Beyond lectures and practical courses: Teaching pharmacology using imaginative pedagogical tools

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ABSTRACT
Pharmacology has broadened its scope considerably in recent decades. Initially, it was of interest to chemists, doctors and pharmacists. In recent years, however, it has been incorporated into the teaching of biologists, molecular biologists, biotechnologists, chemical engineers and many health professionals, among others. Traditional teaching methods, such as lectures or laboratory work, have been superseded by the use of new pedagogical approaches to enable a better conceptualization and understanding of the discipline. In this article, we present several new methods that have been used in Spanish universities. Firstly, we describe a teaching network that has allowed the sharing of pedagogical innovations in Spanish universities. A European experience to improve prescribing safety is described in detail. The use of popular films and medical TV series in biomedical students shows how these audiovisual resources can be helpful in teaching pharmacology. The use of virtual worlds is detailed to introduce this new approach to teaching. The increasingly important area of the social aspects of pharmacology is also considered in two sections, one devoted to social pharmacology and the other to the use of learning based on social services to improve understanding of this important area. Finally, the use of Objective Structured Clinical Evaluation in pharmacology allows to know how this approach can help to better evaluate clinical pharmacology students. In conclusion, this article allows to know new pedagogical methods resources used in some Spanish universities that may help to improve the teaching of pharmacology.

1. Introductory remarks

Since the time when Rudolf Buchheim (1820–1879) began to define pharmacology as a new discipline during his stay in Dorpat (1847–1866) more than one hundred and fifty years ago and the publication of his book Lehrbuch der Arzneimittellehre (1853–1856), its role in the health sciences has changed dramatically. This is not a review of historical aspects of pharmacology, but the recognition of its role in the change of medical therapeutic activities during the twentieth century should be remembered to understand its importance in teaching the new generations of health professionals. In the old times pharmacology was linked with the development of chemistry and physiology, but his has changed in the current century. Some new disciplines, like molecular biology, genetics or nanotechnology, are increasingly important in the scope of pharmacology, and these new interactions are changing the view that drug research is considered today.

What has happened to the teaching of the discipline to today’s health science students? Nowadays, pharmacology is not only taught to medical and pharmacy students, as it was fifty years ago in many countries. Now most students of health sciences and some of the biological fields take courses in the discipline, showing the success of Buchheim’s efforts. Moreover, the traditional way of teaching the discipline through lectures...
and some laboratory activities is no longer acceptable. Pedagogy offers many options, and technological advances counter the concept that students need only information. This assumption ignores an important concept related to our mission as teachers. To quote Albert Einstein, ‘Information is not knowledge’. The only source of knowledge is experience. We would add that our students need to acquire knowledge, and knowledge is learning what to do with the information. Traditional methods are not sufficient to achieve this goal.

This review presents several experiences of teachers from Spanish universities who have tried to introduce new pedagogical approaches to improve the traditional ways of teaching pharmacology. Although the contributions are diverse, they share the objective of convincing students of the importance of our discipline in improving therapeutics and making it more rational. At the same time, they have tried to stimulate critical thinking about what drugs do and do not do. We think they are of enough interest to be known by our community. These experiences have been implemented in schools of Medicine, Pharmacy, Veterinary Medicine, Biomedical Sciences, Optics, Nutrition Sciences and Nursing, as well as several postgraduate studies in the domain of health sciences.

2. Inter-university teaching innovation network in pharmacology: a common space to improve learning

A professional learning network can be defined as a “system of interpersonal connections and resources that support informal learning” [1]. Networks have been proposed to be an organizational answer to the diversity and complexity of educational needs [2], and teacher collaboration in learning networks is a form of professional development that improves the quality of education [3–6]. Within the continuous process of change that characterizes university teaching, a professional learning network which allows to exchange experiences, content, activities and information on a specific subject, constitutes an excellent training tool [7,8]. It is noteworthy that different studies [5,9] and the results of the survey ‘The teaching and learning international survey (TALIS)” [10] show that teachers’ participation in learning networks which result in a more efficient teaching system. In this context, some professors from the Department of Pharmacology at the University of Valencia have organized a professional learning network for university professors of pharmacology. The network, called “Teaching Innovation Network in Pharmacology” (TINP), was created with the following objectives:

1. To organize a common online space for collaborative work, professional development and enrichment of the teachers who integrate it, in order to improve teaching practice and student outcomes.
2. To share and test best practice teaching materials, resources and experiences by creating a repository.
3. To evaluate past experiences through systems that identify the contribution of teaching innovation to improving outcomes in higher education.
4. To undertake new teaching innovation projects within the TINP, in which participants join on a voluntary basis.

The TINP started in the academic year 2015–16, within the framework of a project of educational innovation and improvement of the quality of teaching at the University of Valencia. It started with 45 professors and has expanded year by year, currently involving 131 professors belonging to 22 Spanish universities, one Portuguese, two Chilean and one Mexican. The 131 participating professors teach Pharmacology in 3º, 4º, 5º or 6º years of different degrees and universities: Nursing (22 universities), Pharmacy (24 universities), Medicine (26 universities), Veterinary Medicine (4 universities); Biomedical Sciences, Optics, and Nutrition in 4–5 universities, and in different postgraduate degrees in Health Sciences.

For each of the proposed objectives, the following milestones have been achieved:

1. To organize a common space for collaborative work and for the professional development and enrichment of the teachers involved. To this end, a Moodle platform was created and the dynamics of the action (annual meetings), the type of material or resources to be shared, and the format to be used to facilitate the exchange of experiences were defined.
2. To share and test best practice teaching materials, resources and experiences. A repository has been created through the digital platform which includes:
   - Learning activities
   - Technological innovation
   - Teaching innovation
   - Methodologies in the teaching-learning process
   - Evaluation systems

65 projects have already been implemented, shared, discussed and evaluated so far.

3. Evaluate the experience to date through a system that determines the contribution of teaching innovation to improving outcomes in university education. The evaluation takes place during the annual meetings of the TINP, which started in 2016 and continued until 2019 as face-to-face meetings. From 2020 to the present, the meetings have been planned in a hybrid format. The aim of the meetings was to provide a forum for debate on relevant agreed topics such as: e-learning, blended learning, virtual learning simulations, flipped classroom, gamification and assessment in collaborative environments. To this end, the meeting will include sessions for the presentation of innovative teaching experiences related to the proposed topics, and time for evaluation, debate and exchange of ideas and opinions.
4. To implement new teaching innovation projects within the TINP, involving participants on a voluntary basis. Two projects have been proposed so far:

   I. 'Preparation of teaching materials for active learning'. It is divided into themes, each of which includes three sections.
   - Key ideas
   - Verify: assessment/self-assessment test
   - Apply: Pharmacotherapeutic-clinical or pharmacological cases or problems

   The Project, which started during the academic year 2021–22 and is still ongoing, has provided us with useful teaching materials for different teaching modalities that encourage active learning. These materials, organized thematically and following a common format, can facilitate and update the work of both new and senior teachers, providing tools for face-to-face and/or hybrid/blended teaching of the different pharmacology subjects.

   I. 'Problem-based learning using simulation resources', with robotic patient and/or standardized patient. In this case, learning is interactive and multidisciplinary, includes immediate feedback (simulation system) and mid-term feedback (debriefing), and brings the student closer to the reality of clinical practice. The project started during the academic year 2022–23 academic.

The existence of the TINP has made it easier for member teachers to incorporate improvements in the learning process by integrating and consolidating new teaching methods. In network’s meetings have enable teaching experiences to be analyzed and discussed, providing a critical and contrasting vision of the results obtained. At present, although many innovative teaching projects are proposed and carried out, few are subjected to a critical and pluralistic evaluation, which is precisely one of the results of our network. This is an added value, as it validates the real benefits of the innovation implemented and its usefulness.

The network remains open to the participation of all pharmacology
teachers who can join it by contacting: redfarminn@uv.es

The main conclusions of our experience are:

✓ The TINP allows us to integrate, consolidate and, above all, analyze and evaluate new teaching methods developed in innovation projects.
✓ The experience of the Pharmacology Learning Network shows that inter-university collaboration between teachers is an effective strategy to promote and improve active learning.

3. Minicongresses for medical students

In 1977, the first Minicongress of Pharmacotherapy was held for third-year medical students at the Universidad Autónoma de Madrid (UAM), Faculty of Medicine. It was an initiative of the Department of Pharmacology and Therapeutics, founded and directed by Professor Pedro Sánchez García. As part of the pharmacology course with a tutor professor, groups of 3–4 medical students developed a research project, either in the laboratory, by conducting a survey, reviewing clinical histories under tutor supervision or interviewing patients and doctors from the four university hospitals associated with the UAM. At the end of the academic course (around May), the students prepared their work and presented it at a two-day mini-congress in the form of oral communications or posters.

Students and pharmacology professors showed a high level of enthusiasm and many questions were usually asked during the meeting. At the beginning of each academic course, a professor was in charge of coordinating the pharmacology minicongress with a group of students who organized everything, including the scientific program, coffee breaks, lunches and the invitation of a distinguished scientist to give the closing lecture in memory of Teófilo Hernando, the pioneer of the introduction of pharmacology in Spanish universities at the beginning of the XX century.

The aim of the mini-congress was to involve the medical students in their self-learning process. We expected that these future doctors would develop their critical thinking and problem-solving skills. In addition, they acquired knowledge about the scientific method, the search for clinical evidence for a given disease and the selection of the best treatment among several pharmacological options.

This highly rewarding educational experience was later replicated in some other Spanish universities. Of particular importance was the National Congress of Medical Students of the Universidad Miguel Hernández, initiated by Professor Antonio G. García at the University of Alicante in 1983, with the format of a mini congress of pharmacology and therapeutics. At present, almost a thousand medical students from Spain and abroad attend this congress.

4. Popular movies and teaching of pharmacology

The last five decades have seen the growth of a movement to meet the need for new teaching strategies in the university [11]. In pharmacology, a milestone in this movement was Koren’s (1993) paper reporting the first use of a popular movie, Awakenings, to teach clinical pharmacology [12]. Although movies had been used to teach different points related to clinical microbiology, medical ethics, the doctor-patient relationship, preclinical and clinical research, mental illness, drug addiction, palliative care, medical professionalism, or social conflicts in medical care [13–15], Koren’s (1993) paper showed that this approach could also be useful for improving teaching in pharmacology. Following this seminal publication, we developed an activity to help students better understand some conflicts in the domain of pharmacology based on three films: Awakenings, Lorenzo’s Oil, and Miss Evers’ Boys. We tested this activity in a course for students working toward degrees outside the health sciences [16], and we also used it to teach pharmacology in a course to train clinical research assistants.

The general objectives of the activity were to reinforce the contents of theoretical classes and promote the discussion of complex aspects of clinical drug research. The sessions transpired as follows: students were provided with a template including the most relevant points mentioned in the theoretical classes for them to identify when viewing the movie and were asked to write down relevant aspects from the film. Afterward, the students discussed these aspects while the teacher acted as moderator. At the end of the class, students voluntarily and anonymously rated different aspects of the activity.

These popular movies facilitated the discussion of key aspects of drug use and drug research, and students’ assessments showed that they considered the activity enjoyable and useful. This experience and similar experiences at other colleagues were published together [17].

4.1. Popular movies to teach pharmacology

Besides the above-mentioned movies, many others can be used. For instance, Dr. Ehrlich’s Magic Bullet (1940), which relates how the first chemotherapeutic drugs were discovered, is an invaluable tool for teaching students about the beginnings of treatments for infectious diseases and the development of modern approaches to drug research. Another, more recent film, Basketball Diaries (1995), shows how young people can fall into drug addiction. When analyzed in class, films like these can have an even bigger impact on young university students than when seen alone or with friends in other settings. As an alternative to viewing the entire film in class is to assign students to watch it on their own and show only miniclip of selected scenes in class during the discussion [18,19].

Popular movies are useful for teaching students in all health sciences programs [17,20–22]. Table 1 lists some popular movies that are potentially useful for teaching pharmacology, including basic and clinical pharmacology, clinical and drug research, and bioethics [23].

4.2. General comments

Although we have yet to formally test the hypothesis that complementing traditional lectures activities with activities based on popular movies is more effective than lecture-based learning alone, we have observed students’ heightened motivation to learn as they strive to understand what is happening in the movie and why. Movies are a great way to arouse interest in pharmacology and drive learning [24].

An earlier paper lists some recommendations for using movies in medical education [25]. Films must be chosen carefully. Those that consider social and humanistic aspects of diseases as well as medical topics are especially suitable for teaching purposes. It is crucial to define the educative objectives of the activity, prepare a thorough introduction

<table>
<thead>
<tr>
<th>Title</th>
<th>Year released</th>
<th>Running time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awakenings</td>
<td>1990</td>
<td>128</td>
</tr>
<tr>
<td>Lorenzo’s oil</td>
<td>1992</td>
<td>135</td>
</tr>
<tr>
<td>The fugitive</td>
<td>1993</td>
<td>130</td>
</tr>
<tr>
<td>And the band played on</td>
<td>1993</td>
<td>141</td>
</tr>
<tr>
<td>The basketball diaries</td>
<td>1995</td>
<td>102</td>
</tr>
<tr>
<td>Extreme measures</td>
<td>1996</td>
<td>118</td>
</tr>
<tr>
<td>Miss Evers’ boys</td>
<td>1997</td>
<td>118</td>
</tr>
<tr>
<td>Hilary and Jackie</td>
<td>1998</td>
<td>121</td>
</tr>
<tr>
<td>Requiem for a dream</td>
<td>2000</td>
<td>103</td>
</tr>
<tr>
<td>Wit</td>
<td>2001</td>
<td>98</td>
</tr>
<tr>
<td>The constant gardener</td>
<td>2005</td>
<td>128</td>
</tr>
<tr>
<td>Big bucks, big pharma: marketing disease and pushing drugs (documentary)</td>
<td>2006</td>
<td>46</td>
</tr>
<tr>
<td>Extraordinary measures</td>
<td>2010</td>
<td>106</td>
</tr>
<tr>
<td>Side effects</td>
<td>2013</td>
<td>105</td>
</tr>
<tr>
<td>Dallas Buyers Club</td>
<td>2013</td>
<td>117</td>
</tr>
<tr>
<td>La fille de Brest</td>
<td>2016</td>
<td>128</td>
</tr>
</tbody>
</table>

Table 1
Some popular movies that can be used to teach pharmacology (modified from Baños et al., 2017 [23]).
and points to spark debate, plan the classroom activity carefully, and establish realistic assessments to measure the activity’s contribution to gains in knowledge. Few articles in the medical literature report empirical data regarding the effectiveness of using films to enhance learning, and efforts in this direction are welcome [26].

Film-based teaching activities also have disadvantages, and certain pitfalls must be avoided [27]. Table 2 summarizes some of the strengths and weaknesses of using these activities to teach pharmacology. Some films may not capture students’ interest, while others may contain elements that distract them from the pharmacological teaching objectives. For instance, although The Fugitive can be used to illustrate clinical research and fraud, the plot itself is so exciting that the medical focus is easily disregarded. Teachers need to invest more time in preparing the activity, and their roles in directing and guiding the activity are crucial. It is important to ensure that the films appeal to a wide audience; films that fail to arouse students’ interest in the topic are unlikely to foster learning. Another limitation is the length of the session if the full viewing of the film is included. This drawback can be overcome by using film clips or assigning viewing as homework.

Our experience has convinced us that using popular movies as a complementary method in teaching pharmacology is effective. Students rate these activities highly, and interest and motivation are key to gaining knowledge. However, we need empirical evidence from well-designed studies to determine the extent to which these activities enhance the acquisition of attitudes, knowledge, and/or competences.

5. On the use of TV medical series to teach pharmacology to biomedical students

The use of cinema, extended in medical education, is addressed in a previous section on this review; here we want to describe the use of television (TV) medical series. In the last decades, TV series, especially in English-speaking countries, have reached levels of high quality and extended audiences worldwide. It is even possible to think that the series have become independent of the television format. Many critics and communication experts say that nowadays the best stories—or the most known to the public—come from platforms such as Netflix, HBO, or Amazon Prime, which can be seen with any device, without having to sit in front of a television [28].

In particular, medical series are one of the most successful formats since the beginning of TV, and they attract millions of viewers daily, including many medical students and health science professionals, who prefer the series format over the cinema [29–32]. The varied and complex landscape of medical dramas [33] include the very first ones and popular Dr. Kildare (1961–1966), Marcus Welby MD (1969–1976), Ben Casey (1961–1966), and Medical Center (1969–1976), playing the role of successful physicians trough the “doctor-hero” figure. This representation of nice medical doctors, who cares about their patients and families, can be seen now as stereotypes—not only idealistic but also a little paternalistic, sexist or even racist. In the following years, the successful Emergency Room (ER) (1994–2009), Chicago Hope (1994–2000) and the long-lasting Grey’s Anatomy (2005–), began to place more emphasis on the physicians’ negative characteristics and their difficulties in interpersonal relationships or medical errors. This characterization changed radically in the 2000’s, with the introduction of the anti-heroes characters like the protagonists of House MD (2004–2012), Scrubs (2001–2010) and Nip/Tuck (2003–2010). Nowadays, the more recent and successful medical dramas include both heroes and anti-heroes characters, and complex institutional issues, such as The good doctor (2017–), The resident (2018-) and New Amsterdam (2018-). There are also some interesting “vintage” medical series, such as The Knick (2014–2015), about the advances in surgery in the early 20th century, Charité (2017–), about the homonymous hospital in Berlin in 1888, with the inclusion of historical figures such as Virchow, Koch, von Behring, and Ehrlich, and Call the midwife (2012–), about midwifery in England in the late 1950s and 1960s.

These series allow viewers not only to delve into biomedical issues, but also to enter characters’ psychosocial spheres and their interpersonal relationships. Viewers can submerge in multiple contexts from the points of view of different characters (i.e., doctors, patients, their relatives). The series’ visual language, and its rhythm, can facilitate viewer’s understanding of complex biomedical issues while engaging them emotionally, in episodes of 40 minutes length. Frequently, the episodes of medical series present two clinical cases interconnected by the plot: either they are two aspects of the same disease, or the doctor-patient relationship, etc.

Using these series in medical education is part of a varied landscape of subjects, and series [34]. Some previous experiences included House MD [35–38], Scrubs and Grey’s Anatomy [39,40]. As for using cinema, our approach to using series for teaching health sciences students is grounded in cinemeducation, which is based on a rigorous methodology that requires a sequence of steps to be followed before, during, and after the class based on the activity [41,42]. First, we recommend analyzing special issues in one season of a TV medical drama, in order to determine their potential usefulness in teaching health sciences students. This can be done through content analysis or even searching specific keywords in any scientific or cinematic database, like IMDb. To ensure an accurate and objective analysis, two or more researchers can assess the content analysis—recording the main and secondary topics dealt with, in each episode— and the episode utility for pedagogical purposes.

Regarding pharmacology, it can be systematized main topics such as side effects, pharmacovigilance, drug abuse, as well as the drugs portrayed on the episode, its pharmacological group, and other topics such as how doctor-patient relationship might affect therapeutic compliance. Once the audiovisual material has been selected, teachers should prepare the class taking into account the duration of the course and its pedagogical objectives. The entire episode of the series, or a shorter fragment, should be shown in class. The discussion should take place immediately after the viewing, when the events in the plot and the emotions they stirred are still fresh in students’ minds. The discussion should be interactive, collaborative, and conversational. Student’s active participation is required as in any debate. The discussion can be guided following the important plot events in chronological order. It is essential to situate the plot in the biomedical, historical, and social contexts of when the story takes place, and to emphasize the teaching objectives of the activity. Assessment of the activity is optional: it is possible to assess the usefulness of this methodology and the contents of this class in particular, for example with a pre-post test, or the pedagogical objectives can be incorporated on the final evaluation of the course.

A previous work of our research team showed the results of a content analysis of the first season of House M.D for teaching pharmacology [43,
them to explore and interact with the different contents available within us in the following session; what we intended, and achieved (in 9/12 that we had hidden certain content that they had to find and discuss with to the videoconference-based software class. We were struck by the high degree of acceptance. The first thing that caught our attention is (24 h/7d) in a specific room inside SL.

During a couple of sessions, students were trained on how to create an avatar and how to move and interact with the environment. Then, we challenged the students to freely explore the island with the warning time, and after each session, a round of interventions was established. Other complementary materials; the students could intervene at any choice of whether to use one or both platforms was left up to the faculty. Although the videoconference-based software, which was already known and used at our university, was mostly chosen, the teachers of five modules (Animals in biomedical research, Molecular pharmacology, Strategies for improving patient safety, Technological and clinical advances in Radiodiagnosis and Applied biostatistics) decided to use SL.

SL (Linden Lab, CA, USA), is one of the most widely used virtual worlds in higher education [45–47]. Users can interact with each other, allowing synchronous educational experiences in health sciences and specifically in biomedicine. These SL teaching activities have a great acceptance and recognition among undergraduate and graduate medical students [48] and, when reproduced under the same conditions and educational content, have demonstrated an impact on learning equal to that of the classroom in the real world [49].

"The Medical master island" is a 3D virtual scenario created in SL in 2011 and maintained today, to offer innovative educational experiences in health sciences learning, mainly about medicine. It mimics a university campus on an island, with several buildings arranged around a central esplanade, connected to each other by walkways [50].

The teaching of the aforementioned modules was carried out using the same teaching methodology that would be used in real life. The topics were given to the avatars in a classroom with slides, videos and/or other complementary materials; the students could intervene at any time, and after each session, a round of interventions was established. During a couple of sessions, students were trained on how to create an avatar and how to move and interact with the environment. Then, we challenged the students to freely explore the island with the warning that we had hidden certain content that they had to find and discuss with us in the following session; what we intended, and achieved (in 9/12 students), was to establish a certain game dynamic that encouraged them to explore and interact with the different contents available within the SL. Additionally, all sessions were recorded and made available (24 h/7d) in a specific room inside SL.

The response from the students (n=12) was extraordinary and with a high degree of acceptance. The first thing that caught our attention is that there was not a single student who did not feel comfortable in the SL environment. In fact, most of them (10/12) preferred this environment to the videoconference-based software class. We were struck by the students’ comments that they felt more comfortable speaking English in SL than by videoconference, probably because of the false anonymity provided by the avatar. We also discovered that SL is an exceptional environment for some teaching methodologies such as problem-based learning; the pharmacodynamics sessions were taught entirely through this methodology. Students and teachers (their avatars) met in the meeting room where we set up several virtual computers that could be used to carry out bibliographic searches or for consultation work and thus began to work on the problem. The students’ comments that the experience was comfortable and practical; in fact, two of them defended their final master dissertation through SL.

The faculty stated that the experience was positive but the time invested in creating/managing the meetings is an inconvenience to be considered; designing, validating and executing teaching activities takes time, and the overload associated with designing, implementing and practicing in SL requires effort and skill [45], although as with teaching-learning platforms. SL has some limitations and drawbacks. Firstly, you have to pay to be in SL as a content creator, although it is free for non-creator users; there are also some open-source alternatives like OpenSimulator but you have to install and run the software in your own server and maintain it, or alternatively involve the e-learning services of your institution. We have explored this last option but at the time we did it the graphical environment of SL was much better than any other. Moreover, all the content already created in SL could not be exported to other virtual world application. As mentioned above, a basic training is needed, including the learning of how to correctly use the audio communication controls and the avatar view in order to be able to correctly follow the development of a session [51]. There are also technological limitations, as the reproduction of the world requires minimum computer system and graphics card requirements, as well as sufficient data transfer over the Internet.

During the last courses, including those taught in a pandemic situation, we have resorted to the occasional use of SL in our undergraduate students as a method to break the monotony of face-to-face classes or via videoconference and give a game-like imprint to the learning and teaching processes. In all cases, the acceptance has been exceptional.

In conclusion, we believe that the use of virtual worlds for teaching can offer a number of advantages (and is perceived by students as a more playful activity than a face-to-face or videoconferencing class) and few disadvantages (teacher workload) for a method that is well accepted and appreciated by our students.

7. Social Pharmacology

From a conceptual point of view, social pharmacology is a discipline that evaluates the use of medications after their marketing, analysing the cultural, environmental aspects and habits regarding the use of drugs by individuals and their impact on society. For this reason, the Faculty of Medicine of the University of Malaga incorporated this subject in the Bachelor of Medicine, as a continuation of the learning of pharmacology in a broader context, where public health, health management and patient perceptions take on a priority role.

On the other hand, the social aspect of medicines permeates this discipline, valuing culture, customs, changes in individual and collective behaviour, as well as the value of communication and alliance between doctor and patient. In this sense, Alloza (2005) [52] highlights that social changes due to scientific progress (culture, habits, hygiene) and the freedom granted to the individual to consume medications, make individual decisions, and share them with their doctor, in a modern and global society, is the necessary argument for the development of this discipline.

In recent years, sustainable development has become a priority that governments, society, and individuals must integrate as the main axis of any activity. In this sense, the technological development necessary for scientific progress cannot be an exception. Pharmacological research must be equipped with the necessary means to ensure that its advances have a direct impact on improving the quality of life of the population and that this advance considers the protection of the environment as a guarantee of economic and social development. Science and technology
are interrelated and inseparable social processes that must be properly analysed and explained. In this context, as a subject, social pharmacology acquires enormous importance, on the one hand, it strengthens skills on the role of medicines in people’s quality of life, the social environment where they will be used, and the impact on the environment. (environmental pharmacology) and, on the other hand, incorporates competencies regarding the doctor-patient relationship as the basis of the pharmacological therapeutic alliance. The quality of human life is determined by a balanced relationship with the natural and social environment. The humanization of medicine, at a time when personalized medicine is a priority objective, is a need that we address in the teaching of Medicine. While for precision medicine the appropriate tool is pharmacogenetics, for the humanization of medicine this tool comes from Social Pharmacology, among other disciplines.

How is the subject developed? The backbone of the subject (as stated in the teaching guide for undergraduate teaching at the Faculty of Medicine of the University of Malaga) is the life cycle of the medicine: from conception (research), birth (regulation), life (post-marketing), reproduction (generics and biosimilars) and death (withdrawal from the market) [53]. In addition, it includes the scope of medication use, from the perspective of different medical specialties, as well as other disciplines (nursing, pharmacy, nutrition and dietetics); the role of the patient in the prescription process and the impact of individual decisions (self-medication); sustainable development goals (especially health and well-being) and the role of non-governmental organizations in the quality of life of patients in socially disadvantaged areas; health management and socioeconomic repercussions of medicines and the humanization of medicine. Of course, the development of the subject addresses the use of medications in patients with chronic diseases, polypharmacy, complexity, and fragility; the different health systems; unemployment; access to medications and racial inequalities.

Classes are developed in a participatory environment using different methodological tools depending on the topics to be discussed. We usually have guest professors who act as rapporteurs and lead the debate. In these cases, previously, through the Moodle platform, students have viewed a film, fragments of series or have discussed a clinical case in a forum. We have a blog where students and teachers send material related to the subject and interact with other followers. Students must prepare part of the syllabus, using, in this case, the reverse class methodology. Those topics that explore the doctor-patient relationship are developed through role-play techniques, performed by patient teachers (based on their own experiences with the disease).

The teaching of pharmacology in Spanish medical schools is based on the review of the general characteristics of medications and their application in the clinical context. The clinical trial serves as a paradigm to evaluate the effectiveness and safety of medications, but clinical practice requires the acquisition of other skills related to the use of medications. The prescription of a medication is conditioned by the type of patient and the sociocultural context in which it is prescribed. On the other hand, it is essential to incorporate the objectives of sustainable development in the study of medicines.

8. The value of learning based on social service in pharmacology

Medical schools have based their teaching on a traditional academic model in which the transmission of knowledge, skills and competences of a specialized scientific and technological nature dominate current curricula. This situation needs to be updated in line with a changing society that places the patient and the environment at the centre, and the need for education in freedom within a democratic framework of civil rights and diversity, not only cultural but also ethnic and economic. This requires a transition to a model that should be centered on the community and the values of service that society demands, based on the objectives of care and the right to health. This assumption takes into account not only the traditional missions of the university, teaching and research, but also the so-called “third mission” of social responsibility, which is so necessary and demanded today [54]. University schools need to be prepared with teaching tools, strategies and pedagogical know-how to help future doctors understand and address the health problems of members of communities in need [55]. Faced with this challenge, the need arises to look for teaching proposals that will facilitate the comprehensive training we seek.

We propose Service-Learning (S-L), a teaching methodology that allows universities to extend their involvement in their neighbouring communities by providing a service directly related to their official curriculum. S-L can be defined as a service performed by students, aimed at meeting a real need of the community, and designed in an explicit and planned way to improve the quality of academic learning [56]. In addition, S-L tends to promote the civic and moral development of students. It combines both the learning process and community service in a single, well-articulated activity. This academic approach combines educational and social benefits at the same time [57].

Since the last century, there have been experiences in higher education in North America and Latin America where S-L has been incorporated into the academic curriculum, and currently all over the world [58-60]. In our immediate context, S-L has appeared in universities in the last two decades as a result of studies and contributions from other countries. Officially, S-L was included in the University Student Statute in 2010, as a recommendation to promote social responsibility practices that combine academic learning with service provision to the community [61]. In 2015, the Conference of Rectors of Spanish Universities approved the document on Institutionalization of S-L as a teaching strategy, and in 2023 the Organic Law 2/2023, of 22 March, of the University System, S-L is explicitly mentioned (articles 18.4 and 33) [62].

S-L has been implemented in numerous health science courses, such as nursing and pharmacy [58,63,64] and to a lesser extent in medicine. Some S-L experiences have also been developed in pharmacology. For example, an experience on “promoting the responsible use of antibiotics” through an academic service-learning activity at the University of Barcelona [65]. In the Universidad de Málaga, it has been implemented in a compulsory subject ‘General Pharmacology (GP)’ and an optional subject ‘Pharmacotherapeutics in Disadvantaged Environments (PDE)’.

In the PDE, students developed an international experience. They spend eight weeks in different projects in Honduras, Peru or Palestine, integrated into the structure and activities of the different NGOs (ACOES, Fe y Alegria, Health Work Committees). As S-L promotes learning through participation in community service experiences, the students were involved in a reality very different from that in which they live in the classroom, in the hospital practice settings and even in their usual social environment. The potential and quality of what it means for future doctors, to work in contexts with hardly any resources and with a high diversity of health cases is observed and assessed in the results obtained after analyzing their final reports. The students expressed that the experience was very positive and productive. They acquire new skills, both specific and transversal (Table 3). They perceive medicine as much more than a solution to health problems, reinforcing their motivation to work generously for the improvement of socio-health well-being. The moral and solidarity aspects were the most valued [66].

In the local projects, PG and PDE students were involved in activities with NGOs (Doctors of the World) and other institutions such as schools or the Association of Relatives of Alzheimer’s patients (AFAMijas). As they asked us for more information about the pharmacological treatment of Alzheimer’s patients, an S-L project was developed in the GP. The aim was to facilitate the management of the polypharmacy in these patients. In the evaluation, the students highlighted that, in addition to the acquisition of competences (Fig. 1), the S-L project, through the service, promotes professional skills and strategies, facilitating the transfer of knowledge from the university to society [67].

It will be noted that S-L contributes to the shift from possessive individualism to the paradigm of joint action, a collective vision of the world and of education. Four derived theses complement this statement:
the concept of education must change, educational goals should be modified, a different teaching and learning methodology is required, and relevant innovations must be incorporated into the organization of the educational system [68].

We can conclude that the S-L methodology is useful for developing a more humane model in health and pharmacology training, focused on the person and the community and the values of social justice and equity, contributing to the social transformation and better acquisition of specific and transversal competences of the degree in Medicine.

9. Objective structured clinical evaluation (OSCE) in clinical pharmacology

Prescribing is an essential part of clinical practice. Medical students need to have a solid theoretical base of pharmacological knowledge, but also good training in the practical aspects of therapeutics to be able to prescribe effectively, safely and rationally. The latter is difficult to assess in traditional written examinations.

The Objective Structured Clinical Examination (OSCE) is a multipurpose, and highly versatile tool used to assess healthcare professionals in a clinical setting. In a series of 8–25 clinical situations, called “stations,” the student must solve various clinical problems within a set time limit, while being assessed by trained medical evaluators and scored using standardized scoring rubrics [69]. It is an assessment in a high-pressure environment, with a high level of stress, but which appears to have little or no impact on student performance [70].

In Spain, it is now compulsory to pass a final assessment of clinical skills using an OSCE in order to obtain a degree in Medicine. This test, as is the case in other countries [71], is designed to assess clinical performance in a simulated environment, at the ‘shows how’ level of Miller’s pyramid of assessment [69,72]. This assessment must be carried out in a setting that is as realistic as possible, using resources such as standardized patients (actors or real patients), mannequins, reports, images, among others. In 2020, due to the Covid-19 pandemic situation, e-OSCE has been developed to be used online in most countries [73]. We currently use a hybrid format with an online test (computerized clinical cases) and a face-to-face test (simulated clinical situations) in the hospital.

With a focus on pharmacotherapy, the key skills that can be demonstrated are those of clinical judgment and therapeutic management, but history taking, communication and certain technical skills can also be assessed. The OSCE has been widely used in both undergraduate and postgraduate clinical education and has been shown to have a positive impact on participants’ confidence in therapeutic areas such as the safe use of opioids [74,75].

Eight years ago, the Faculty of Medicine of the University of Málaga set up a general OSCE at the end of the course, and since then pharmacologists have participated in various stations. In most cases, the assessment has consisted of drawing up a treatment plan for a given patient, prescribing or de-prescribing and justifying the choices. In other pharmacotherapy OSCEs we have tested technical skills such as parenteral drug administration (using mannequins and real vials of medication). In the clinical pharmacology prescribing stations, students were presented with a clinical case, physical examination, laboratory data

Table 3
New skills acquired by medical students in pharmacotherapy in a disadvantaged setting.

- Knowledge of other cultures and customs
- Ability to apply theoretical knowledge to practice
- Ability to organize and plan
- Ability to solve problems
- Decision-making capacity
- Capacity for reasoning and critical analysis
- Ability to work autonomously
- Self-improvement ability
- Creative ability (generation of new ideas)
- Ethical commitment
- Research skills
- Ability to adapt to new situations
- Oral and written communication abilities
- Skills in interpersonal relationship
- Team-work skills
- Ability to recognize diversity and multiculturalism
- Ability to work in an international context
- Knowledge and development of human rights
- Knowledge of the principles of environmental protection

![Table 3: New skills acquired by medical students in pharmacotherapy in a disadvantaged setting.](image-url)

![Fig. 1. New pedagogical approaches of teaching pharmacology.](image-url)
and medication use. They then had to optimize the therapeutic plan and complete it using a common model of electronic prescribing.

Over the last 8 years we have assessed a total of 1024 final year medical students and found that the OSCE therapeutics stations are feasible and useful for assessing prescribing skills and also show a good level of discrimination. The easiest items were those related to anti hypertensive treatment and antibiotic selection based on the antibiogram, whereas the correct choice of analgesia and dose adjustment of drugs in renal insufficiency were the most difficult items. Failure to withdraw inappropriate or unnecessary medications was also noted. All this points to areas for improvement [76]. In general, the results show that competencies related to prescribing (clinical judgement and therapeutic management) received lower scores than other competencies such as communication or technical skills. We believe that there is some dissociation between what students ‘know’, ‘can do’ and ‘can demonstrate’. In addition, the degree of learning seems to fall short of achieving certain competencies with certainty, which has already been pointed out in the literature [77]. It can be said that correct medication management is a complex task that requires knowledge and more practice.

These results lead us to reflect on the need for a greater degree of practical learning for medical students, given the complexity of appropriate review and optimization of pharmacological treatment. We believe that an educational model in rational pharmacotherapy, such as that proposed by the WHO, should be further explored [78,79]. Other options that have shown good results are those of contextual learning based on simulation. Learning is best achieved by practicing, so doing so in a simulated scenario that is as realistic as possible, combining role-playing with a subsequent OSCE, has been shown a positive effect on pharmacotherapeutic skills, both in choosing treatment and in informing patients [80–82]. And what do the students think? When they are surveyed after a therapeutic OSCE, they say that they find it difficult, but that they learn from it and that it should be used more often [77].

The development of a pharmacological therapy OSCE is therefore a feasible method of practical examination. It is also a useful tool for evaluating the effectiveness of different teaching techniques. Most importantly, it has the potential to identify gaps or practical difficulties in the prescription and administration of medicines that are not apparent from multiple-choice tests. Although not yet proven, OSCE assessment in clinical pharmacology could help to reduce inappropriate prescribing or prescribing errors by bringing forward the first phase of experiential learning to the final year of study (rather than the early years of training) [83].

In agreement with other authors [84], we think that, despite certain drawbacks, the evaluation of the OSCE test should be included in the final assessment of medical students, as it assesses important qualities that theoretical examinations do not detect or improve.

10. Prescribing safety to ensure new graduates are prepared for a challenging field. The case of the European prescribing exam EuroPE+

There is substantial evidence that despite abundant theoretical knowledge of Medicine and Pharmacology, most newly graduated physicians lack enough skills and confidence to prescribe drugs efficiently and safely [85,86]. The number of medication errors produced by young physicians is of concern, despite the supervision they should be exposed to [87,88].

When final-year European medical students were evaluated about essential knowledge, skills, and attitudes in clinical pharmacology and therapeutics (CPT), they showed an overall lack of essential prescribing competencies: ‘Students had a poor knowledge of drug interactions and contraindications and chose inappropriate therapies for common diseases or made prescribing errors’ [85]. The results from that study suggest ‘that undergraduate teaching in CPT is inadequate in many European schools, leading to incompetent prescribers and potentially unsafe patient care’. A study in 185 medical schools from 27 countries has shown that ‘Pharmacology and therapeutics education in the European Union needs harmonization and modernization’ [89]. The same deficiencies have also been shown in the specific field of antibiotic prescription [90].

In several countries, final exams to ensure a minimum prescribing competency are established, remarkably the UK compulsory ‘Prescribing Safety Assessment’ [91] or the ‘Reader Pharmacotherapy’ in The Netherlands [92]. Those tests just before or immediately after graduation are supposed to ensure that graduates can be granted the ‘prescription rights’.

Several attempts have already been made to promote a core curriculum in clinical pharmacology for undergraduate medical students in Europe [93–97] without a real effect on most medical schools. Based on the concern to improve the quality of CPT and prescribing training, the Education Subcommittee of the EACPT (European Association for Clinical Pharmacology & Therapeutics) has been involved, since 2015, in three research projects aimed at analysing and proposing changes in the teaching of Clinical Pharmacology and Therapeutics and developing a core curriculum for newly graduated physicians in Europe [98,99].

As ‘Evaluation Directs Learning’ [100], the first project (within the ERASMUS+ program) has developed and tested a common ‘European Prescribing Exam’ (EPE) [99] (https://www.prescribingeducation.eu), freely available to all medical schools in Europe. The test covers the main subjects in therapeutics, namely, analgesics, anticoagulants, antimicrobials, cardiovascular drugs, psychotropics, emergency medications, and others, as well as questions about medication reviews. The exam contains 47 questions organized in two steps. The first one refers to ‘knowledge’: 12 MCQ (‘Knows’), 12 case-based MCQ (‘Knows How’), 12 case-based medication reviews (‘Shows’); and the second one to ‘skills’ based on 11 prescriptions for clinical cases (‘Does’). In this way, the EPE covers basic knowledge and how the students can use the knowledge in real-case scenarios. The exam is developed in English but could be translated into other European languages. The content focuses on essential knowledge and skills for daily practice, and it is supposed to be used more as a formative assessment and quality indicator for medical graduates because it is not a compulsory requirement for qualification. However, it can also be used as a summative and evaluative assessment. The students have access to national or international guidelines or their personal formulary developed according to the WHO’s ‘Guide to Good Prescribing’ [78] for the second part of the exam, as they might have in real life. The exam is automatically scored. The consortium members produce the questions and cases under a peer-review system and a quality and pertinence checkout. To balance the questions on the EPE, a group meeting is called to follow the exam’s blueprint. This document and the learning objectives, the list of essential medicines, example questions, and a Reader (syllabus) are available at the project site. The EPE is accessible and free of charge to any medical school in Europe, provided that a CPT teacher registers with the group. Those using the EPE are also expected to contribute to the creation and maintenance of the question bank.

The EPE has already been tested in several European universities. Consistently, the scores on the ‘knowledge’ part of the exam are high enough to feel confident. However, the scores in the skills part, where doctors have to prescribe in different case scenarios, are still poor, which calls for a type of education that tends to teach skills and criteria rather than pure facts. This separation between theoretical and applied knowledge was also noted [101].

The same EACPT education subcommittee is running two other projects aimed at improving the teaching of CPT in Europe, the ‘EuroOP2E: The European Open Platform for prescribing education’ [102,103] open to all CPT teachers to share educational resources and the ‘CP4T: Clinical Pharmacology for Teachers’ offering courses and tools to improve their teaching capabilities, both supported by the ERASMUS+ program. A consortium of nine universities leads these projects, but they are open to all medical schools. The Universidad de La Laguna has been a prominent partner in developing these projects.
Currently, a dozen medical schools in Spain are piloting the EPE.

11. Conclusion

This article describes several experiences that have been running to improve the teaching of Pharmacology in Spanish universities in recent years. They have been used to train students from different backgrounds and most of them could be used to improve not only the contents of this subject but also to develop critical knowledge regarding the use of drugs. It also describes the experience of a network to share and promote innovation initiatives, and how to improve the evaluation of pharmacology courses. The examples provided also consider simple strategies, e.g., use of popular movies and TV series, and some more complex, like the virtual worlds and social service (Table 4). A critical analysis of the innovation initiatives is also included and we believe that this complete picture may help those interested in making the adequate choices for their needs (Table 5). The real pedagogical value of each tool measured in the improvement of students’ marks is not established in each case, but the experience of those who used them is highly positive and advises for their use in the improving of pharmacology teaching in many students from health disciplines. Future studies should confirm the actual value of these innovations compared with traditional methods used until now.

Contributions

- **Introductory remarks** by Josep E. Baños.
- **Inter-university teaching and Minicongresses for medical students innovation network in pharmacology: a common space to improve learning by Pilar D’Ocon, M. Dolores Ivorra and Marisa Ferrándiz.
- **Prescribing safety to ensure new graduates are prepared for a challenging field. The case of the European Prescribing Exam EuroPE+** by Emilio Sanz.
- **Popular movies and teaching of pharmacology** by Félix Bosch and Josep E. Baños.

### Table 4

Comparative characteristics of the innovative teaching experiences.

<table>
<thead>
<tr>
<th>Item</th>
<th>Objectives</th>
<th>Feasibility</th>
<th>Resources</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| Inter-University Teaching Innovation Network in Pharmacology (TINP) | - To organize a common space for collaborative work  
- To share and evaluate innovative experiences  
- To undertake new projects within the TINP | Medium-high   | Human resources, informatic tools and virtual platform                    | Incorporation of improvements in the learning process by integrating and consolidating new teaching modalities previously contrasted |
| Popular movies | - To reinforce the contents of lectures  
- To promote the discussion of complex aspects of drug research and use | High          | One teacher per session, the film in digital format, a student’s template, and a classroom with adequate equipment for projection | Participation and learning outcomes by students has been good. |
| TV series | - To delve into biomedical issues  
- To enter characters’ psychosocial spheres and their interpersonal relationships | High          | Content Analysis and Databases. Platforms like IMDb are suggested as potential resources. Two or more researchers are recommended to assess the main and secondary topics in each episode. Audiovisual Material. Teachers can use the entire episode or shorter fragments as audiovisual resources. High-speed internet connection, computer, tablet or cell phone are required, although we recommend computers in all cases. | Identification of relevant educational content, structured integration of pharmacological topics, and fostering contextual understanding. The method also promotes interactive and collaborative discussions, encouraging active student participation and critical thinking. |
| Virtual worlds | - To compare classic videoconferencing with immersion in virtual worlds for online teaching. Teachers: It requires hard work to set up the activity. Students: It requires a short adaptation to the environment. | Moderate       | High-speed internet connection, computer, tablet or cell phone are required, although we recommend computers in all cases. | Virtual worlds are preferred over videoconference by students as teaching methodology. Conversely, teachers prefer videoconference as it produces less work load. Virtual worlds are perceived by students more as a playful activity than a face-to-face class. Drawbacks: The workload for the teacher to set up the activity. Integration of social aspects with the management and use of medications. |
| Social pharmacology | - To recognize the essential elements of medicine including ethical principles, legal responsibilities and patient-centered professional practice. | High          | University professors and health professionals. Moodle platform, subject blog. Availability of viewing movies and series. | - Acquisition of specific and transversal skills  
- Motivation to work generously for health and welfare of the society  
- Development of solidarity and ethical values |
| Social service | - To enhance the quality of learning attending to a real need of the community  
- To promote the comprehensive human, ethical and professional training of medical students | Moderate       | Social partners and partners institutions | - OSCE stations are feasible and useful showing a good level of discrimination  
- It may uncover gaps in the prescription, showing areas that need improvement  
- Prescription skills are difficult for students, confirming that correct medication management is a complex task whose resolution requires more practice |
| Objective Structured Clinical Evaluation, OSCE | - To assess therapeutics’ clinical skills (mainly prescription writing and drugs administration) | Moderate       | - Clinical setting (hospital rooms)  
- 4-8 qualified staff (teachers and residents)  
- Model of electronic prescription, reports, mannequin, medication’s real vials | - Acquisition of specific and transversal skills  
- Motivation to work generously for health and welfare of the society  
- Development of solidarity and ethical values  
- Acquisition of specific and transversal skills |
<p>| European Prescribing Exam (EuroPE+) | - To assure a minimum standard of knowledge and skills to prescribe for common conditions at graduation | High          | Computer connections and agreement with the European Association for Clinical Pharmacology &amp; Therapeutics (EACPT) Education Committee | Identification of strengths and weaknesses in the skills capabilities of newly graduated medical students. |</p>
<table>
<thead>
<tr>
<th>Item</th>
<th>Miller’s pyramid</th>
<th>Clinical or general pharmacology</th>
<th>Courses (years)</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Outcome learning measures</th>
<th>Future trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-University Teaching Innovation Network (TINP)</td>
<td>All</td>
<td>Both</td>
<td>Nursing, Pharmacy, Medicine, Veterinary medicine, Biomedical Sciences, Optics, Nutrition (3rd, 4th, 5th or 6th)</td>
<td>Sharing and validation of teaching innovative experiences</td>
<td>None</td>
<td>Surveys</td>
<td>To improve the collaboration between teachers on an international scale</td>
</tr>
<tr>
<td>Popular movies</td>
<td>Knows how</td>
<td>Both</td>
<td>Medicine (3rd, 6th) Biology (3rd) Pharmacy (3rd) Continuous medical education for CRA Master in pharmacological research</td>
<td>It fosters students’ empathy. It allows reviewing and reinforcing theoretical knowledge. It addresses humanistic aspects of diseases. It stimulates students’ discussion.</td>
<td>The activity takes around 3 h. It can distort or exaggerate the learning information. It can contain some distracting elements</td>
<td>Student’s satisfaction questionnaire, Short questions and multiple-choice questions evaluation.</td>
<td>To expand the experience using new movies. To communicate them at conferences and scientific journals. Better designed studies are needed to determine the improvement in competences</td>
</tr>
<tr>
<td>TV series</td>
<td>Knows / Knows how</td>
<td>Both</td>
<td>Medicine (3rd)</td>
<td>Ability to engage students through TV medical dramas Facilitate contextual learning Encourage interactive discussions.</td>
<td>Dependence on accuracy Time constraints Varied student preferences</td>
<td>Pre/post test Satisfaction questionnaire</td>
<td>Advancements in technology for interactive learning, increased collaboration between entertainment and academia, ongoing research on the long-term impact. Virtual worlds are gaining place in teaching, especially on-line, as they offer more possibilities than videoconference.</td>
</tr>
<tr>
<td>Virtual worlds</td>
<td>Knows</td>
<td>General pharmacology</td>
<td>Medicine (3rd) Master degree. PhD students.</td>
<td>Teachers: Easy to maintain once stabilized. Students: Perceived more as a playful activity than a regular teaching activity. Sessions are recorded and available at any time.</td>
<td>Payment to create/ maintain contents. Represents a big workload for teachers to set up the activity.</td>
<td>In process</td>
<td>Virtual worlds are gaining place in teaching, especially on-line, as they offer more possibilities than videoconference.</td>
</tr>
<tr>
<td>Social pharmacology</td>
<td>Knows how</td>
<td>Social pharmacology</td>
<td>Medicine (2nd)</td>
<td>It describes the social reality related to the use of medications</td>
<td>Subject not included in other curricula</td>
<td>- Participation of students in the activities - Preparation of a diary about the activities and personal experience Students’ self-evaluation, Evaluation of the S-L project. Qualitative assessment of the students’ learning</td>
<td>To improve the doctor-patient relationship</td>
</tr>
<tr>
<td>Social service</td>
<td>Does</td>
<td>General pharmacology</td>
<td>Medicine (3th and 5th)</td>
<td>S-L is useful for developing a more humanistic and integral model in health and pharmacology training</td>
<td>S-L requires a great deal of time and effort to coordinate and monitor the projects</td>
<td>OSCE assessment in therapeutics could contribute to reducing inappropriate prescribing or prescribing errors by bringing the first phase of experiential learning forward to the final year as a student</td>
<td>To focus on the person and the community and the values of social justice, to contribute to the social transformation and better acquisition of competences through a compulsory subject</td>
</tr>
<tr>
<td>Objective Structured Clinical Evaluation, OSCE</td>
<td>Shows</td>
<td>Clinical pharmacology</td>
<td>Medicine (6th)</td>
<td>- It is a feasible and versatile method of practical evaluation - It evaluates important topics that other theoretical exams do not evaluate. - It is well accepted by students International checking of knowledge and skills. Easy to implement</td>
<td>- Its planning and implementation are complex - It requires a significant logistical effort</td>
<td>An electronic prescription, therapeutics management, technical skills and clinical judgement to assess learning</td>
<td>OSCE assessment in therapeutics could contribute to reducing inappropriate prescribing or prescribing errors by bringing the first phase of experiential learning forward to the final year as a student</td>
</tr>
<tr>
<td>European Prescribing Exam EuroPE+</td>
<td>Does</td>
<td>Clinical pharmacology</td>
<td>Medicine (5th –6th)</td>
<td>Alignment of the curriculum of each school with the exam. Logistic conditions to be implemented.</td>
<td>Final evaluation and comparison with other medical schools</td>
<td>Final evaluation and comparison with other medical schools</td>
<td>To be widely implemented in Europe.</td>
</tr>
</tbody>
</table>
• On the use of TV medical series to teach pharmacology to biomedical students by Irene Cambrada-Badí and Josep E. Baños.

• The value of learning based on social service in pharmacology by María R. Cabello.

• Objective Structured Clinical Evaluation (OSCE) in clinical pharmacology by Encarnación Blanco-Reina and Immaculada Bellido.

• Social Pharmacology by J.A. González Correa, J.P. de la Cruz and Francisco Martos.

• Using virtual reality to teach pharmacology by José Pavia and Elisa Martín-Montañez.

Declaration of Competing Interest
None

Data availability
No data was used for the research described in the article.

References


