**Evaluating Pharmacology Teaching Methods for the Second Year Medical Students: A Systematic Review**

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Abstract

**Background:** Pharmacology is considered one of the crucial subjects of the medical courses, because drugs are the basis of disease treatment; as a result, the basic description of drug treatments to optimize benefits and reduce side effects is considered an essential and practical subject. Therefore; proper and primary education for medical students is considered necessary. The purpose of this systematic study is to investigate the methods of pharmacology education for second-year medical students.

**Methods**: This study was conducted using PubMed, Web of Science, SCOPUS, Google Scholar, and ProQuest databases. Two independent reviewers assessed included studies for methodological quality and extracted data by using standardized tools from the Joanna Briggs Institute (JBI). Primary study findings were read and reread to identify teaching methods used in the studies for medical students. The extracted findings were categorized on the basis of their similarity.

**Results:** A total of 56 studies were included in this systematic review. The results were presented according to the teaching methods used in educating of second year medical students: team-based learning, computer-assisted learning, autobiography of medicines, role-play, integrated education, case-based learning, problem-based learning, student-led objective tutorials, e-learning module, museum, pre-lecture, concept mapping, crossword puzzles, game, flipped classroom, and mixed methods.

**Conclusions:** This systematic review was conducted to provide new insight and vision about the methods of pharmacology education that are used around the world. the information obtained from the review can be a way to revise the traditional teaching methods of pharmacology.

**Keywords:** Pharmacology, teaching methods, active learning

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**Systematic review registration:** Not registered

Introduction

The field of pharmacology is considered a separate pre-clinical field in the standard curriculum of medical sciences. In most cases, it is offered together with other pre-clinical lessons (e.g., anatomy, physiology, biochemistry, etc.) (1). The scientific basis for the rational and safe prescription of drugs is discussed in pharmacology; therefore, incorrect and insufficient training, as well as a lack of skill in prescribing and providing advice on how to use medicines correctly, can threaten the health of patients or lead to death (2). Due to the importance of this field, pharmacology should be considered a required course in medicine, nursing, pharmacy, dentistry, and many other medical curricula (3).

Traditional pharmacology education is lecture-based and deals with learning factual knowledge about drugs, which causes students not to be adequately trained in therapeutic applications (1, 4-6). In this type of education, professors are the main body of education that teaches abstract knowledge to students, which reduces their ability to practice and solve problems. In addition, decreasing the power of active learning and independent thinking is another disadvantage of traditional education (7). To revise the educational goals and be in line with the use of all the required competencies, a curriculum should be developed as a necessity in education (8, 9).

 Analysis of teaching and evaluation methods should be prioritized, and modifying these methods based on students' feedback can be effective (10, 11). Active learning as one of the most influential and essential parts of education by involving students in the learning process, enables them to use the acquired knowledge. Lack of active learning causes forgetting the learned knowledge, and using this information without understanding it makes future arguments difficult (12). Pharmacology is usually recognized as one of the most tedious and time-consuming courses by students (13). However; active learning increases motivation, promotes critical thinking, and improves students' performance compared to people exposed to traditional and common education (14, 15).

Nowadays; the use of new teaching techniques is considered a necessity because of the increase in the number of drugs and the acquisition of more and more accurate information about the mechanisms of drug action, especially at the intracellular and genomic levels (generally, pharmacological characteristics), require revisions in traditional teaching methods (16). The development of society and the progression of the standard of living mean that the conventional medical services do not respond to the needs of patients, and people demand higher standards of health services, which themselves require initiative in education (17). Therefore; the challenge of effective pharmacology education has attracted a lot of attention, and its goal is to empower students to make rational treatment decisions in clinical scenarios (18).

Considering that teaching the essential and elusive topics of pharmacology is important, we decided to examining the methods of pharmacology education systematically for second year medical students. By using the results of this review, we will be able to identify the most effective and applicable teaching method and improve the quality of the learning process.

Method

To review and identify the existing and new evidence in the field of pharmacology educational methods, the present systematic review was conducted following the JBI instruction (19).

**Search strategy**

In this systematic review we aimed to consider both published and unpublished studies. an initial search applied on MEDLINE and CINAHL databases to develop a search strategy. The main keywords for search, based on the research question, were pharmacology, teaching, teaching methods, second year medical students, educational methods, active learning.

This review was limited to studies published in English and Persian. Also, all articles written in non-English and Persian languages were reviewed by the abstract. The following databases were searched in the present review: PubMed, SCOPUS, Web of Science, Cochrane and ProQuest. The Google scholar database also searched for Persian studies.

**Inclusion criteria**

To screen the various studies obtained from the search phase, we set specific criteria to select the ones related to the research topic and to exclude the studies that do not include the specified conditions. The inclusion criteria were as follows:

Inclusion criteria

Population: studies included second year medical students.

Intervention: studies included one of the methods of teaching pharmacology.

context: Studies that were conducted throughout the world

Outcome: this following outcomes considered: Students' final grade, Students' satisfaction with the method of teaching and Student participation rate

Type of studies: Original quantitative studies with different study designs and qualitative studies with different methodologies were included.

**Study selection**

After searching each database, the items found were entered into EndNote x8 software (Clarivate Analytics, PA USA) and duplicate items were removed. The relevant file then reviewed and screened separately by two independent reviewers regarding title and abstract The full text of the studies which met the inclusion criteria were then screened. In the event of disagreement between the two, the relevant cases referred to a third party.

**Assessment of Methodological quality/bias**

Two independent reviewers assessed included studies for methodological quality using JBI checklist based on the type of studies. In case of no agreement between the two, the relevant cases were referred to a third party. According to the guidelines of this institution, the articles that scored more than 70% were recognized as high-quality articles.

**Data Extraction**

The data extracted from the full text of the articles, were further reviewed and analyzed to provide collected data on research questions. Data were extracted from the full text of the articles by one reviewer by using the specified checklist **(appendix 1)**. The extracted data included information related to the citation, country, type of study, teaching method, number of participants in each training course, role of professors, necessary teaching skills, and resources.

**Data synthesis**

After extracting all findings from papers, we grouped these findings based on their concepts and similarities in order to develop categories. One of the reviewers extracted findings and developed categories, which were then checked for accuracy by other reviewers.

Results

**Study inclusion**

Initial search results across all databases resulted 1286 articles. After removing duplicate items, 874 articles remained. screening of title and abstract excluded another 395 articles . The remaining 321 were investigated for further details. Another 265 articles were removed and 56 articles remained **(table 1)**. Article selection results depicted in **figure 1**.



Figure 1. PRISMA study selection and inclusion process

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| Table 1. studies included in systematic review  |
| **No.** | **First Author** | **Year of Publication** | **Educational Context** |
| 1. | NK Zgheib (20) | 2010 | Team-based learning |
| 2.3. 4. | Parama Sengupta(21)Sunil Nettath(22)R. Amirtha(23) | 201720192017 | Computer-assisted learning (CAL) |
| 5.6. | Anuradha Joshi(24)Bhargav Purohit(25) | 20152020 | Autobiography of Medicines  |
| 7. | IPK Demak(26) | 2021 | peer tutoring methods |
| 8.9.10. | Daniel Gotardelo(27)Supriyo Choudhury(28)S. H. Lavanya(29) | 201420152016 | Role play |
| 11.12. | Shahram Ejtemaei(30)Preeti P Yadav(31) | 20112016 | Integrated teaching module |
| 13.14.15.16.17.18. | Gurleen Kaur(32)Ameya A. Hasamnis(33)Kanchan Gupta(34)UK Chiranjeevi (35)Sandhya K. Kamat(36)Amit Kumar(37) | 202020192014202220122016 | Case-Based Learning |
| 19. | Amy C. Halliday(38) | 2010 | Primary research resources |
| 20. | DINESH K BADYAL(39) | 2018 | Immediate feedback |
| 21.22.23. | Anupama Sukhlecha(40)Kriti Arora(41)MNS Adiga(42) | 201620162020 | Student-led objective tutorials (SLOTs) |
| 24. | Helen Qin(43) | 2022 | peer teaching initiative |
| 25.26.27. | Raakhi K Tripathi(44)Nitin Gaikwad(45)P. B. Patel(46) | 201720132018 | E-learning models (ELMs) |
| 28. | Urwashi I. Parmar(47) | 2018 | pharmacology museum |
| 29. | Marya Ahsa(48) | 2016 | Pre-lecture assignment (PLA) |
| 30.31.32. | Parama Sengupta(49)KD Karpa(50)Sachidananda Adiga(51) | 202120132010 | Problem-based learning (PBL) |
| 33.34. | Sarmila Nath(52)Vimala Ananthy(53) | 20212021 | concept mapping module |
| 35.36.37.38.39. | FA dos Reis Lívero(54)Anuradha Joshi(55)Sarah A. Aynsley(56)AM Gudadappanavar (57)John Wilhelm(58) | 20202015201820212021 | Game-based learning (GBL) |
| 40. | Sushil Sharma(59) | 2017 | scenarios approach |
| 41. | Nitin Gaikwad(60) | 2012 | crossword puzzles |
| 42. | Margaret Shanthi FX(61) | 2016 | Tutorial/Self-study  |
| 43. | H Jaiprakash(62) | 2022 | Flipped Classroom |
| 44. | Jennelle Richardson(63) | 2021 | Over recorded lectures |
| 45.46.47.48.49.50.51.52.53.54.55.56. | prR Ramachandrudu(64)Rashmi Raghava Rao(65)Parimala K(66)Vikas Seth(67)HS Amane(68)Rajesh Kumar(69)Dinesh K. Badyal(70)Vasudha Devi(71)Uma A. Bhosale(11)Patil Banderao(72)Raakhi K. Tripathi(14)Preethi J Shenoy (73) | 201620202013201020132021201020162013201820152021 | Mix method  |

**Methodological quality of included studies**

The final score of methodological quality for the included studies in the current systematic review appeared in the range of 35%- 80%. Although authors considered studies with a score of 70% and higher, as a high-quality study, studies with a score of less than this percent were not excluded from the final synthesis.

**Review findings**

The studies differed in the type of training method, the number of participants, and the outcome measures. All participants were second-year medical students and the length of the educational intervention was different. Most of the studies were from India (43 studies). The remaining 13 studies were conducted in the USA (3), United Kingdom (2), Brazil (2), Lebanon (1), Malaysia (2), Iran (1), Indonesia (1), and Australia (1). The results are presented according to the teaching methods used in educating second-year medical students: team-based learning, computer-assisted learning, autobiography of medicines, role-play, integrated education, case-based learning, problem-based learning, student-led objective tutorials, e-learning module, museum, pre-lecture, concept mapping, crossword puzzles, game, flipped classroom, mixed methods etc.

Team-based learning

Team-based learning (TBL) is a new and creative teaching method that strengthens active learning and some studies showed improvement in student performance. Zgheib et al. (20) investigated the effect of using this method. In this method, 3 phases were conducted: in phase 1, two PowerPoint lectures were presented that included educational materials and also a brief explanation of the TBL method. In phase 2, students were asked to answer the “true/false” and “multiple choice” questions individually and in phase 3, they formed their groups and started to answer questions in the team and the class discussion began. The students showed positive feedback towards this method and the test result improved compared to the previous courses.

Computer-assisted learning

Computer-assisted learning (CAL) is used as a method in medical education. It can replace traditional lectures and complement conventional teaching methods. Sunil Nettath (22) and R. Amirtha et al. (23) used “Ex-Pharm T 1.0 Software” and Parama Sengupta et al. (21) used “EP Dog version 1.1.0” for teaching to evaluate the change in knowledge gained by students compared to conventional lecture-based methods. Students’ knowledge was analyzed by multiple-choice questions. Studies have shown that integrating CAL with previous teaching methods can improve students' performance and increase the score obtained.

Autobiography of medicines

Autobiography of medicines is a method of education where a medicine explains itself to students. For example, a description of the unique characteristics of pharmacokinetics and pharmacodynamics, information about dosage and pharmaceutical form, medicinal uses, mechanism and side effects. Stories about drugs whose discovery history is interesting, such as Serotonin, Adrenalinen etc. also can be used. Anuradha Joshi and her colleagues(24) and Bhargav Purohit et al. (25) used this method which showed that combining this method with traditional education has many advantages. Still, it cannot replace the lecture-based method. The biography can be used at the end of classes to review the taught materials, which will increase the enthusiasm and curiosity of the students.

Role-paly

One of the methods that encourage active learning is role-playing. It increases students' communication skills, which can be used in pharmacology education. Supriyo Choudhury et al. (28) used this method to describe antimicrobial drugs inhibiting bacterial protein synthesis’s mechanism of action. Students took on different roles, for example, peptidyl site, host site, t-RNA, tetracycline, macrolide, aminoglycoside and chloramphenicol. Throughout the role-play, the teacher guides the activity. A multiple-choice test was conducted to evaluate students' learning. S. H. Lavanya et al. (29) limited the role-playing to 3 students in each session and each of them took the role of doctor, patient and observer. After a lecture session, the students received and played their roles, which included all the necessary information about medical cases and drugs. After the session, the students expressed their opinion about this method based on a 5-point Likert scale, which, based on the results, the role-playing, has a positive effect on the student's learning and communication skills. In another study Daniel Gotardelo et al. (27) discussed the impact of playing a role in education and they asked the students to implement the information related to medicines in the form of a show. Based on the 5-point Likert scale and Dundee Ready Education Environment Measure (DREEM), they checked the results, which show the dynamism, efficiency and creativity of the method in the education of students.

Integrated education

Integration is an effective teaching method in medical education. The lack of integrity in conventional teaching methods has caused the students' low understanding. Using an integrated method in education can improve students' performance. Preeti P Yadav et al. (31) and Shahram Ejtemaei Mehr et al. (30) designed and implemented integrated training in the following topics: "basal ganglia, " "epilepsy and tuberculosis and their treatment management. " In integrated education, topics related to anatomy, physiology**,** pharmacology, neurology, Microbiology, and Pathology were formed. These sessions were noticed and welcomed by the students and improved their reasoning and self-directed learning.

Case-based learning

Case-based learning is a creative method that is taught all over the world. Clinical cases are used as training stimuli. It enables students to know the real situations and makes it easier to retain the educational material. Various studies have been used to show the importance and efficiency of this method. In all these studies, students were divided into two groups, the first group was taught based on the lecture-based method and the second group was taught based on the CBL. To check the effectiveness of the method, pre- and post-tests were taken. The results showed an increase in students' scores and an improvement in their performance compared to the traditional method. (Gurleen Kaur et al. (32), Ameya A.Hasamnis et al. (33), Kanchan Gupta et al.(34), Uday Kumar Chiranjeevi et al. (35), Sandhya K Kamat et al. (36), Amit Kumar et al. (37) )

Problem-based learning

Problem-based learning (PBL) is a student-centered approach in which students learn by working in groups about a topic to solve a problem. In this method, students discuss in smaller groups to solve unknown problems and issues. Sachidananda Adiga et al. (51) and Kelly Dowhower Karpa et al. (50) tried this method and showed that Problem-based learning should be an integral part of teaching. The knowledge gained from education is reviewed in an interactive circle between students, and problems are identified and discussed. Parama Sengupta et al. (49) compared the use of this method in the class and WhatsApp applications. An issue is raised in the class by the professor and the students allowed to write down their answers and explanations. there is also the possibility of consultation among the students. Finally, the professor examines the relevant problem. In the method of using WhatsApp, the teacher shares the relevant problem on WhatsApp and students can post their answers. During this method, the teacher can also use challenging questions to arouse students' curiosity. Students' feedback was evaluated based on a Likert scale. Although the use of WhatsApp cannot replace the classroom, due to the increase in the use of social media in the world, it can be considered a hybrid method in the classroom.

Student-led objective tutorials

Student-led objective tutorials (SLOTs) are one of the ways to increase students' motivation and strengthen active learning through group work. Anupama Sukhlecha et al. (40), Kriti Arora et al. (41) and Manoor NarasimhaSachidananda Adiga et al. (42) investigated the effectiveness of using SLOTs compared to using conventional methods(CT). The students were divided into two groups, the first group received traditional training and the second group used the SLOTs method. Students in two groups were taught the educational content in the form of lectures at first. Then the SLOT group is divided into several subgroups and each group designs a certain number of multiple-choice questions about the subject of the lesson in PowerPoint format and it is presented in class by the group leader. Students are asked to answer the questions. In the CT group, the questions given by the professor and the students answer. The results show that SLOT compared to CT, improved students' learning, strengthened active learning, increased students' interest and it can be included in curricula alongside conventional training.

Electronic learning module

Electronic learning (E-learning) is one of the methods that strengthen self-directed learning and also provides easy access to educational content. This method can be used to complete lecture classes. P. B. Patel et al. (46) used the Microsoft 2007 and iSpring suite (8.3) for this task. The perception of students and professors was collected using the survey monkey tool. Raakhi K Tripathi et al. (44) and Nitin Gaikwad et al. (45) also investigated the effectiveness of this method. To check the effect of this method, a pre- and post-test was conducted and the results show that this method can be used in combination with the traditional method and is a simple and affordable method.

Pharmacology museum

Urwashi I. Parmar et al. (47) used the pharmacology museum as a teaching and learning method. The museum includes medicinal samples in different medicinal forms. The teaching-learning method (TL) consists of 2 phases. In step 1, students are instructed to visit the museum and observe various forms of medicines. A pre- and post-test were taken for evaluation. In phase 2, the students will have allowed to volunteer at the museum and solve their problems about pharmaceutical forms. The results showed that the museum could strengthen students' knowledge about medicinal forms, but still making the museum environment attractive for students seems a big challenge.

Pre-lecture assignment (PLA)

Marya Ahsan et al. (48) used PLA as a teaching method. In this method, students were randomly divided into two groups. For the first group, before the lecture session, a clinical case of peptic ulcer was explained in detail and they were asked to give an assignment about the treatment approach of the case. PLA was done five days before the presentation of the speech. The first group only participated in the lecture session. The results show that this method can make learning more active and reduce teacher-centeredness in education.

Concept mapping

A concept map is a graphic, educational method in which concepts and the relationship between them are displayed in a visual form. This method can be very effective for medical students because the whole concept can be understood from one picture. Sarmila Nath et al. (52) and Vimala Ananthy et al. (53) used this method and the results show that it can be used as a complementary method in the educational program.

Crossword puzzle

Crossword puzzles are an attractive way to review and identify important words and information. It can be used as a tool for self-testing. Nitin Gaikwad et al. (60) used a crossword puzzle on the topics of antihypertensive and antiepileptic drugs. Pre- and post-tests were taken from the students. The results show that the use of this method can be used as a self-education tool to improve students' knowledge.

Game-based learning (GBL)

The use of gamification has increased in recent years and has been made available to professors and students as a tool for diversity in learning. Using games can increase motivation and make the class more interesting for students. Francislaine Aparecida dos Reis Lívero et al. (54) examined 11 types of games in pharmacology education, which are summarized in **table 2**.

AM Gudadappanavar et al. (57) used the hot seat race. The students were divided into two groups, the first group used traditional education and the second group used education with games. In this game, a second group of students were divided into smaller subgroups. The person placed on the hot seat must start answering multiple choice questions that increase in order of their difficulty. 3 helpful ways were considered for rescue: 1- ask a friend in the group - 2- ask the whole group - 3- remove two incorrect options with the help of a teacher. According to the pre-test and post-test results of the two groups, GBL can be an effective method for education.

Anuradha Joshi et al. (58) used the game of cricket to teach cardiovascular drugs. The students were divided into two groups, the first group received regular education and the second group received innovative education. The results show that there was no significant difference between the pre- and post-test scores of the students, but the students found the use of innovative training more attractive and it caused active participation.

John Wilhelm et al. (58) investigated the use of virtual games during the COVID-19 pandemic. Trivia and Jeopardy games were played, and students preferred Trivia. Students considered using virtual games to be effective in increasing interest and learning pharmacology. Also, they preferred the teacher's voice feedback to simple text feedback.

Sarah A. Aynsley et al. (56) used the “Braincept” game to teach pharmacology, which is a card-based role-playing and team game. Students were divided into groups of 4 and had the task of completing three patient-therapist scenarios of their choice from 6 available scenarios. A round of the game lasts 10-15 minutes and during this time, the roles are changed between the students. The results show an increase in self-confidence and learning and management of the practical use of pharmacological knowledge in students.

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| Table 2. 11 types of games in *Francislaine Aparecida dos Reis Lívero*’s study  |
| No. | Type of game | Procedure | Advantages | Disadvantaged  |
| 1. | Game of words | The teacher writes down two sentences related to the subject of the lesson on paper with a large font and then cuts to each word and mixes it up and gives it to the students in the envelope, and the students have to make the desired sentences with the jumbled words. | 1. Increasing student participation2. low cost3. Easy activity | - |
| 2. | Hunting words | The teacher chooses the keywords. It is used at the beginning or end of the session. Free sites like Educolorir.com can be used to create word search tables. | 1. Increase students' attention2. Remembering keywords 3. low cost4. Easy activity | 1. Individual activity2. Lack of interaction between students3. Lack of critical thinking |
| 3. | Puzzle | The teacher prepares four puzzles in 4 different subjects. The puzzles are created in PowerPoint and then printed and laminated. The teacher mixes 16 pieces and gives them to the groups to arrange. | 1. Increasing student participation2. Increasing discourse among peers 3. low cost4. Easy activity | - |
| 4. | Crossword | The teacher selects keywords and important content and makes it into a crossword puzzle that can be made on the Educolorir.com site, which offers this possibility for free. | 1. High variety in producing crosswords with the same concept2. low cost3. Easy activity | 1. Individual activity2. Lack of interaction between students3. Lack of critical thinking |
| 5. | Tic-tac-toe | In this game, a board containing squares of the same size is prepared, students are divided into two groups, and each group is assigned a color. Each group will be asked questions by the teacher, and if they can answer correctly, they will change one of the squares of the board to the color of their group, and if they cannot answer, this opportunity will be given to the opposite group. Finally, the winner is the group that makes a row, column, or diagonal line in the color of their group. | 1. Increasing interaction and participation of students2. Using emotional intelligence3. low cost4. Easy activity | 1. The possibility of time-consuming construction of boards and facilities |
| 6. | Target shooting | The teacher designs several questions and scores them from 1 to 10 based on their difficulty and places them inside the inflated balloons. The balloons are connected to the board and the students are divided into two groups, and each group alternately throws darts at the balloons and answers the relevant question. if they do not know the answer, the corresponding score goes to the opposite group. The winning group is the group that gets more points. To make the game more exciting, empty balloons or balloons with extra points can be used.  | 1. Increasing interaction and participation of students2. Using emotional intelligence3. low cost4. Easy activity | - |
| 7. | Bingo | In this game, the teacher designs 24 questions with answers and uses the Bingobaker.com site to create game cards that contain only the answers to the questions in a different sequence. Students are divided into groups of 4 or 6 and the teacher spins a bingo ball and reads the question related to the number that appears. Each group that knows the answer to the question, marks on the card. The group that fills a row or column faster says “Bingo”, and the group is the winner if the given answers are correct. | 1. Increasing interaction and participation of students2. Using emotional intelligence3. Group work practice | - |
| 8. | Racetrack | In PowerPoint, a table is set up by the teacher to prepare the race route with 12 columns (start point, end point and race rounds). The number of lines is equal to the number of groups. Each group is represented by a different machine. Each round of the competition consists of 2 true and false statements presented by the teacher and the groups must answer. Each group that answers correctly moves forward one house to reach the end of the path. | 1. Increasing interaction and participation of students2. Using emotional intelligence3. Group work practice | 1. It takes time to move the cars of each group |
| 9. | Trail | The teacher prepares a canvas track and a dice. This route includes empty houses, question houses, and challenging houses (such as physical activity or returning to the first house, etc.). For this activity, students are divided into two groups. One of the members throws a dice to be placed in the square of the question, and if the answer is correct, it remains in place, and if the answer is wrong, it goes back. The team that crosses the finish line faster is the winner. | 1. Increasing interaction and participation of students2. Using emotional intelligence3. Group work practice | 1. Large physical space2. construction cost |
| 10. | Memorang | Memorangapp.com is an educational program that is used to memorize the contents. The teacher creates a link and enters the cards related to the subject, and the program automatically designs intelligence games, multiple choice questions, etc. from the cards, and the students have the right to choose. This software gives the students this opportunity to work at more advanced levels based on their performance and the teacher can supervise everyone. | 1. Memorizing keywords2. Easy access to course content throughout the course3. Creating interest and participation | 1. Lack of critical reasoning 2. The English language of the program |
| 11. | Rally | The teacher designs a sample question (100 multiple-choice questions) about the topics he has taught in the last few months or during the semester. The class is divided into two groups and each group is divided into two sets of test teams and support teams. The test team answers questions without consultation, but the support team can use all the facilities to review the material during this time. They are placed in different classes. During 1 hour, the members of the two teams can be changed at the discretion of the members, and the team that has the correct answers is the winner. | 1. Increasing interaction and participation of students2. Using emotional intelligence3. low cost4. Easy activity5. teamwork  | - |

Flipped classroom

The use of this method became common during the corona pandemic. Heethal Jaiprakash (62) used this method to measure the knowledge of students trained using online tools. Before the training session, materials for reading including PowerPoint and AMBOSS links, were sent to the students. The students were taken pre- and post-tests during the session and their feedback was evaluated with a 4-point Likert scale. The results show that the students got a better understanding of the subject and it improved the knowledge of the students.

Other methods

In addition to the methods mentioned above, other methods are not included in the previous categories, but it is worth remembering them.

Sushil Sharma et al. (59) discussed the effect of using scenarios at the end of lecture classes so that the students could analyze and use the medicinal applications that they investigated. The results show that students find the scenarios attractive at the end of the class and their grades have increased compared to before. Margaret Shanthi FX et al. (61) investigated the difference between education and self-study. The students were divided into two groups and one group received training and the other studied the same topic by themselves. The results show the necessity of education in the curriculum and with education by professors, students will get a better understanding of the topics.

Jennelle Richardson (63) used the recorded lecture before the class started. Students listened to this lecture 15 minutes before the class, which is related to the related physiology topics and drug tips. So that students enter the lecture session with prior information and knowledge, which increases the interaction of students in the lecture session.

Indah Puspasari Kiay Demak et al. (26) examined education through peer tutoring. In this method, students were divided into four control and four experimental groups, and the experimental group benefited from private tutoring. This course was held in 3 two-hour sessions and the team leaders were selected from among the assistant professors of the pharmacology department. Each group is given a worksheet and the group discussion begins with the help of the leader of each group. And finally, a general discussion is formed in the whole class and they express their results. The results show an increase in students' motivation, but they did not show a better performance in the score, which requires the careful recruitment of peer tutors and their commitment to doing the work.

Helen Qin et al. (43) used peer-led training. Using the principles of Pecha Kucha, they designed PowerPoint slides (automatic slides with a limit on display time and content to maintain the audience's attention), held by professors in eight one-hour sessions. An evaluation was done by the Likert scale. Positive results were obtained from this method, and it was decided to use this format in the review sessions.

Dinesh K Badyal et al. (39) used immediate feedback in training. Students were divided into two groups, one with feedback and the other without feedback. Multiple-choice questions related to the lesson’s subject in the software for making electronic tests “Hot Potatoes” were created. In the quick feedback group, if the answer is correct or incorrect, an explanation about the question and options was displayed, but in the group without feedback, only the correctness or incorrectness of the choice was demonstrated. The results showed a deeper understanding of the students towards the subject and increased in their grades.

Amy C. Halliday et al. (38) used primary research sources to hold seminar sessions by students. In this method, the students in smaller groups reviewed the research articles that were provided to the students by the professors. Finally, it was presented by the students in a public meeting. The results show an increase in students' learning and competition for using research articles as a tool for education.

Mixed methods

In addition to the studies that have been reviewed, a series of studies also investigated two or more methods side by side and identified the most appropriate and effective method, which are summarized in **table 3**.

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| Table 3. studies included mix methods |
| First Author | Methods | Procedure | Results |
| Raakhi K. Tripathi et al. (14)  | problems on case scenarios, critical appraisal of prescriptions and drug identification vs. traditional teaching | 1- In the case scenario, a case is described and the group must determine drug therapy2- In the critical evaluation of prescriptions, students are given a prescription about a specific disease with errors, and students must review and correct it.3- in drug identification, Students should present the characteristics of a drug such as pharmacodynamics and pharmacokinetics, etc. in the form of a drug auto-biography. | Improving students' grades according to pre- and post-test results, and Students prefer active teaching methods.  |
| R. V. S. N. S. Ramachandrudu (64)  | Chalk Talk Teaching vs. PowerPoint Teaching | The students were divided into two groups and the first group experienced the lesson using a chalkboard and the second group experienced the lecture with PowerPoint. And at the end, a questionnaire was provided to the students for evaluation. | Students preferred using PowerPoint and showed better comprehension and retention. |
| Vikas Seth et al. (67), H. S. Amane (68) | the lectures using chalkboard, the lectures using PowerPoint presentations and the lectures utilizing transparencies with an overhead projector | Students were divided into three groups and each group received the lecture in different ways. A test was conducted to evaluate the students' performance and to check the effectiveness of the implemented methods. | Students had the most preference for presenting lectures with PowerPoint and considered using this method to be more effective. |
| Dinesh K. Badyal (70) | Lectures, tutorials, seminars, demonstrations, experimental pharmacology, revision class, clinical pharmacology | The different methods implemented were evaluated by a written questionnaire that examined various aspects of the teaching method. | The students evaluated the use of revision classes as the best method, which is held at the end of the class, and then practical demonstrations were identified as an effective method. The lectures were evaluated as average or ineffective. |
| Preethi J Shenoy et al. (73) | Crossword puzzles vs. Student-Led Objective Tutorials (SLOT) | The students were divided into two groups. first group used the crossword method and the second group used the SLOT method in which the students held a contest with multiple choice questions designed by the students themselves in the class. The results were evaluated by an independent t-test with SPSS version 15. |  SLOT Improves students' grades more than crosswords because it improves critical thinking and teaches students teamwork. Students mentioned crossword puzzles as a way to memorize drug names, but it had no effect on students' deep learning. |
| Rajesh Kumar et al. (69)  | Didactic lectures, PowerPoint presentations, case-based learning, group discussions | The mentioned methods were used during 18 months of student training and the quality of each method was evaluated using a survey. | The result showed that case-based learning was recognized as the most effective method, and after that, group discussions and presentations using PowerPoint were accepted. |
| Patil Banderao et al. (72) | Lectures, audio-visual, Discussion of a subject in tutorial classes, Interactive learning like asking questions during pharmacology classes, Discussion of graphs | Based on the survey, the teaching methods were investigated and the perception and feedback of the students were evaluated. | The results show that the use of audio-visual facilities is helpful for increasing students' understanding, for example, the use of educational video clips. Participating in group discussions increases students' motivation and interest |
| Parimala K et al. (66)  | theory lectures, tutorials, students seminar, group discussions, quiz programs, clin.pharm.sessions | To evaluate the teaching methods, a questionnaire with several options was designed and the results were analyzed. | Based on the results, students evaluated theoretical lectures and clinical pharmacy sessions as more beneficial than other methods. secondly, group discussions were identified as one of the most effective methods. |
| Vasudha Devi et al. (71) | lecture classes, SDL sessions, problem-based learning (PBL), case-based learning (CBL) | Methods were evaluated by a short essay, multiple true-false questions (MTF)  | The results show an increase in the ability of critical thinking and problem-solving, active participation of students, presentation skills and an increase in information about drugs. |
| Uma A. Bhosale et al. (11) | Audiovisual, Demonstrations, tutorials, Student seminars, Museum study, Clinical (patient-related) pharmacology, Integrated teaching, Problem-based learning, Microteaching  | A 22-question questionnaire was designed to examine students' opinions about the quality of teaching methods. | The majority of students preferred clinical pharmacology. as the second priority, they found the use of audio-visual facilities functional. Microteaching and problem-based learning were also prioritized, and students expressed their interest in these methods. Seminars and museum studies were also considered as educational aids. |
| Rashmi Raghava Rao et al. (65) | Classroom lecture/ Powerpoint (PPT)/ Blackboard/ Audio video demonstrations/ Task-based learning/ Problem-based learning/ Assessment for learning/ Student seminars/ Small group discussion/ Integrated teaching | A questionnaire was distributed among students and their opinions about teaching methods were collected. | Among the mentioned methods, group discussions got the most points among other methods. Among integrated teaching and problem-based learning, students preferred integrated teaching and lectures were less helpful. |

Discussion

We conducted this systematic review to assess teaching methods of pharmacology for second year medical students. Synthesizing our results indicated that the main teaching methods used in the included studies were team-based learning, computer-assisted learning, autobiography of drugs, role-play, integrated education, case-based learning, problem-based learning, student-led objective tutorials, e-learning module, museum, pre-lecture, concept mapping, crossword puzzles, game, flipped classroom, and mixed methods.

The traditional curriculum follows the lecture-test method and is teacher-centered, which today has lost its place as a useful and targeted educational method and has been replaced by new learning and teaching strategies. Education that is learner-centered, causes lifelong learning with greater understanding, improves critical thinking, and students will have the ability to manage the acquired knowledge in different situations and clinical scenarios. In all the methods that reviewed in this paper, the teacher's presence is still necessary. New approaches do not eliminate the teacher, although the teacher’s role and task may be different than before. As an educational facilitator, the teacher is next to the students and helps them, who need appropriate expertise and knowledge. The need for innovation in training methods is the use of specialized personnel, so in addition to changes in training methods, training of specialized and literate personnel should also be done (74).

In most cases, the presentation of pharmacology courses is limited to lecture classes, but it is worth mentioning that lecture classes can also be useful if the principles of the lecture method are followed. There are many tricks to increase interaction and attention that should be taught to teachers, which are often neglected and again remind us of the training of experts (75).

The amount of publication of texts related to pharmacology teaching methods has increased significantly in recent years, which shows the growing interest in alternative teaching methods by professors.

A review by Manu Gill et al. in 2019 (76) Several educational strategies used to teach pharmacology to undergraduate baccalaureate nursing students were summarized and compared based on their impact on the maintenance of pharmacology information, practical pharmacology and students satisfaction. In this study, online, simulation and integrated teaching methods were considered as more effective and practical methods and resulted in the satisfaction of students. But in contrast to the use of traditional lectures, problem-based learning and flipped classroom were identified as the least effective methods for education. Considering the increasing progress of technology and easier access to technology tools, it seems that the use of online learning methods can be effective and in line with the needs of the world, which is confirmed by the study of Gill et al.

Joan Carles Trullàs et al. in 2022 (77) conducted a scoping review on the effectiveness and efficiency of the problem-based teaching method. According to this study, the PBL method has achieved a high level of student satisfaction because it increased communication and social skills and problem-solving ability among students. However; this method is still not recognized globally and is not implemented because it requires human resources and proper and continuous training, which can become a limiting factor for the correct and appropriate implementation of this method. As mentioned in the study of Gill et al., PBL was not the priority of students' choice for education. In this regard, another study was conducted in Iran in 2022 by Mehdi Sayyah and colleagues (78), which systematically investigated the use of PBL for the education of medical and nursing students. The results showed that the use of this method brings better results than traditional education, but it still requires more attention for the correct and effective use of this method for teaching by professors.

Therefore, it is not only challenging to use a new teaching method, but its accurate and correct implementation is also an important challenge that affects both students and professors and requires further investigations.

In another study by Chen-Lin Xiao (79), a network meta-analysis (NMA) was conducted to evaluate the use of 24 different strategies for pharmacology education. The scores of the theoretical and experimental tests and the satisfaction of the students were examined. According to the obtained results, it shows that PBL and CBL increased students' grades. Also, the use of PBL, TBL, FC and CBL methods are effective strategies for pharmacology education.

 The results of this study indicate the necessity of using innovative methods and active learning in educational curricula. Maintaining the attractiveness of the classroom environment and motivating students requires a change in the usual and traditional methods as in a study conducted in 2010 by Dinesh K Badyal et al. (70) ; Based on the feedback they got from the students; In 2006, they used innovative methods for education. A written questionnaire that included all the different aspects of teaching methods was used in 2007 to evaluate the effectiveness of these strategies.

The results again indicated that the students preferred the use of new teaching methods to traditional teaching and lectures, and their acceptance rate also increased. It is also important to note that students had more demand for practical and clinical training, which indicates the increasing need for changes in lecture-based methods for training.

In general, the conducted studies show that improving the educational methods of pharmacology can ultimately improve health care, which has a significant value for the society. However, more research is needed to use new and creative teaching methods to educate students.

Strength and limitation

the strengths of this study are the generalizability, reliability, and adaptability of existing methods with educational curricula for second-year medical students. In addition, this study has categorized and summarized a set of applicable methods that can be used by professors and students. Despite our efforts, there were limitations to our study. Considering that 56 articles in this study met the necessary conditions for inclusion, more research is needed to investigate the teaching methods. Also, our study was limited to second-year medical students, which did not include all students taking the pharmacology course.

Conclusion

As a result, this systematic review examined a set of pharmacology teaching methods conducted around the world that can be used as a guide for medical course instructors. Students and the educated and active persons in the field of education will have better information in the future health services by using new teaching methods. Students can make a better impact with the skills taught and their practical use in the society in need of service (patients), and the level of healthcare services in the society can be improved. Along with the students, the use of new teaching methods will prompt the professors to always keep their knowledge up-to-date and to use approved and effective techniques all over the world to transfer it to the students., which ultimately increases the scientific level of professors and students. The results of this review indicate that the change in educational methods is an undeniable need and the use of traditional teaching methods can no longer meet the needs of students. The use of active learning encourages students to learn, which can ultimately increase their performance in the university and in clinical environments.

Availability of data and materials

The corresponding author will make any data created and analyzed in this study available upon reasonable request.

Competing interests

The authors state that they do not have any competing interests.

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Authors' contributions

The study was designed by SGH and HV. SA, NK and DO gathered the information. The data was evaluated and the findings were interpreted by all of the writers. The original draft of the work was written by SA. All authors read and revised the initial draft critically before agreeing on the final form of the manuscript.

Ethics approval and consent to participate

This study was authorized by the Tabriz University of Medical Sciences ethics committee board (The approval code number: IR.TBZMED.REC.1400.1131). The study was approved by the competent committee at Tabriz University of Medical Sciences, and all procedures were followed in accordance with the rules, regulations, and ethical guidelines that were in force

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