909-020-02362-4.

22. Wang B, Jin S, Huang M, Zhang K, Zhou Q, Zhang X, et al. Application of lecture-and-team-based learning in stomatology: in-class and online. BMC Med Educ 2024; 24:264. doi: 10.1186/s12909-024-05235-2.

23. Megee PC, Uhley V, Grogan J, Silverman A. Foundational and Clinical Science Integration in a Team-Based Learning Module Modeling Care of a Patient with Dyslipidemia. Med Ed PORTAL 2024. doi: 10.15766/mep_2374-8265.11397.

24. Rehman R, Ahmad S, Nasir SP, Ali R. Acceptance of team-based learning by students and faculty: A pilot study. Pak J Med Sci 2024;40. doi: 10.12669/pjms.40.5.8515.

25. Sterpu I, Herling L, Nordquist J, Rotgans J, Acharya G. Team-based learning (TBL) in clinical disciplines for undergraduate medical students—a scoping review. BMC Med Educ 2024; 24:18. doi: 10.1186/s12909-023-04975-x.

26. Li Z-Z, Lin H, Xu Y-M, Man Q-W, Wu T-F, Shao Z, et al. Application of PRI-E–a combined learning method in oral and maxillofacial oncology education. Sci Rep 2024; 14:8127. https://doi.org/10.1038/s41598-024-58878-y.

27. Merritt E, McNulty MA, Byram JN. Integrated Case-Based Learning Session for Breast and Upper Limb Anatomy. Med Ed PORTAL 2024. doi: 10.15766/mep_2374-8265.11399.

28. Kolahdouzan M, Mahmoudieh M, Rasti M, Omid A, Rostami A, Yamani N. The effect of case-based teaching and flipped classroom methods in comparison with lecture method on learning and satisfaction of internship students in surgery. J Educ Health Promot 2020; 9:256. doi: 10.4103/jehp.jehp_237_19.

29. Arai M, Mazuka R. The Development of Japanese Passive Syntax as Indexed by Structural Priming in Comprehension. Quarterly Journal of Experimental Psychology 2014; 67:60–78. doi: 10.1080/17470218.2013.790454.

30. Anderson C, Macrae P, Taylor-Kamara I, Serel S, Vose A, Humbert IA. The perturbation paradigm modulates error-based learning in a highly automated task: outcomes in swallowing kinematics. J Appl Physiol 2015; 119:334–41. doi: 10.1152/japplphysiol.00155.2015.

31. Edwards MS, Rosenfeld GC. A Problem-Based Learning Approach to Incorporating Nutrition into the Medical Curriculum. Med Educ Online 2006; 11:4611. doi: 10.3402/meo.v11i.4611.

32. Ramis M-A, Chang A, Conway A, Lim D, Munday J, Nissen L. Theory-based strategies for teaching evidence-based practice to undergraduate health students: a systematic review. BMC Med Educ 2019; 19:267. doi: 10.1186/s12909-019-1698-4.

33. Grado de Ciencia y Tecnología de los Alimentos. Programa de la asignatura Dietética Aplicada a la Industria Alimentaria. Madrid: 2019.URL: ucm.es/

34. Buzón-García O, Fernández-Rincón JA, Mena-Rodríguez E. Presente y futuro de la educación: planteamientos teóricos, experiencias y nuevos modelos educativos. Primera. Sevilla: Ediciones Egregius; 2018. ISBN: 9788417270117.

35. Nagaraj D, Khandelwal P, Steyaert S, Gevaert O. Augmenting digital twins with federated learning in medicine. Lancet Digit Health 2023;5: e251–3. doi: 10.1016/S2589-7500(23)00044-4.

36. Holland K. Editorial comment. Nurse Educ Pract 2003; 3:185. doi: 10.1016/S1471-5953(03)00070-2.

37. Kolobe THA, Fagg AH. Robot Reinforcement and Error-Based Movement Learning in Infants with and Without Cerebral Palsy. Phys Ther 2019; 99:677–88. doi: 10.1093/ptj/pzz043.

38. Lermanda S. C. Aprendizaje Basado en Problemas (ABP): una experiencia pedagógica en medicina. REXE 11:127–43. 2007 URL: rexe.cl/197

39. Vera Velázquez R, Valdés Tamayo P. Uso de recursos tecnológicos en la enseñanza de las matemáticas. Journal TechInnovation 2022; 1:29–45. https://doi.org/10.47230/Journal.TechInnovation.v1.n1.2022.29-45.

40. Hernández-Huaripaucar E, Yallico Calmett R. El Aprendizaje Basado en Problemas (ABP) como estrategia didáctica innovadora en la enseñanza de la Anatomía Humana. (2020). Horizonte De La Ciencia, 10(19), 165-177. doi: 10.26490/uncp.horizonteciencia.2020.19.595

41. Ali SS. Problem Based Learning: A Student-Centered Approach. English Language Teaching 2019; 12:73. doi: 10.5539/elt.v12n5p73

42. Salazar Malerva I, Heredia Escorza Y. Learning Strategies and academic achievement in medical students. Educación Médica 2019; 20:256–62. doi: 10.1016/j.edumed.2018.12.005.

Declarations

Ethics committee approval and consent to participate

The bioethics committee of the Faculty of Medical Sciences, University of Guayaquil in Guayaquil, Ecuador approved the study.

Publication consent

This information was unnecessary because the present study did not publish images, radiographs, or specific patient studies.

Conflicts of interest

This research has no financial interests or conflicts of interest. The investigation does not reflect the policy or official position of the organization and the government.

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