

# **The Role of eLearning on Antimicrobial Stewardship Programs (ASPs): A Review**

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# **The Role of eLearning on Antimicrobial Stewardship Programs (ASPs): A Review**

## **Abstract**

The inappropriate prescription of antimicrobials is currently one of the primary public health problems around the world. As a result, bacteria become drug-resistant resulting in increased patient stays in hospitals and affecting the economy of a community by elevating the costs of its treatment. In order to prevent those complications, several kinds of educational initiatives have been taking place; some of which have included the use of technology to expand its reach and to boost their learning effects. The purpose of this study was to explore and determine how eLearning can enhance the educational outcomes of programs on antimicrobial's prudent use and optimization. Hence, a literature review that followed Fink's seven tasks approach was conducted. Based on the available evidence, the online educational interventions designed by healthcare organizations to promote the rational and responsible use of antimicrobials were divided into four categories: (1) learning and instructional theories, (2) online learning platforms, (3) multimedia learning, and (4) motivation. In short, this study shows that eLearning can assist in enhancing the educational outcomes of ASPs by appealing to students' desire and motivation to engage in tasks that encourage the love of learning. Also, by providing the institutions in charge of designing these learning initiatives with an extensive range of learning and instructional theories and an almost infinite set of technological resources to carry out sound learning experiences.

Keywords: education; learning; eLearning; e-learning; antimicrobial stewardship

## **Introduction**

The inappropriate use of antimicrobials is a global concern that not only affects the health of a community but also its economy because, among other factors, bacteria become drug-resistant resulting in increased patient stays in hospitals due to the need for intensive care (WHO, 2021). In the United States of America, for example, a third of hospitalized patients that were exposed to antibiotics were not prescribed adequately

(Satterfield et al., 2020). In order to prevent those complications some initiatives have been taking place around the world. For instance, at regional level, the Latin American Network for Antimicrobial Resistance Surveillance (ReLAVRA by its Spanish acronym) was created officially in 1996 to inform reliable, comparable and reproducible antimicrobial resistance prevention, control policies, and interventions (PAHO/WHO, n.d.). In Colombia, local health authorities created a district system for epidemiological surveillance of bacterial resistance (SIVIBAC by its Spanish acronym) to promote the prudent use of antibiotics (Minsalud, 2019).

In turn, some of those initiatives, that have been created to reduce the adverse consequences and the negative effects of antimicrobial's misuse in order to positively impact prescribing behaviors, are often referred to as *Antimicrobial Stewardship programs (ASPs)*. However, due to the ambiguity of the term in English stewardship and to the fact that it does not have a direct translation into many other languages, it is hard to determine for non-English speakers exactly what are and what are not ASPs (Dyar et al., 2017). In a systematic review, (Filice G et al., n.d.) defines ASPs as coordinated set interventions designed by healthcare organizations to promote the optimal, rational and responsible use of antimicrobials. Education directed towards health workers mostly (albeit not exclusively) with prescribing authority, is a common component of ASPs which are often technology-aided to facilitate teaching and learning processes (Satterfield et al., 2020).

Thus, *eLearning* has been implemented to support *ASPs*' education mainly to introduce or reinforce knowledge on the optimal and responsible use of antimicrobials (Satterfield et al., 2020). eLearning makes use of information and communications technology (ICT) to expand the reach of education by delivering interactive, adaptive, and flexible training (Ivanova, 2020). According to the Oxford Advanced Learner's

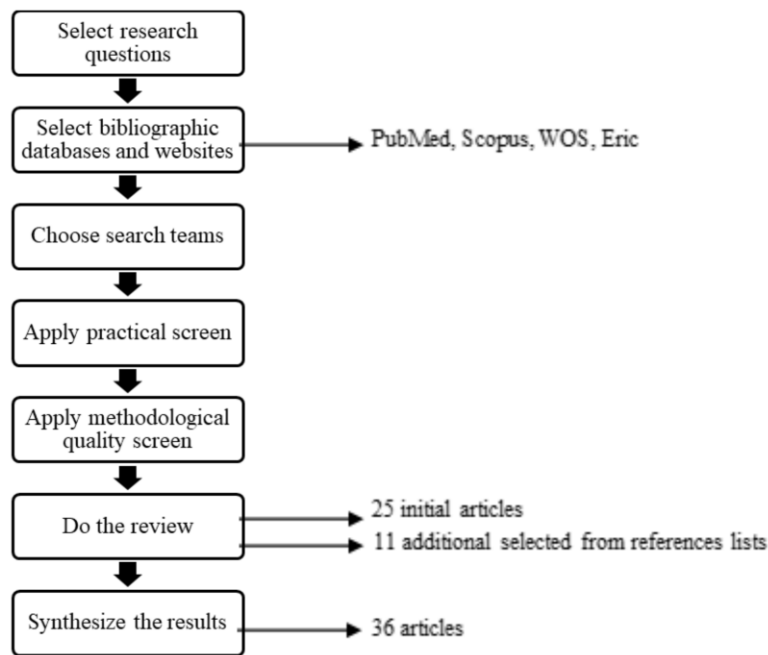
Dictionary (2022), the term eLearning refers to: “a system of learning that uses electronic media, typically over the internet”. Moreover, the term is made up of the prefix “e” and the word learning. However, although the prefix “e” stands for electronic, its use has spread and evolved over the years to refer, not exclusively to electronic but, to any data or information transmitted through the computer or over the Internet (e.g., eMail, eCommerce, eBook). ASPs use eLearning to facilitate the achievement of learning goals and expand its reach. Both terms, ASP and eLearning, are too complex to come up with a single definition and, in addition, both are subjected to constant change and evolution.

On the other hand, the spread of Covid-19 around the globe has made governments, health authorities, and the general public aware of the importance of preventing future pandemics. According to Nadimpalli et al. (2021), the misuse of antimicrobials could potentially disseminate to the point of becoming the next global pandemic. For this reason, it is imperative to train, not only physicians but other stakeholders involved and even patients, to prevent the negative consequences aforementioned. Hence, a literature review was conducted in order to explore and determine how eLearning can enhance the educational outcomes of programs on antimicrobial's prudent use and optimization, namely ASPs.

## **Methods**

The selection of literature for this review followed Fink’s (2019) approach, in which a systematic and reproducible method was used to identify, evaluate and synthesize the academic output on the ASPs that implemented eLearning. Fink’s (2019) seven tasks approach is depicted in the following figure (Figure 1):

FIGURE 1. Fink’s seven steps approach.



*Select research questions.* A research question was explicitly stated in order to guide the review: How can eLearning enhance the educational outcomes of ASPs?

*Select bibliographic databases and websites.* With the purpose of answering the research question, a keyword search was conducted, from June to August 2020, on PubMed and Scopus mainly, although results from WOS and Eric were also considered.

*Choose search terms.* Initially, PubMed yielded 35 results, while Scopus produced 45, and WOS generated 29 using the keywords “antibiotic”, “antimicrobial”, “eLearning”, and “educational technology”. Conference papers, book chapters and letters were excluded from Scopus' results to only retrieve articles. On WOS, all databases were selected. On Eric, 14 results were produced with the search terms “antibiotic”, “education”, and “technology”.

*Apply practical screen.* The review was carried out in English because, even in countries where it is not spoken as a first language, initiatives that entail the prudent, proper and responsible use of antimicrobials, are most often referred to using the term in English: Antimicrobial Stewardship. Further, no time limit was applied because most results were recent enough. So, after eliminating 44 duplicates results went from 123 to

79. A table detailing the search equations used in each of the selected databases is found next (Table 1):

TABLE 1. Search equations in each database.

PubMed (35 results)	(antibiotic OR antimicrobial) AND (e-learning OR "educational technology")
Scopus (45 results)	(antibiotic OR antimicrobial) AND (e-learning OR "educational technology")
WOS (29 results)	(antibiotic OR antimicrobial) AND (e-learning OR "educational technology")
Eric (14 results)	Antibiotic, education, technology

*Apply methodological quality screen.* Selected articles must have had involved a description, not only of an educational initiative related to prudent or proper antimicrobial management but also an intervention that had incorporated the use of technology for educational purposes.

*Do the review.* An analysis was performed by reading through the titles and abstracts. Subsequently, after reading thoroughly the initial selection of 79 papers, 54 were discarded for not meeting the aforementioned criteria, leaving eventually 25 articles.

*Synthesize the results.* The review was synthesized descriptively according to Wu's (2011) IMRaD (introduction-methods-results-and-discussion) structure.

Additionally, other relevant articles were included using a snowball sampling approach. That is, 11 additional studies were gathered from the selected articles' references lists, following the same criteria whereby articles must have entailed an educational initiative related to prudent or proper antimicrobial management that had

implemented an intervention that incorporated the use of technology for educational purposes. All in all, this literature review consisted of 36 articles.

## **Results**

Based on the available evidence, the online educational interventions —i.e., eLearning— designed by healthcare organizations to promote the optimal, rational and responsible use of antimicrobials —i.e., ASPs— were divided into both a priori and inductive categories. On the one hand, two a priori categories emerged almost naturally due to their relevance to the research question. That is, ASP and eLearning.

On the other hand, inductive categories emerged from the analysis of the studies consulted in this review. Several key themes appeared from an axial coding across concepts that were mentioned several times and the relationship among them: (1) learning and instructional theories, (2) online learning platforms, (3) multimedia learning, and (4) motivation. Lastly, when new information and concepts stopped emerging theoretical saturation occurred.

### ***Learning and Instructional Theories***

This category includes the definitions of *learning theories*, *instructional theories* and how they are put in place in ASPs that have implemented eLearning. On the one hand, Mergel (2007) defines *learning theories* by comparing their development to the development of the atomic theory. Much like the atomic theories, which have evolved over time, and which have disaggregated the basic constituents of atoms (i.e., protons, neutrons, and electrons) into the current model; learning theories have matured through history and have broken down their fundamental elements into smaller chunks. Among those fundamental learning theories are: *behaviorism*, which considers learning as the conditioning of a person's conduct through stimulus-response; *cognitivism*, which

contend learning as the thought process behind a person's behavior and what happens inside their mind; and *constructivism*, which entails that every learner has their own perspectives of the world, their own experiences and schemas and, thus, constructs their own knowledge.

On the other hand, *instructional theories* cover anything that is done deliberately to facilitate learning. They are design-oriented, that is, they relate to the creation of products that assist learning; whereas learning theories are descriptive-oriented, meaning that they are more concerned with describing how learning processes occur (Merrill, 2002). Likewise, Reigeluth and Carr-Chellman (2009) describe instructional theory and technology from a post-industrial perspective. They state that current education and training systems, developed during the industrial age, were designed more for sorting students than to maximize their learning. This implies that, even though people have different learning needs and learn at different rates, many educational institutions (e.g., universities) and organizations still teach predetermined content in a fixed amount of time.

Thereby, Reigeluth and Carr-Chellman (2009) came up with a set of core ideas for the post-industrial paradigm of instruction that combine the best of behaviorist, cognitivist and constructivist learning theories. Among the most relevant to this study are: *learner-centered vs. teacher-centered*, which contends that instruction is tailored so that much of the learning endeavor is carried out by the student rather than by the teacher; *learning by doing vs. teacher presenting*, covers problem-based, project-based or case-based learning where most of the student's time is spent executing tasks instead of listening to a teacher; *customized vs. standardized instruction*, encompasses tailor-made rather than predetermined learning experiences that let students pursue their own interests, talents and strengths; *criterion-referenced vs. norm-referenced testing*, covers



both formative assessment—which purpose is to guide student’s learning and provide immediate feedback to let them learn from mistakes— and summative assessment—which certifies student’s attainment—; and finally, *enjoyable vs. unpleasant*, which contend lifelong learning as indispensable in the age of knowledge.

However, according to Schunk (2019), instructional research can have a significant effect on learning theories and on how they are applied to induce learning. Researchers have found several reasons why the fields of instruction and learning have had such a small overlap. One possible explanation could be the different theoretical principles that govern both areas. For instance, the lack of integration between psychologists (who have carried out most of the early learning theories in animals or in one-person situations) and educators (who have been more concerned with applying teaching methods to learning contexts or environments). Fortunately, now researchers and practitioners from many different disciplines recognize that it is better to study both instruction and learning in conjunction because, regardless of perspective, most instructional and learning theories share principles that can potentially enhance learning by applying instruction.

The documented ASPs that have implemented eLearning take advantage of the wide variety of learning and instructional theories available. For example, some of the studies consulted were categorized as learner-centered because they intended to offer a more personalized experience and the students played a crucial role in directing their own learning (Bond et al., 2017; Medeiros et al., 2008; Sikkens et al., 2018; Sørensen et al., 2018). However, others include a mix of online with face-to-face components (i.e., blended learning) to benefit from both traditional classrooms (i.e., teacher-centered instruction) and fully online learning environments (Pratt & O’Malley, 2007; Rocha-Pereira et al., 2015; Walsh et al., 2010). Another significant use of the core ideas of the

post-industrial paradigm of instruction applied by the ASPs that implemented eLearning is “learning by doing vs. teacher presenting”. In this constructivist approach to learning, the student spends most of the time performing authentic tasks that are problem-based or case-based instead of listening to a teacher lecturing (Evans et al., 2015; Finch et al., 2012; Guerra et al., 2010; Hadadgar et al., 2018; Tsopra et al., 2020; van Dort et al., 2020).

### ***Online Learning Platforms***

*Online learning platforms* are built on software that allows teachers and institutions to design, create, distribute, and manage the delivery of educational content. However, it is up to every institution to decide which of the currently available platforms better fits their educational needs (Liu et al., 2020). Online learning platforms have been playing an important role in education lately given the popularization of online education, not only because of the advancements of technology in all aspects of modern life, but because the Covid-19 pandemic has reduced students’ physical interaction in order to decrease the spread of the virus. In this regard, web-based learning has become a suitable alternative for education under remote teaching conditions.

The ASPs that implemented eLearning were carried out using websites set up through open-source *content management systems (CMS)* such as WordPress or any other technology for displaying web content like HTML or PHP (Allison et al., 2020; Finch et al., 2012; McHugh et al., 2010; Medeiros et al., 2008; Nicolson et al., 2017; van Dort et al., 2020); *learning management systems (LMS)* such as Moodle, which are software applications that provide a framework for administering, creating and delivering learning content and tracking or reporting students’ activity (Guerra et al., 2010; Hadadgar et al., 2018; Laks et al., 2019; Sørensen et al., 2018); *massive online*

*open courses (MOOC)*, which are free online learning platforms, such as Coursera or FutureLearn, where anyone can enroll to learn a wide variety of topics (Duarte et al., 2020; Pérez-Moreno et al., 2018; Rocha-Pereira et al., 2015; Sneddon et al., 2018); and *tailor-made online software*, which refers to software developed exclusively for a specific learning initiative (Castro-Sánchez et al., 2019; Desai et al., 2000; Wanford et al., 2018).

### ***Multimedia Learning***

Mayer's (2002) definition of *multimedia learning* is wide enough to include any type of material intended to foster learning by building mental representations from words and pictures. While words can be any kind of text either displayed on a computer screen or verbalized through speakers; pictures can be either static (i.e., photographs, illustrations, charts, tables or infographics) or dynamic (i.e., videos or animations). Similarly, Schunk (2019) states that multimedia learning takes place when learners interact with technologies that integrate the different capabilities of computer media (i.e., text, sound, or video).

Among the most relevant types of multimedia applied in the ASPs that implemented eLearning are: *videos*, which are nowadays one of the most popular formats for delivering educational content, perhaps due to the rapid and continuous expansion of high-speed internet access and the proliferation of personal devices like smartphones (Allison et al., 2020; Bond et al., 2017; Desai et al., 2000; Goff, 2012; McHugh et al., 2010; Nicolson et al., 2017); *presentation slides*, that are already a widespread practice among teachers for showing or explaining content to students either in PowerPoint or PDF format (Eley et al., 2019; McHugh et al., 2010; Pratt & O'Malley, 2007; Senbanjo et al., 2017); *question and answer scenarios*, which can be either formative or summative and sometimes provide feedback to increase interactivity

(Bond et al., 2018; Desai et al., 2000; Laks et al., 2019; Senbanjo et al., 2017); and *interactive or multimedia material*, that are educational resources built with any of the different technologies available for displaying web content (Laks et al., 2019; Little et al., 2013; Pantoja et al., 2020; Walsh et al., 2010; Wanford et al., 2018; Wollny et al., 2019).

Another widespread use of multimedia learning in ASPs are *serious games or simulations* (Bond et al., 2018; Castro-sánchez, 2014; Castro-Sánchez et al., 2019; Eley et al., 2019; Evans et al., 2015; McHugh et al., 2010; Pantoja et al., 2020; Satterfield et al., 2020; Sørensen et al., 2018). Serious games or simulations are computer-based environments in which students are faced with real or imaginary situations. They allow learners not only to add information to their memory by being delivered interactively but to have a more active role by making sense of the material presented. In other words, students must try to solve problem-based or case-based situations where clinical cases are posed.

### ***Motivation***

Motivation in learning is the process by which students engage in activities that facilitate learning and make it enjoyable. Some learning can happen with no motivation but in general terms most of the time learning is motivated. Likewise, motivated students engage in the activities proposed, follow instruction, and seek solutions when they find difficulties with the material instead of quitting (Schunk, 2019).

Some ASPs that implemented eLearning reported motivation in different ways. Sørensen et al., (2018) mentioned how a gamified and interactive course design had a positive impact on learners' motivation to stay interested throughout the whole experience and to complete it. Likewise, Van Dort et al., (2020) reported that a game-based e-learning initiative was more effective than a conventional script-based when it

came to motivating students to impact prescribing behaviors. On the other hand, Caris et al., (2018) explained in detail that the implementation of eLearning together with face-to-face education helped increase students' motivation and encourage them to make a greater effort at participating and completing their learning experiences. Bond et al., (2017) described the use of narrative resources like dramatic tension, humor, and challenge as means to engage learners with the educational contents and keep their interest and motivation to learn. Finally, Pratt & O'Malley, (2007) carried out a visually appealing case-based serious game to illustrate and contextualize concepts and reinforce learning with the purpose of encouraging participation and completion.

## **Discussion**

The exploration and description of the categories that emerged from this review suggest that eLearning enhances the educational outcomes of ASPs by providing stakeholders with an extensive range of learning and instructional theories and an almost infinite set of technological resources to carry out sound learning experiences. However, ASPs implemented with the use of eLearning should also be designed to be enjoyable in order to increase students' motivation and allow them to remember better by having tangible real-life references and, thereby, encouraging meaningful learning.

Although most of the time the learning or instructional theories were not mentioned explicitly in the studies consulted in this review, it was possible to infer them by the description of each intervention. The educational component of the ASPs that implemented eLearning call for instructional strategies that pose open-ended learning experiences where students are faced with authentic case-based problems that reproduce the natural complexity of the real world. Structuring such environments presents very particular challenges for the instructional designer since it requires the creation of products where students can learn, not only one way to approach a problem, but where

they can interpret multiple realities to apply them in different situations and promote self-directed and autonomous learning practices.

ASPs make use of the wide variety of online resources available to train their target audiences on the prudent, optimal and responsible use of antimicrobials. Online learning platforms provide technology-aided environments where teaching and learning is facilitated and where knowledge is constructed. Those technologies, that range from open-source content and learning management systems to MOOCs and tailor-made online software, allow universities and other training organizations to support knowledge delivery on antimicrobial stewardship. In addition, online learning platforms assist the configuration of environments that support learning by doing to reach the instructional goals.

Another important component of the ASPs that implemented eLearning consulted in this review are the multimedia learning materials that were put together into those online learning platforms. Even though there is currently an impressive arsenal of formats and technologies to choose from, interactive digital resources seem to be the ones that bear most benefits. It is not enough, nevertheless, to just consider the delivery method in which the information is presented, learning materials ought to encourage learners to actively process information. That is, students must face problem-based real or simulated situations that otherwise would be impossible to bring to a learning setting. Also, students can benefit from multimedia learning by increasing the odds of at least one of the types of media being effective.

All in all, learning mediated by digital technologies (i.e., eLearning) has impacted educational programs on the optimal, rational and responsible use of antimicrobials (i.e., ASPs) by providing stakeholders with an extensive range of learning and instructional theories that help improve and refine both its teaching and

learning practices. Also, by providing a variety of technology-aided platforms to deliver rich learning experiences that facilitate thinking and knowledge construction.

Furthermore, by handing out a vast repertoire of multimedia learning resources that engage students in problem-based tasks that require thinking creatively, that foster meaningful learning and that encourage twenty-first century skills which are demanded to every professional in a globalized labor market. Lastly, by appealing to students' desire and motivation to engage in tasks that encourage the love of learning.

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