REVISTA CÁTEDRA

Comparison of two teaching methods in immunology for medical students: a quasiexperimental study with nonequivalent control group

Comparación de dos métodos de enseñanza en inmunología para estudiantes de medicina: estudio cuasiexperimental con grupo de control no equivalente

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Abstract

The chalk talk and slide projection methods in biomedical science lectures show differences in student learning in the short and medium term, which impacts future therapeutic decision-making in favor of the patient. A 2017 study by the Faculty of Medical Sciences at the Central University of Ecuador reported that 50% of students did not fully understand the lectures. Therefore, a quasi-experimental operational study with a non-equivalent control group was conducted with first-semester medical students during the 2024-2025 academic year to compare the effectiveness of both methods in short- and medium-term learning. Participants were assigned to the interventions: chalk talk and slide projection; and received a Basic Immunology lecture using the respective methodology. Each group was evaluated before, immediately after, and one week after the lecture. The level of learning was estimated using a 20-point test specific to the course. The chalk talk group improved from a pre-intervention mean score of 5.07 ± 2.76 to a post-intervention mean score of 12.92 ± 3.86 and scored 8.33 ± 3.68 one week later ($p < 0.05$). The slide group improved from a pre-intervention mean score of 6.06 ± 3.29 to a post-intervention mean score of 8.76 ± 3.19, with a score of 6.93 ± 3.57 one week later ($p < 0.05$). It was concluded that the chalk talk method is more effective than slide projection in the short and medium term for teaching medical students, with no influence from IQ or gender.

Keywords

Chalk talk, slides, teaching, quasi-experimental, immunology, medicine, blackboard.

Resumen

Los métodos chalk talk y proyección de diapositivas en clases magistrales de ciencias biomédicas muestran diferencias en el aprendizaje de los estudiantes a corto y mediano plazo, lo que repercute en la futura toma de decisiones terapéuticas a favor del paciente. En un estudio de la Facultad de Ciencias Médicas de la Universidad Central del Ecuador en 2017, se reportó que el 50% de estudiantes no comprendía totalmente las clases magistrales. Por ello, se realizó un estudio operativo cuasiexperimental con grupo de control no equivalente, en estudiantes de medicina de primer semestre periodo académico 2024-2024, con el objetivo de contrastar la efectividad de ambos métodos en el aprendizaje a corto y mediano plazo. Los participantes se distribuyeron a las intervenciones: chalk talk y proyección de diapositivas; y, recibieron una clase de Inmunología Básica con su respectiva metodología. Se evaluó cada grupo antes, inmediatamente después y una semana luego de la clase en cada grupo. Se estimó el nivel de aprendizaje con test propios de la cátedra sobre 20 puntos. El grupo chalk talk pasó de un promedio preintervención de 5.07 ±2,76 a 12,92 ±3,86 postintervención, y obtuvo 8.33 ±3,68 una semana después ($p <0.05$). El grupo diapositivas pasó de 6.06 ±3,29 a 8,76 ±3.19 postintervención, con 6.93 ±3.57 en la evaluación una semana posterior ($p <0.05$). Se concluyó que el método chalk talk es más efectivo que la proyección de diapositivas a corto y mediano plazo en la enseñanza a estudiantes de medicina, sin influencias por coeficiente intelectual o sexo.

Palabras clave

Chalk talk, diapositivas, enseñanza, cuasiexperimental, inmunología, edicina, pizarra.

1. Introduction

Education is understood as an act of "instruction through teaching" (Royal Spanish Academy, 2025). It is a process that unfolds across different levels, from primary school to higher education, each with its own strategies and goals, though always involving both teachers and students (Biesta, 2020, p. 89). Beyond preparing individuals to integrate into society, education seeks to foster lasting learning, providing tools for individual and collective professional development. Flores et al. state that teachers must be constantly updating their skills; professional careers such as medicine and nursing, for example, require mastery of the physiological functioning of the human body through the basic biomedical sciences learned at the undergraduate level (Flores et al., 2021).

The central problem addressed in this study is the variability in the effectiveness of chalk talk and slide projection models in teaching basic biomedical sciences. Although both methods are widely used, some authors, such as Parashar et al. (2018), suggest that "a disadvantage of PowerPoint appears to be that the student becomes a passive observer rather than an active participant" (p. 4). However, opinions are divided. Saca and Tituaña (2016) maintain that this same technique "encourages students to take initiative in their own learning" (p. 23).

Therefore, this operational study was conducted to analyze and compare the effectiveness of these two pedagogical models to determine which offers a greater advantage in the teaching and learning process of basic biomedical sciences. Specifically, it focuses on basic immunology in first-semester medical students, considering sex and IQ range as moderating variables.

Regarding the structure and content of the article, the second section delves into a literature review of the available information on teaching and learning models. The third section describes the materials, subjects, and methods used for the operational experiment. The fourth section details the results obtained from the interventions. The fifth section compares these results with those found in similar studies and presents a discussion and conclusion.

2. Literature review

2.1 The teaching and learning process

"The teaching-learning process is conceived as a deliberate communication system that involves the implementation of pedagogical strategies to foster learning" (Osorio et al., 2021, p. 2). In this context, teaching is understood as the guidance and instruction provided by a teacher through pedagogical strategies; while learning is a dynamic and continuous process through which the student receives, modifies, or strengthens knowledge, skills, and practices. This process involves both neurobiological mechanisms and contextual and emotional factors.

Authors such as Rochina et al. state that the teaching-learning process establishes a network of complex interactions that include the relationships between teacher and student, among students, between the student and knowledge, and between the student and their practical environment. These interactions reflect that learning is not limited to the simple transmission of information from teacher to student, but rather is a collective process involving multiple theoretical, practical, and relational factors. Currently, based on the teacher's role, some authors assert that these activities are carried out in groups, with an approach that integrates theory, practice, and social interaction within the classroom. They

also state that, in general, knowledge construction is based on problem-solving, which fosters both the individual and collective development of the participants (Rochina, et al., 2020, p. 388).

The teaching-learning process naturally involves various actors and elements. Among the human factors, the teacher and the student stand out. The teacher is responsible for planning, organizing, and facilitating learning through appropriate pedagogical strategies. They must carry out the didactic act, which is "the concrete realization of the teaching process; that is, the materialization of said process in time and space" (Meneses, 2007, p. 61). Their role not only involves the transmission of knowledge but also the guidance, evaluation, and constant updating of their methodologies. For their part, students are ideally active agents in their own learning, responsible for assimilating, analyzing, and constructing their own knowledge, developing research and critical thinking skills.

Meanwhile, the non-human elements that influence this process are content, tools, and context. Content encompasses the educational objectives and the theoretical and practical knowledge imparted, as well as fundamental values and attitudes, such as effort, reflection, and decision-making. On the other hand, according to Vargas, tools include diverse teaching strategies and resources, such as reading, writing, oral expression, problem-solving, research, and collaborative work (Vargas, 2017). And the context, which is conditioned by factors such as physical space, the number of students, the availability of economic and educational resources, as well as external aspects such as stress or fatigue, can affect academic performance.

Meneses also raises other non-human elements, such as educational resources, which play a key role in teaching, as they facilitate student understanding and interest. These resources include printed texts, audiovisual materials, interactive whiteboards, and information and communication technologies. In particular, interactive whiteboards, such as the traditional blackboard and interactive materials, as well as the use of slides and audiovisual content, are widely used tools in current educational processes (Meneses, 2007, p. 32). Consequently, if the focus is on higher education, pedagogical and andragogical models play a leading role among teaching strategies; the existence of several models has “created confusion among teachers and administrators, since they all refer to education” (Correa & Pérez, 2022, p. 131). There are several pedagogical approaches that describe how the teaching-learning process is carried out. Therefore, when compiling the attitudes and practices of university classes, the authors, citing Zubiría, ultimately classify pedagogical models into three main approaches: “self-structuring, intra-structuring, and hetero-structuring” (Correa and Pérez, 2022, p. 131).

2.1.1 Self-structuring current

The self-structuring approach is based on the idea that "the student develops autonomously as the artisan of their own learning, being the core and sole agent of didactic transposition" (Not, 1992). In other words, the student transforms the technical knowledge obtained through their arduous research into assimilable or less specialized concepts, thus retaining the new knowledge and even sharing it with others, becoming the student's own educator on the subject. Dupouy argues that this approach includes theories such as social cognition, active learning, information processing theory, and constructivism. He mentions that these theories highlight the importance of the student's active and personal participation, experimentation, and lived experience for understanding knowledge. It also considers the student's individual characteristics, differentiating traits, and their particular concepts about situations, words, phrases, and facts (Dupouy, 2023).

To achieve this, according to Vergara and Cuentas, students should be encouraged to acquire knowledge through observation, processing of new information, and application in practical situations, progressing from simple to complex concepts based on their own experience, thus making the student the architect of their own knowledge construction (Vergara and Cuentas, 2015, p. 918). However, this approach can be influenced by the institution, impacting the creation or reconstruction of knowledge. In the classroom, teachers will use methods according to the student's interests, needs, and motivation, fostering in them a desire to investigate a particular topic independently.

2.1.2 Intrastructural current

According to Dupouy, the focus of this approach is on personalized learning, adapting the educational process to the individual characteristics of students to optimize their understanding (Dupouy, 2023). According to Gómez et al., it centers on combining active roles for both students and teachers, emphasizing guided reflection and thus ensuring the participation of both parties in the process. Following this proposed norm, this approach is considered an intermediate point between the self-structuring approach described earlier and the heterostructural approach described below (Gómez et al., 2019, p. 173).

2.1.3 Heterostructural current

In this approach, the teacher plays a central role in the transmission of information, using repetitive and expository methods to ensure comprehension of the content. Furthermore, every effort is made to break down the information so that the learner can reintegrate it, thus understanding the concepts conveyed. These are heterostructuring models whose objective is the transmission of specific knowledge, values, and culturally and socially accepted norms. According to Gómez et al., this classification includes pedagogical models such as connectionism, classical behaviorism, continuity conditioning, operant conditioning, and the traditional school (Gómez et al., 2019). Correa and Pérez analyze the proposal of teacher Julián De Zubiría, whose work advocates the transmission of knowledge, values, and cultures accepted by society. Moreover, the traditional pedagogical model, which includes lectures, is a representative example of this approach (Correa & Pérez, 2022, p. 131).

In higher education, especially in basic biomedical sciences training, different pedagogical methods are used to enrich the teaching process under the hetero-structuring approach, in which the teacher serves as a presenter of information with the help of tools that guide their teaching. “A blackboard is exceptionally effective as a teaching tool in the classroom and has been frequently used in classes, while the use of transparencies with an overhead projector is also popular” (Parashar, et al., 2019, p. 4). Petimani and Adake state that Chalk Talk consists of the use of a blackboard by the professor to illustrate ideas in real time through diagrams, drawings, or keywords. The teacher uses markers or liquid chalk to illustrate the content while communicating with the students. This technique is valuable, allowing for dynamic interaction and giving students the opportunity to take notes and analyze the information as it is presented. Furthermore, the flexibility of chalk talk to adjust the explanation based on the group's response and the possibility of making gradual corrections make it particularly valuable in medical training, where a deep understanding of complex concepts is crucial (Petimani & Adake, 2015).

Slide Projection:This refers to a method that uses a video projector to display a series of slides prepared beforehand with programs such as Microsoft PowerPoint, Canva, Slidesgo, and others. While this approach can be more efficient in terms of content preparation and

organization, it can limit the time available for detailed explanation. “The professor prepares photographic slides and distributes them to the students before class. They show the PPT slides and explain the important points during the class” (Petimani & Adake, 2015, p. 290).

2.2 Education in health areas

Medical education has not always been as it is known today; like most processes in our environment, it has undergone a series of transformations at the institutional, regional, and global levels. Just a few centuries ago, the level of technology that exists today as a support and teaching tool for those aspiring to become doctors, nurses, or artists was the stuff of science fiction. The following is an overview of the evolution of teaching practices in the medical field.

2.2.1 Historical review of medical education

With the formation of the first population groups and cultures of the ancient world, valuable documentation began of various acts that can be considered the foundations of human medicine, starting with the recording of information that for decades had only been transmitted verbally and practically from master to apprentice. “The first records of medical teaching exist in ancient Sanskrit. They provide detailed information about the training of physicians” (Fiddes, 2024). Fiddes makes a particular clarification: at that time, the main and most famous school of thought was the “Corpus Hippocraticum,” considered the pinnacle of medical education. Within this corpus, the Hippocratic Oath was implemented over the years, emphasizing respect for those who were the pupil's teachers in medical training. Galen not only revolutionized the teaching of students but also generated one of the most remembered and widely used teaching practices today: bedside teaching. Thanks to this renowned philosopher, surgeon, and physician, those trained in medicine became known as physicians (Fiddes, 2024).

According to the renowned historian Pilar Cabanes, later, in the Middle Ages, medical education was managed by monasteries and certain emerging universities. In the 11th century, in Italy, the Salerno School initiated a process of formalizing medical education by incorporating ancient Greek and Arabic texts. Gradually, figures from the Islamic world, Bologna, and Paris focused on the study of specialized branches: physiology, anatomy, etc. (Cabanes, 2023). However, medical practices remained, at the very least, bloody, disturbing, and largely experimental. There was no clear boundary between the practice of healing and the art of learning; the latter likely involved actions that could contradict the former.

It wasn't until the Scientific Revolution in the 16th century that the approach to medicine changed. Renowned physicians like the Belgian Andreas Vesalius contributed fundamental knowledge to anatomy through an extensive program of dissecting human body parts, providing information that facilitated a more accurate understanding of the human body's architectural structure. "The young Vesalius delved deeper into Galen's studies and found that his anatomical descriptions did not agree" (Santillán, 2019, para. 7). During this same period, the importance of research and experimentation as a source of new information was emphasized. On the other side of the globe, in the New World, the Americas, medicine was in its infancy. The continent was in a transition from pre-Columbian practices to the new cultural impositions of the conquerors. After several years of expansion, invasion, and colonization in the territories under the rule of the Spanish Crown, the territory that is now Ecuador, then known as the Royal Audiencia of Quito, was the subject of a proposal to establish a medical school, thanks to the Dominican friars:

> The initial idea of establishing medical studies in Quito originated with the Dominican friars. Friar Ignacio de Quesada clearly recognized that university education needed less theologians, canon lawyers, rhetoricians, and Latinists, and more physicians. He engaged his community and, with their help, organized a Faculty of Medicine at the Royal University of Saint Thomas Aquinas of the Dominican Order in Quito, founded in 1688. This faculty included a three-year curriculum and two professors. By Royal Decree of April 13, 1693, the first Chair of Medicine in Quito was established there, in the Dominican convent of San Fernando (Estevez et al., 2018, p. 149).

According to Estevez's own research, throughout the history of this medical school, there have been a series of changes in the educational structure. Initially, the program was three years long. Over the years, many distinguished physicians were trained within its walls, one of the most renowned being Dr. Francisco Javier Eugenio de Santacruz y Espejo. A native of Quito, he was highly regarded for his fight against the marginalization of historically excluded social groups, his critique of the university system, and his scientific contributions to Ecuador's health regulations at that time (Estevez, 2018, p. 151).

In recent history, amidst political and ideological struggles, the Faculty of Medicine continues to train professionals in medicine and surgery. The Faculty of Medical Sciences has experienced “changes in the educational systems themselves and in social, economic, productive, ecological, political, cultural, scientific, technological, philosophical, and human structures” (Barros et al., 2018, pp. 77–78). Estevez et al. recount that the teaching of basic medical subjects such as anatomy was based on the direct observation of dissected cadavers in the anatomy theater. In these classrooms, at least one hundred students received lectures from a single professor. For clinical subjects, bedside teaching remained the foundation; moreover, the correct execution of the medical history was paramount. Amidst disputes regarding its proper preparation, an important bibliographic work was established at the Faculty: the Medical Examination, by Dr. Carlos Guarderas in 1982 (Estevez et al., 2018, p. 151).

2.2.2 Pedagogical models used in current medical teachingl

Medical education is one of the settings where the pedagogical models contained within the hetero-structuring approach are commonly applied. Medical schools, such as the one mentioned earlier, use both the chalk talk model and the slide projection model for lectures. However, the effectiveness of these methods in teaching basic biomedical sciences, such as immunology, is still a subject of debate.

Saca and Tituaña conducted a cross-sectional analytical epidemiological study between 2016 and 2017 at the Faculty of Medical Sciences of the Central University of Ecuador, regarding the pedagogical models used by nursing faculty. They found that 50% of faculty members who teach rotating internships consider memorization of concepts important. Meanwhile, 50% of students did not fully understand the lectures, citing some problem with content retention and comprehension (Saca & Tituaña, 2017). This finding highlights the need for further investigation into the efficacy and effectiveness of different pedagogical methods in biomedical science education and their relevance to student learning.

In addition to considering the lecture-based methodologies employed, Reyes et al. analyze the students' sex and IQ range as moderating variables. According to a 2019 study by the Eloy Alfaro Lay University of Manabí, both men and women have a reflective learning style. However, individual differences may exist between the two genders, modifying their

learning styles. It was observed that women are more active and practical in completing tasks, which may lead to higher scores on academic assessments. The study also found that women may be more skilled in perceptual speed, verbal fluency tests, manual dexterity, and mathematical calculation; while men perform better in spatial tasks, motor skills, and mathematical reasoning. However, it is worth clarifying that there are not enough studies to demonstrate that one sex has a greater learning capacity than the other (Reyes et al., 2019, pp. 48–50).

Similarly, intelligence quotient (IQ) could affect or influence the learning process. Aravena et al., in an analytical cross-sectional epidemiological study, concluded that, as an assessment of multiple domains, IQ is understood to influence the teaching-learning process depending on the approach and model used. This is why this and other studies have shown that in cases of moderate IQ deficiency, academic performance decreases, while with a normal or average IQ, there are no significant differences between individuals (Aravena et al., 2017).

3. Materials and methods

A quasi-experimental operational study with a non-equivalent control group was conducted to compare two pedagogical methods for teaching basic immunology to first-semester medical students at the Faculty of Medical Sciences of a public university in Ecuador. Four of the eight parallel sections of first-semester students were randomly selected for the study. The implications of participating in the project were explained to the students beforehand, so that they could voluntarily sign informed consent forms, along with providing basic information required for identification within the study. Participants were students over 18 years of age, enrolled in the first semester of medicine, with regular class attendance, who agreed to participate in the study and receive the educational intervention. Those who did not complete the pre-intervention and post-intervention questionnaires, did not attend the class (intervention), or had previously taken the course were excluded. Participant information was collected in person using printed forms.

In addition to the identification data according to Wang et al., the survey technique was applied to estimate IQ range using a psychometric test, Raven's Progressive Matrices Test, which measures educational intellectual reasoning ability; that is, reasoning, planning, cognitive flexibility, decision-making, abstraction, and complex problem-solving. Based on this, it estimates an individual's IQ range on a scale from Range I (Superior) to Range V (Poor) (Wang et al., 2019, p. 6441). It does not represent overall intelligence quotient and was administered using each participant's mobile device.

The sample size was estimated using a statistical calculation for two proportions based on an estimated difference in effectiveness of 0.60 versus 0.30 between the interventions. The study by Petimani was used as a reference, resulting in a minimum of 50 participants per group to ensure statistical significance (Petimani & Adake, 2015, p. 292). Based on this criterion, two of the four sections were randomly assigned to the experimental group (chalk talk class) and the remaining two to the control group (slides class).

The intervention, implemented during the 2014-2015 academic period, was delivered by the same instructor to both groups. Each session lasted 50 minutes and included an introduction to the topic, objectives, lesson development, and questions. Each group underwent three assessments: before the intervention, immediately after, and one week later, with strict monitoring to prevent cheating on the tests. Knowledge tests validated by the histoimmunology department of the same institution were used to estimate the level of

knowledge. Each test consisted of 10 multiple-choice questions, each with 5 options, only one of which was correct. The study adopts a quantitative approach.

A traditional pedagogical model, similar to lectures, was implemented with two variations: one using chalk talk techniques and the other using slide presentations. During the chalk talk intervention, the instructor used only an enameled steel whiteboard (1.20 x 2.40 m) and dry-erase markers; no images were projected. In contrast, the control group received PowerPoint slides, limited to a maximum of seven lines of text per slide and without animations; these were projected on a 100 x 56 in image by an Epson S18+ projector. The intervention took place in a classroom with a capacity of 100 people, with tiered seating at an average distance of 5 meters from the presentation.

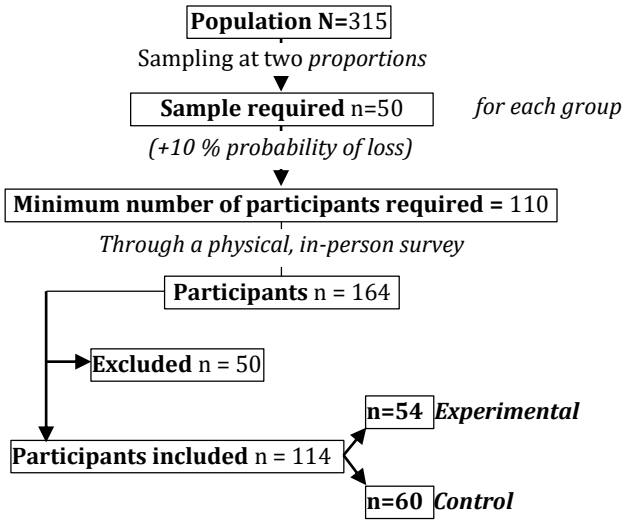

Figure 1. Sampling and allocation of study participants

The data were managed in both physical and electronic formats, collected using questionnaires printed on A5 bond paper with text in 12-point Arial font, and analyzed using Microsoft Excel and SPSS version 18.0.0. The results were anonymized with alphanumeric codes. The statistical analysis included the description of the qualitative variables sex and intellectual range (IQ) using absolute frequency, relative frequency, and the respective 95% confidence interval; Student's t-test for differences of proportions between independent groups was used to compare these data. To compare the learning level before, after, and one week after the intervention, for each study group, the scores were compared using medians, ranges, and respective 95% confidence intervals; and, for the pre-post inferential analysis in the same group, the Friedmann test was used.

For the intergroup analysis, means, standard deviations, and respective 95% confidence intervals were used. For inferential analysis, Student's t-test for the difference of means between independent groups with homogeneous variance was used. Results were compared before, after, and one week after the interventions, after the Kolmogorov-Smirnov test had been used to determine data normality. To compare the results of the two groups (experimental and control) and to verify the intervention's effect on the moderating variables of sex and IQ score, the Mann-Whitney U test was used, following the same comparison logic described above. Results were considered statistically significant as long as $p \leq 0.05$.

The study complies with the ethical principles of the Declaration of Helsinki and the Nuremberg Code, guaranteeing the confidentiality of information and obtaining informed consent from participants. The study was conducted in accordance with current legislation and regulations.

Moderating variables	Chalk talk	Slides	p
N	54	60	
Gender			
Men	17 (31.5 %)	17 (28.3 %)	0.719
Women	37 (68.5 %)	43 (71.7 %)	0.719
IQ Range			
I-II	28 (51.9 %)	41 (68.3 %)	0.072
III-IV-V	26 (48.1 %)	19 (31.7 %)	0.072

Table 1. Comparison of sex and IQ range between chalk talk group and slides

4. Results

Of the 164 participants included in the study, 50 met one or more exclusion criteria, leaving 114 who completed all phases of the study. Of these, 54 were in the experimental group and 60 in the control group, as shown in Figure 1. These participants received the intervention in their assigned group, were assessed at three time points, and provided complete information.

The experimental group (n=54) consisted of 17 men (31.5%; 95% CI: 20.7-44.7%) and 37 women (68.5%; 95% CI: 55.3-79.3%) [p>0.05]. 28 (51.9%; 95% CI: 38.9-64.6%) were part of Intellectual Range I and II, and 26 (48.1%; 95% CI: 35.4-61.1%) were in range III, IV and V [p>0.05]. Meanwhile, the control group (n=60) consisted of 17 men (28.3%; 95% CI: 18.5-40.8%) and 43 women (71.7%; 95% CI: 59.2-81.5%) [p>0.05]; 41 (68.3%; 95% CI: 55.8%-78.7%) were in Intellectual Range I and II, and 19 (31.7%; 95% CI: 21.3%-44.2%) were in Range III, IV, and V [p>0.05]. These data are presented in Table 1.

In the experimental group (chalk talk), scores out of 20 were measured pre-intervention (O1), post-intervention (O2), and one week later (O3); all these measures are presented in Table 2. The mean O1 score was found to be 5.07 ± 2.77 (95% CI: 4.34-5.81), and the mean O2 score was 12.93 ± 3.86 (95% CI: 11.90-13.96). and the mean O3 score was 8.33 ± 3.68, 95% CI: 7.35–9.32.

In the control group (slide presentation), scores out of 20 were measured pre-intervention O4, post-intervention O5, and one week later O6; all these measures are shown in Table 3. The mean O4 score was found to be 6.07 ± 3.29, 95% CI: 5.23–6.90; the mean O5 score was 8.77 ± 3.19, 95% CI: 7.96–9.57; and the mean O6 score was 6.93 ± 3.58, 95% CI: 6.03–7.84.

Chalk Talk	O1	O2	O3
N	54	54	54
Average	5.07	12.93	8.33
DE	2.77	3.86	3.68
EEM	0.38	0.53	0.50
Minimum Value	0	6	2
Maximum Value	12	20	18
Lower Limit	4.34	11.90	7.35
Upper Limit	5.81	13.96	9.32

Table 2. Test results of the experimental group experimental0

Slides	O4	O5	O6
n	60	60	60
Average	6.07	8.77	6.93
DE	3.29	3.19	3.58
EEM	0.43	0.41	0.46
Minimum Value	0	2	0
Maximum Value	12	16	16
Lower Limit	5.23	7.96	6.03
Upper Limit	6.90	9.57	7.84

Table 3. Test results of the control group

In the statistical analysis of scores between interventions, no statistically significant difference was found between the means O1 and O4 ($p>0.05$). However, a statistically significant difference was found between the means O2 and O5 ($p<0.05$); and one week later, the means between O3 and O6 remained statistically different ($p<0.05$). The aforementioned means and their 95% confidence intervals are shown in Figure 2. All these results assume that the data were not broken down by sex or age.

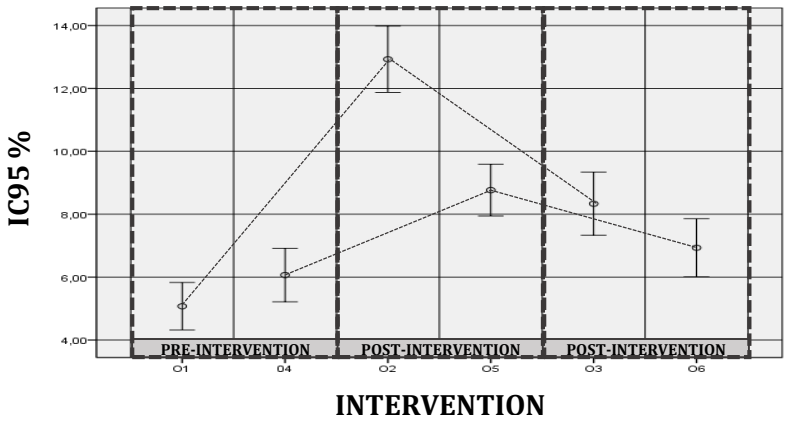

Figure 2. Averages of the six observations (O1-O6), with their 95% CI

Observations O2 and O5, conducted only on men, indicate that the medians are different ($p<0.05$), as do the medians of observations O2 and O5 in women ($p<0.05$). Observations O2 and O5, conducted only on individuals with IQ Ranks I and II, indicate that the medians are statistically different ($p<0.05$). Similarly, the medians of O2 and O5, conducted only on those with IQ Ranks III, IV, and V, are also statistically different ($p<0.05$).

5. Discussion and conclusions

This study aimed to determine the effectiveness and efficiency of chalk talk and slide presentations in basic biomedical sciences. The collected data indicate a statistically significant superiority of chalk talk over standard slide presentations. These findings align with those of Asian Diphu University in 2021; as noted by Putul, medical students in the microbiology department reported a better learning experience with chalk talk (97%) compared to PowerPoint (86%) (Putul et al., 2021, p. 471). However, Lagare et al. point out data from a descriptive study conducted at Sankalchand Patel University in 2023, in which 54% of students reported a better academic experience with slide presentations compared to 46% who preferred the blackboard. It should be noted that, in this case, the presenters were not faculty members, but students during a pharmacology seminar (Lagare et al., 2023, p. 856).

On the other hand, Brown et al. state that the control material used in this study was inanimate; the differences may be partly explained by this lack of animation. This is based on the results of a study conducted by Brown in 2022 at the University of Hawaii School of Medicine, USA, which demonstrated that virtual animations in teaching medical residents were superior to chalk in learning pharmacological therapy for diabetes (Brown et al., 2022, p. 2256). It is also possible that the observed differences depend not only on the overall teaching format but also on the interactivity the methodology allows: students who actively interact with the material (discussing cases, answering questions, working in teams) retain and apply the content better than those who receive a passive lecture. In a randomized crossover trial with 146 medical students, Boedeker et al. showed that the large group session conducted as an interactive activity resulted in higher learning scores ($p = 0.010$) and a greater "sense of learning" ($p < 0.001$) compared to the passive lecture; furthermore, students with lower prior performance benefited from the interactive modality (Boedeker et al., 2024).

Another point to consider from Jabben and Ghani's perspective is the type of information to be conveyed to students; immunology and microscopic sciences are areas of study that differ from areas such as macroscopic anatomy. In these cases, the use of images via slide projection is more viable, as postulated by Jabeen from the Department of Anatomy and Orthopedics at the Faculty of Medicine of the University of Jammu, Asia (Jabeen & Ghani, 2015).

The chalk talk method shows effectiveness in the short- and medium-term teaching process for medical students; while the slide projection method shows effectiveness in the short term, but not in the medium term. In terms of efficacy, the chalk talk methodology demonstrates superiority over the slide projection methodology in both the short and medium term. The results are not influenced by the student's IQ range or gender. The academic community is recommended to consider the data presented in this study for the modification, or if necessary, ratification, of their teaching and pedagogical plans.

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Declaration of the use of artificial intelligence

The authors declare that they did not use Artificial Intelligence (AI) tools for any part of the manuscript. No part of the scientific content, results, analyses, or interpretations was generated by artificial intelligence. All material was reviewed and validated by the authors, who are responsible for its accuracy and rigor.