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## FORMATIVE ASSESSMENT: AN INNOVATIVE APPROACH TO ENHANCE LEARNING IN MEDICAL EDUCATION

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***Lavínia Silva Farias***

Faculdade de Medicina de Olinda

***Beatriz Cezar Barreto de Moura***

Faculdade de Medicina de Olinda

***Maria Eduarda Moraes Candeia***

Faculdade de Medicina de Olinda

***Maria Iasmim Fernandes Pouso***

Faculdade de Medicina de Olinda

***Victor Barbosa Magalhães Amorim***

Faculdade de Medicina de Olinda

***Amanda Vasconcelos de Albuquerque***

Faculdade de Medicina de Olinda

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**Abstract: Introduction:** Formative assessment is a continuous process throughout education, guided and influenced by the three essential pillars of the educational process: teaching, learning and assessment, establishing an intrinsic relationship between them. It can be particularly challenging to formatively accompany many students simultaneously. In this sense, just as formative assessment is designed to help the student, it can also be useful in enabling teachers, through multiple feedbacks, to guide teaching effectively and flexibly, and to have reference points for the application of specific pedagogical strategies. **Objectives:** The study investigated the impact of innovative strategies for formative assessment of medical students with 100% active methodology and how these practices can contribute to the development of different medical competencies. **Methodology:** The study consists of the application of 4 innovative educational strategies designed according to educational learning objectives: 1- Google Forms, 2- Multiple choice tests on Zip Grade answer sheets, 3- Construction of Mind Maps aided by artificial intelligence, 4- Interactive online game, and subsequent application of an evaluation questionnaire to students for critical analysis. **Results:** 559 students from the second to fifth year of the medical course took part in this study. There was high student satisfaction with the innovative strategies, with unanimous affirmation that they made a significant contribution to their learning and subsequent formative assessment, while 94.7% highlighted their effectiveness in teamwork. Among the strategies used, 8.15% of the students preferred Zip Grade exercises; 18.7% preferred the use of mind maps, with unanimous agreement that the use of artificial intelligence helped to organize the content. Forms were preferred by 21.6% of the students, given the possibility of immediate learning feedback and, remarkably, the majority

of students (51.4%) preferred games. Finally, the strategies developed received a final average rating of 9.75 on a scale of 0 to 10, demonstrating their effectiveness in the educational context of the medical course. **Conclusion:** The adoption of innovative educational strategies, including the use of artificial intelligence, games and collaborative methods, has been shown to contribute significantly to student learning and their formative assessments, promoting engagement, teamwork and immediate learning feedback. These findings highlight the importance of investing in innovative and adaptable educational approaches to optimize the training of competent health professionals who are prepared for the challenges of the constantly evolving clinical environment.

**Keywords:** Teaching, learning, skills, technology, innovation

## INTRODUCTION

The theory of andragogy is an important concept in the field of adult education and refers to the art and science of teaching adults. Unlike pedagogy, which focuses on the education of children, andragogy focuses on the needs, characteristics and learning approaches of adults. In 1973, Malcolm Knowles published a classic on this theory, exploring the distinct characteristics and effective teaching approaches for adults as learners, such as autonomy and self-direction, problem orientation, learning orientation and motivation<sup>1</sup>. In , Knowles emphasizes that the educator should no longer be seen as the central authority, but as a facilitator of learning, guiding adults to explore, discover and apply knowledge. This requires a collaborative learning environment open to active student participation, typical of a constructivist, cognitive, social and situated approach<sup>1,2</sup>.

According to the National Curriculum Guidelines (DCN), the undergraduate medical course must have a pedagogical project, built collectively, centered on the student as the subject of learning and supported by the teacher as a facilitator and mediator of the teaching-learning process<sup>3</sup>. Also according to the DCN, the undergraduate medical course must use methodologies and criteria to monitor and evaluate the teaching-learning process and the course itself, in line with the evaluation system defined by the Higher Education Institution (HEI) to which it belongs. In this medical training scenario, active methodologies are in line with the current demands of medical education and can use different models such as case studies, inverted classrooms, gamification and PBL (Problem-Based Learning).

Although the PBL model is a different approach to the teaching and learning process for students in the medical field, it shares some of the fundamental educational principles of constructivism, such as active, student-centered education, contextualization, critical thinking and decision-making, as well as the need formative assessments<sup>4</sup>. PBL can be considered a practical application of constructivist principles by requiring students to actively construct knowledge in order to solve real problems, thus promoting a deeper and more lasting understanding of concepts. In this sense, we can make a connection between the concept of lifelong learning in medical practice and the principles of PBL: the importance of recognizing the diversity of learning contexts, whether formal in the classroom or in the classroom.

In clinical settings to informal learning through daily clinical practice and interaction with other health professionals. According to Dornan and colleagues (2007), learning does not end with the completion of medical training, but continues as doctors engage in clinical practice, interactions with colleagues, continuing education and reflection on their own experience<sup>5</sup>.

In 2007, Ten Cate and colleagues published 10 practical tips for the effective implementation of competency-based education for students in medical education, promoting a mindset of continuous and adaptive learning<sup>6</sup>. According to the authors, educational objectives should be aligned with the competencies expected for medical practice, and they also emphasize the need for authentic, formative assessment, which not only measures student performance, but also provides valuable feedback for continuous improvement. Good formative assessment is capable of promoting the development of complex cognitive processes, such as self-regulation, and when associated with formative feedback, stimulating student protagonism, as well as increasing their enthusiasm for the teaching-learning process itself, leading to better academic performance<sup>7</sup>. However, although it is a valuable educational approach, formative assessment offers some challenges, such as the development of clear criteria, student acceptance, curriculum integration, as well as a balance with summative assessment.

Today, artificial intelligence has brought positive changes modern society. In education, therefore, it would be no different. The development of information technology has transformed the way students learn. Teaching-learning interactions are more than ever focused on virtual channels and platforms, which use an intelligent management system, avoiding wasting human resources and promoting the development of better teaching tools<sup>8</sup>.

In view of the above, this study set out to explore the impact of different technologies and integrative educational practices based on active methodologies, and how these practices can contribute to the development of different medical skills such as critical thinking, scientific knowledge, ethics, teamwork and student empathy.

## **METHODOLOGICAL PROCEDURES**

### **TYPE OF STUDY**

This is a cross-sectional observational study aimed at gaining a deeper understanding of the impact of different innovative educational strategies based on active teaching methodologies, with and without the use of artificial intelligence, on learning and consequently on the development of different competencies of medical students, developed according to Bloom's taxonomy (Figure 1).

### **PARTICIPANTS**

Students from the second to the fifth year of the medical course took part in five curricular units (CU), developed in the morpho-functional laboratory of a higher education institution (HEI) in the city of Olinda - PE.

### **VIRTUAL LEARNING ENVIRONMENT**

The Google Classroom platform was used as a virtual learning environment (VLE). This environment was used as an inverted classroom, where students could access trigger materials, learning scripts, schedules, as well as facilitating communication between teachers and students, being an environment for uploading materials, links, updating progress and performance for the semester, as well as being open feedback and questions from students.

### **INTEGRATIVE PRACTICES**

#### **Google Forms**

Google Forms is a free service for creating online forms. This tool was used to produce multiple-choice and true/false questions, mainly assessing the students' previous study according to the learning objectives previously set in the VLE. The tool was also used for performance evaluations, gauging students' expectations and the level of difficulty of the classes with the proposed exercises.

#### **Mind maps**

Throughout the semester, group activities were proposed in which students were challenged with real clinical cases, here called problem situations, taken from scientific articles, to develop critical thinking and present their clinical, morphological and physiological findings in the form of mind maps. For this practice, different applications using artificial intelligence were used. Subjectively, these activities also assessed student collaboration in the development of the groups and empathy with the facilities or difficulties of their members.

#### **Zip Grade test type evaluations**

We used exercises containing multiple-choice questions and Zip Grade answer sheets, referred to here as templates. The tool allows automatic correction of the answer cards and quick feedback on the students' performance.

#### **Gamification**

The Quizizz tool was used to gamify the summative pre-assessment reviews. Students were able to log in anonymously and test the knowledge they had acquired during the semester in a fun and light-hearted way. For teachers, it provides an immediate assessment of class performance, whether or not the educational objectives have been met, as well as a relaxed interaction about the content covered.

#### **Feedback**

Different forms of feedback were developed between teachers and students throughout the semester. Google Forms was used for most of the feedback, both quantitative and descriptive. Personal and face-to-face feedback was offered in isolation, given the large number of students in the classroom, and also according to the student's performance or the teacher's judgment. In addition, an anonymous feedback dynamic was proposed to assess the performance and conduct of the teacher responsible for this study.

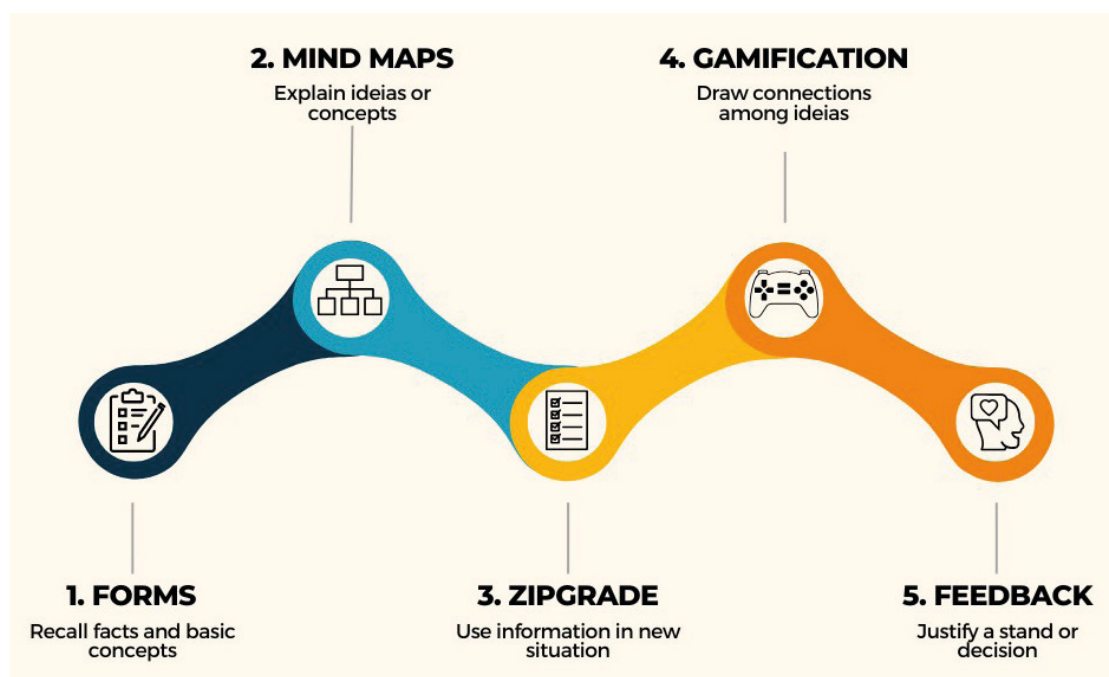


Figure 1. Integrative practices used in the morphofunctional laboratory.

## PRESENTATION AND DISCUSSION OF RESULTS

### INNOVATIVE EDUCATIONAL STRATEGIES

Table 1 summarizes the number of students taking part in the study, as well as the total number of each innovative educational strategy: Forms, mind maps, Zip Grade multiple-choice tests, and the interactive Quizizz game. The number of feedbacks received and sent to students is also shown.

Period	Stu- dents	Forms	Mind maps	Zip Grade	Quizizz	Fee- dback
P2	142	20	10	10	10	104
P3	127	20	10	10	10	109
P4	140	20	10	10	10	119
P5	150	20	10	10	10	111
Total	559	80	40	40	40	443

Table 1. Innovative educational strategies developed in the morphofunctional laboratory.

P2: second term; P3: third term; P4: fourth term; P5: fifth term of the medical course.

Source: The authors.

### STUDENT PROFILE

During the first weeks of classes, the students were asked about their expectations of studying in the morphofunctional laboratory. Of the 559 students, 81.39% felt comfortable listing their main difficulties and desires using the Forms platform. Adherence to the questionnaire was observed in 95% of students in the second term (P2); 90% for the third term (P3), 83% for the fourth term (P4) and 60% of students in the fifth term (P5).

Regarding the main difficulties, the microscopic aspects of the diseases were listed as the greatest difficulty in all periods, present in 70.5% of the students in P2, 61.2% in P3, 67.5% in P4 and 66.4% in P5.

It is crucial that medical students feel comfortable and safe to express their learning expectations and their main difficulties. Being open to discussing these issues not only promotes a more inclusive learning environment, but is also essential for students' academic and personal development. The integration of innovative educational technologies such as google forms and active learning methods



not only enhances engagement and knowledge retention, but also guides educators in setting realistic goals and creating better teaching strategies. It can be seen, however, that most teachers belonging to the traditionalist generation are reluctant to use innovative technologies, preferring traditional classroom guidance with a focus on communication in person or in writing<sup>9,10</sup>. Therefore, change for this generation is challenging, so new knowledge or changes in their didactics require time, as well as thorough and detailed guidance.

### RESISTANCE TO CHANGE

As the semester progressed, different educational strategies were put into practice, and once all the proposals had been covered, the students were asked how they would like to exercise their theoretical and practical knowledge (Figure 2).

The results show that 21.6% of the students felt more able to use “forms” as a way of testing their theoretical and practical knowledge. 18.7% wanted to use artificial intelligence in their research to create mind maps; 51.4% wanted games as a priority educational strategy and only 8.15% wanted to test their knowledge using Zip Grade answer sheets. Although assessments in the latter format are equally important as they simulate national performance exams by testing students’ theoretical and practical understanding independently, they were the least accepted by the students. Surprisingly, when asked about their desire for traditional lectures, many (27% of all students) opted for this over active methodologies.

The transition to active methodologies, which require more active and autonomous student participation in the learning process, can be uncomfortable and challenging for those who are used to the more passive model. It is important that the results of implementing active methodologies are achieved without overloading students, given that its benefits do not necessarily depend on an excessive worklo-

ad<sup>11</sup>. In addition, a lack of understanding or familiarity with active methodologies can also contribute to student resistance. If they do not understand the benefits of these approaches or have not received adequate guidance on how to effectively participate in them, they are more likely to resist their implementation.

### GAMIFICATION OF HIGHER EDUCATION

It is common knowledge that medical students experience a high level of tension and stress in the academic environment from the first semesters of the course. A cross-sectional quantitative epidemiological study carried out at the Federal University of Rio Grande do Norte (UFRN) found that 66.3% of students had stress, 33.6% had anxiety symptoms and 28% had depressive symptoms. With regard to stress, the resistance phase predominates (lack of motivation, excessive tiredness and difficulties with attention and memory), associated with personality aspects reinforced by the medical environment, such as a high level of personal demand, rigidity and perfectionism<sup>12</sup>. Among the strategies used to promote communication, empathy and reduce this feeling of excessive pressure are mentoring by teachers who know how to establish a healthy relationship between teacher and student<sup>13</sup>.

Having observed a certain resistance to active teaching methodologies (23% opted for traditional methodologies), the Quizizz tool was used in the to revise knowledge and as a way of relieving pre-test tension. The pedagogical approach based on the application of games - gamification - can promote more effective educational performance. Although more research is needed in this area, it is known that games have the potential to facilitate and enrich the teaching-learning process through active experiences experimented by the participants<sup>14</sup>. Games were perceived as promoting a collaborative environment, albeit competi-

## Which of the innovative strategies contributed most to your learning?

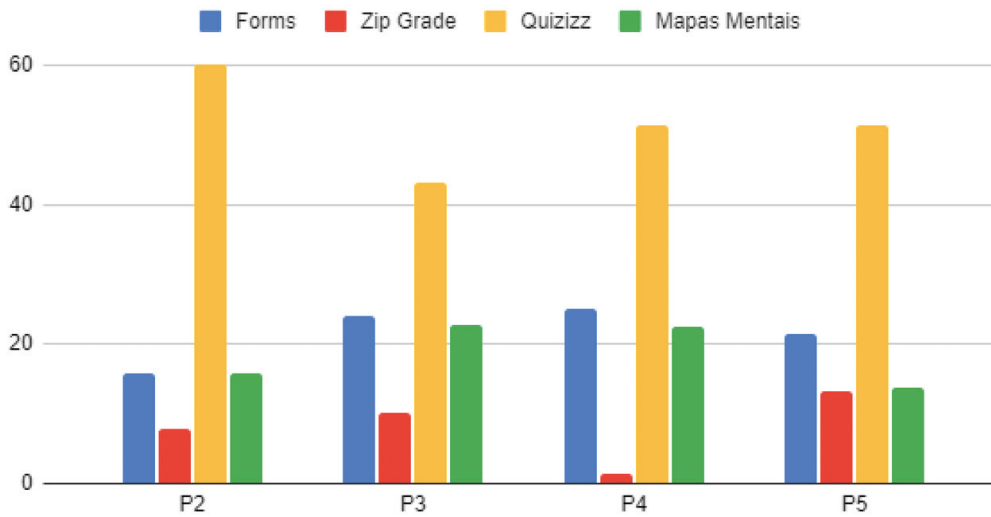


Figure 2: Students' preference for innovative educational strategies (%). P2: second term; P3: third term; P4: fourth term; P5: fifth term of the medical course. Source: The authors.

tive, by 97.5% of the students. Adherence to the playful form of assessment was well accepted by the students as it allowed them to log in anonymously and test their knowledge without being identified or exposed. In addition, the platform offers real-time feedback on the performance of each quiz taken, helping educators to set achievable goals, develop more effective teaching strategies and create didactic-pedagogical bonds based on trust, respect and respect humility. In this study, the gamification of teaching, especially as a pre-assessment review, enabled the analysis of interactive clinical cases, in which students simulated imaging exams, patient histories and laboratory data to formulate diagnoses and treatment plans, helping to develop clinical reasoning skills in a playful way. Although competition is an essential part of games, their relevance goes beyond this, as it is essential to create a collaborativeenjoyable environment conducive to learning to ensure the effectiveness of the method<sup>15, 16</sup>. The teacher who creates the game can therefore contribute to the development of critical minds, with notions of ethics and citizenship, regardless of the results and the winners<sup>15, 16</sup>.

## ARTIFICIAL INTELLIGENCE IN EDUCATION

It is common knowledge that the medical curriculum is extensive and requires coverage of a wide range of topics. Adapting active methodologies to ensure that all relevant aspects are covered can be challenging, especially when time is limited. E-learning refers to the use of digital technologies to facilitate the teaching and learning process with a wide range of resources, such as mind maps, interactive quizzes, discussion forums and reading materials<sup>17,18</sup>. According to Freire (2016), a student who is critical, inquisitive and restless in the face of the task learns more, as well as subsequently contributing to the transmission of knowledge among their classmates<sup>19</sup>. In this context, active methodologies are configured as a teaching model where the teacher is no longer the primary holder of knowledge and becomes an intermediary, a facilitator of learning<sup>19,20,21</sup>. In our study, the use of artificial intelligence was encouraged and all the students (100%) agreed that the application of artificial intelligence facilitated the organization of mind maps. It was also observed that this practice provided moments of discussion

and reflection on the importance of protagonism, engagement and online collaboration in the construction of knowledge, which are so essential to andragogy.

## PARADIGM SHIFT

An analysis of citation trends over time demonstrates the changing priorities and approaches in medical education and how new discoveries and innovations are shaping the way doctors are educated and trained. According to the bibliometric analysis proposed by Azer (2015), the majority of works focused on the They can be divided into the two main journals: Academic Medicine and Medical Education<sup>22</sup>. In Brazil, RBEM (Revista Brasileira de Educação Médica) is the dissemination organ of ABEM (Associação Brasileira de Educação Médica), whose journal annually publishes most topics related to education, including pedagogical innovations. The Covid-19 pandemic, for example, has highlighted the need for innovation in teaching and learning methods and has accelerated the use of digital technologies and adaptation to them<sup>23</sup>. In our study, different innovative tools and strategies were used for educational practice, such as Google Classroom. This tool made it possible to create a virtual learning environment (VLE) that can even be shared by different teachers, facilitating integration and creating an environment of online interactivity between . The tool also makes it possible to schedule classes, announce deadlines handing in assignments and give feedback on activities individually or collectively<sup>24,25</sup>. However, like any other resource or tool, Google Classroom has some disadvantages, such as the need for an internet connection<sup>24</sup> and the need for medical educators to update their teaching skills. Notably, 95.5% considered that the innovative strategies were aligned with the established learning objectives, and 99.1% expressed interest in using them in future monitoring activities.

## FORMATIVE EVALUATION AND FEEDBACK

The concept of assessment is imbued with multiple intentions, of which the three main ones stand out: diagnostic, summative and formative. Formative assessment is centred on the student's training process, characterized by reflection, self-learning and co-responsibility on the part of the agents involved (teachers, students, management and the community). It is continuous throughout the educational process, guiding and being influenced by it and intrinsically related to the three fundamental pillars of the educational process: teaching, learning and assessment<sup>26, 27</sup>. According to the results obtained, 100% of the students were satisfied, stating that the strategies employed had made a significant contribution to their learning and formative assessment, while 94.7% highlighted their effectiveness in developing teamwork. In addition, 93% of participants reported an increase in motivation to study unfamiliar subjects. It can therefore be concluded that if formative evaluation is intended to help the student, it can also be useful in teachers, through multiple feedbacks, to guide teaching effectively and flexibly, and to have reference points for the application of pedagogical strategies of a certain range<sup>28</sup>.

This study has limitations. The first refers to the study conducted with convenience samples, which in themselves represent a sampling bias. The second limitation is that the analysis focused only on the morphofunctional laboratory environment and did not address other active methodology strategies such as TBL (Team Based Learning) and OSCE (Objective Structured Clinical Examination), limiting the generalization of the results, which are limited to the scenario investigated. We therefore suggest further studies to explore the subject in other contexts, as well as analyzing the evolution of these findings over time, considering the changing conditions of teaching in the medical education scenario.



## FINAL CONSIDERATIONS

The results of this study highlight the relevance and effectiveness of innovative strategies in the educational context of the medical course. The adoption of these approaches, including the use of artificial intelligence, games and collaborative methods, has been shown to contribute significantly to student learning, promoting engagement, teamwork and inte-

rest in diverse topics. The high acceptance and interest of students in these methodologies suggest that they are in line with the contemporary demands and expectations of medical learners. These findings highlight the importance of investing in innovative and adaptable educational practices to optimize the training of competent health professionals who are prepared for the challenges of the constantly evolving clinical environment.

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