A contextualized design of Problem-Based Learning cases as a curricular innovation in Veterinary Medicine and Animal Husbandry

Diseño contextualizado de casos de Aprendizaje Basado en Problemas como innovación curricular en la Facultad de Medicina Veterinaria y Zootecnia

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The purpose of this paper is to describe and exemplify a theoretical-methodological proposal for the design of case studies used in Problem-Based Learning (PBL). The profession and the empirical knowledge that teachers who use this theoretical-methodological proposal possess in order to meet the formative needs of students were analyzed. The Investigation-Action (IA) was used as a methodological perspective, supported by a focus group, with the participation of 10 tutor-teachers who use this proposal. The results strengthen the central importance of the PBL theoretical-methodological proposal as a triggering element and starting point for the teaching of Veterinary Medicine and Animal Husbandry (VMAH). The teaching experience on the phenomenon was examined and the elaboration of more case studies was reconsidered. Finally, a case study design is proposed, supported by the Clinical and Animal Husbandry of the profession, united by a didactic-pedagogical system of learning activities and evaluation criteria.

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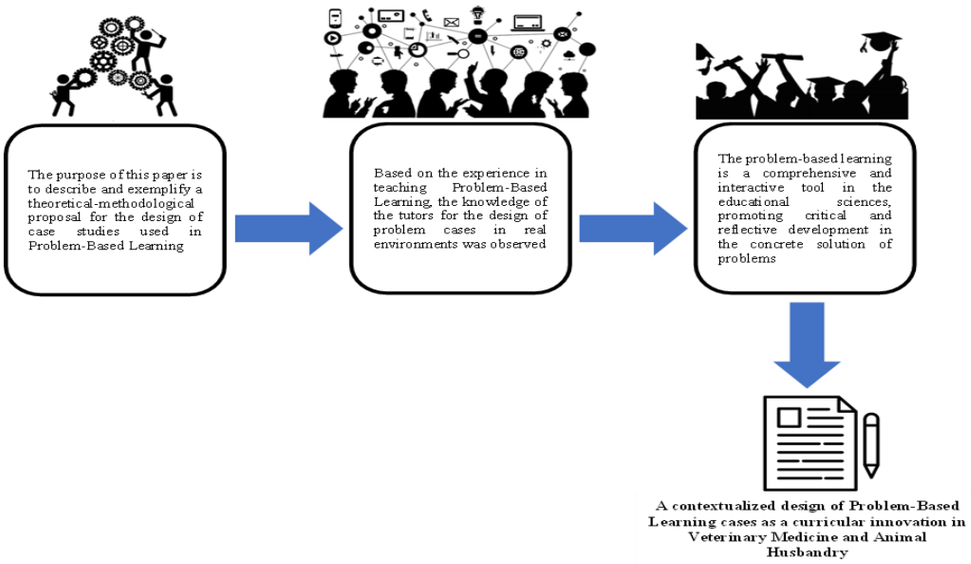
Abstract

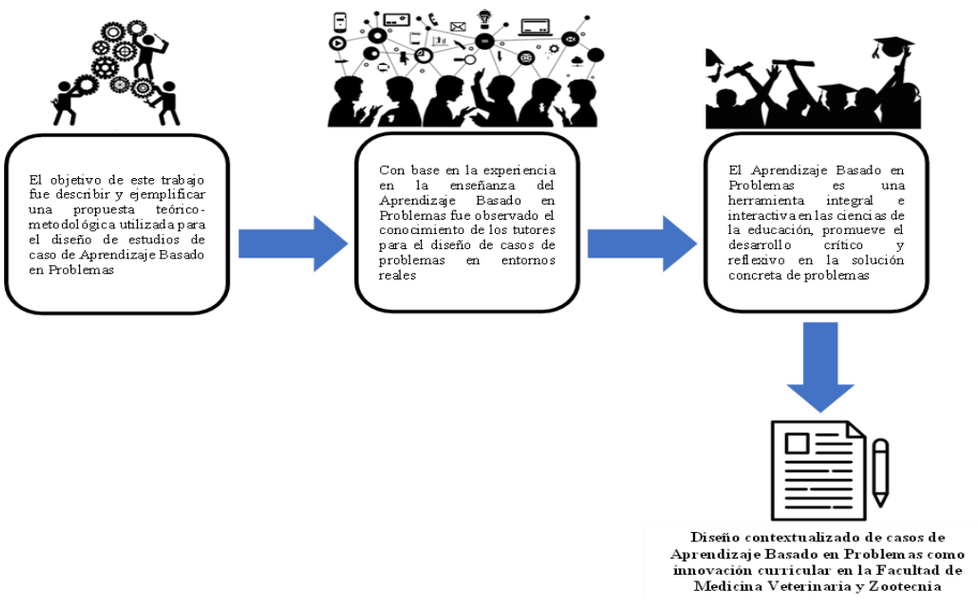
The purpose of this paper is to describe and exemplify a theoretical-methodological proposal for the design of case studies used in Problem-Based Learning (PBL). The profession and the empirical knowledge that teachers who use this theoretical-methodological proposal possess in order to meet the formative needs of students were analyzed. The Investigation-Action (IA) was used as a methodological perspective, supported by a focus group, with the participation of 10 tutor-teachers who use this proposal. The results strengthen the central importance of the PBL theoretical-methodological proposal as a triggering element and starting point for the teaching of Veterinary Medicine and Animal Husbandry (VMAH). The teaching experience on the phenomenon was examined and the elaboration of more case studies was reconsidered. Finally, a case study design is proposed, supported by the Clinical and Animal Husbandry of the profession, united by a didactic-pedagogical system of learning activities and evaluation criteria.



Methodological, Pedagogical, Formative, Husbandry, Evaluation

Resumen

El propósito de este capítulo es describir y ejemplificar una propuesta teórico-metodológica para el diseño de estudios de caso utilizados en el Aprendizaje Basado en Problemas (ABP). Se analizó la profesión y los conocimientos empíricos que poseen los docentes que utilizan esta propuesta teórico-metodológica para satisfacer las necesidades formativas del estudiantado. Se utilizó como perspectiva metodológica la Investigación-Acción (IA), apoyada en un grupo focal, con la participación de 10 docentes-tutores que utilizan esta propuesta. Los resultados fortalecen la importancia central de la propuesta teórico-metodológica del ABP como elemento desencadenante y punto de partida para la enseñanza de la Medicina Veterinaria y Zootecnia (MVZ). Se examinó la experiencia docente sobre el fenómeno y se reconsideró la elaboración de más estudios de caso. Finalmente, se propone un diseño de estudio de caso, apoyado en la Clínica y Ganadería de la profesión, unidos por un sistema didáctico-pedagógico de actividades de aprendizaje y criterios de evaluación.



Metodológico, Pedagógico, Formativo, Ganadero, Evaluación

Introduction

Problem-Based Learning (**PBL**) is a didactic methodology of an active nature (Zhang et al., 2023) which arose from the need for knowledge and learning to be student-centered (Wang et al., 2023). Currently, university health careers have accepted, with popularity, this theoretical-methodological approach to teaching (Lang and Parkinson, 2023; Shad et al., 2023; Sharma et al., 2023; Showstark et al., 2023).

However, the main obstacle for schools implementing PBL for the first time lies in the absence of case studies, or "problems" appropriate to the discipline to be taught (Bai et al., 2023; Fung et al., 2023). Therefore, the need represented by this issue is solved to the extent that professionals in the field design and write these educational resources (Zheng and Wang, 2022; Zhu and Zhang, 2022).

The educational resource called PBL case/problem can be oriented, adjusted, and shaped according to the needs of a school's context (Wang et al., 2023), as it has the didactic ability to be adapted to the needs of the institution or profession (Staff, 2023). Even as it is the trigger of this teaching methodology, elements can be combined and adapted from the reflection of the context, such as experience and knowledge, without compromising the active nature of the methodology (Bai et al., 2023).

PBL is a methodology, since its development involves a series of specific pedagogical steps (Tadesse *et al.*, 2022). It is also a didactic strategy in itself, since it employs activities that promote discovery, information searching, and knowledge construction for the conception of new knowledge (Zhang *et al.*, 2022). In this research, methodology, method, and strategy are used as synonyms of interchangeable concepts to refer to PBL (Xu *et al.*, 2022). In case/problem design, there is an attractive reservoir for change management to improve processes, procedures, instruments, and structures around the current phenomenon (Xie *et al.*, 2022), which provide PBL with new didactic resources for teaching professional competencies (Lang and Parkinson, 2023).

Additionally, at the Faculty of Veterinary Medicine and Animal Husbandry (**FVMAH**) of the University of Colima, we have had the opportunity to work for seven years with PBL as a teaching strategy in the last semesters of the profession. As a result of this experience, it was identified that the implementation of this methodology required using triggering "problems" that went beyond a conceptual construct in its design, since the case/problem as a starting point was ambiguous, precisely because of its theoretical elaboration that, although attached to reality, was decontextualized, and lacked meaning in relation to the Clinical and Animal Husbandry. Therefore, this paper aims to describe and exemplify a theoretical-methodological proposal for the design of case studies used in PBL through an analysis of the profession and the empirical knowledge that teachers who use this theoretical-methodological proposal possess.

Problem-Based Learning

As it is considered an integrative, didactic activity, PBL allows for the introduction of curricular innovation processes (Fung *et al.*, 2023). This does not respond to an unfounded institutional procedure, but rather to an intentional change that emerges from the needs of the school context (Bai *et al.*, 2023).

The central feature of PBL as a teaching method is the use of case study "problems", which map out a didactic path for information seeking (Zhu and Zhang, 2022). It also considers the construction of new knowledge and the conception of the student as a leader in the management of their learning (Zhang *et al.*, 2022). Innovating from this perspective is valuable, since it has a direct impact on how it is taught, and on the starting point for the transmission of knowledge (Xu *et al.*, 2022). The PBL methodology (**Figure 1**) is active in nature (Lang and Parkinson, 2023). Therefore, it utilizes self-directed and autonomous learning skills (Wormley *et al.*, 2022). In combination with IA and information seeking by the learner (Wong and Kan, 2022), these activities should be preceded and motivated by a didactically triggering element, referred to as a "problem" (Wang *et al.*, 2023).

Lang and Parkinson (2023) indicated that the student body is not a passive entity that receives all knowledge from the teacher; rather, it is based on the analysis of case studies, where the student body is in constant discovery and construction of its own learning. In this regard, Xu *et al.* (2022) identified the "problem" as a fundamental, didactic structure in PBL, pointing out that learning begins with it, and there is no achievement of knowledge without it.

In practical terms, the case study “problems” used by PBL are generally presented in simple and non-technical language (Wondie *et al.*, 2022). They are a series of sets, facts, or phenomena that pose a challenge or a question about a specific topic (Webster *et al.*, 2022). The “problem” must be interesting and relevant to the students, so that it captures their attention (Wang *et al.*, 2022). Therefore, what is to be problematized should reflect a real -life situation- i.e., with a real-life context (Virk *et al.*, 2022).

Box 1

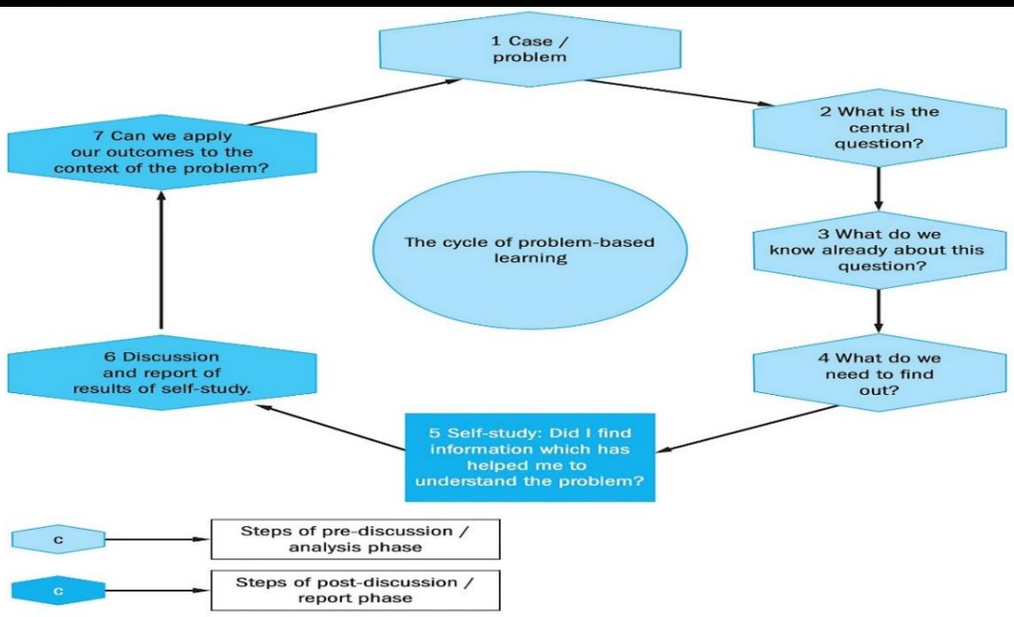


Figure 1

The cycle of Problem-Based Learning

Source Virk et al., 2022

Elaborating upon a “problem” to be executed under the PBL methodology is a critical issue that helps determine whether or not the student's work in constructing their learning was a significant achievement (Tsai *et al.*, 2022; Wang *et al.*, 2023). Therefore, the situations with which PBL starts are a key factor for its optimal performance (Nomura *et al.*, 2023), and, in that vein, the adequate design of this educational resource is a key factor for the success of the method (Trullas *et al.*, 2022).

The pedagogical role played by the PBL “problem” is fundamental, similar to the axle of a wheel, which, in essence, is the center of gravity from which the entire teaching-learning process of the method revolves (Tadesse *et al.*, 2022; Servos *et al.*, 2023). Therefore, the following section outlines some methodologies for the elaboration of PBL “problem” case studies, which propose how they should be designed, including the situations circumscribed in this regard.

PBL “problem” case study design

It is difficult to deny the evidence that PBL is an active methodology with proven effectiveness in education (Zamir *et al.*, 2022; Fung *et al.*, 2023; Lang and Parkinson, 2023; Shad *et al.*, 2023). As a result, PBL has positioned itself as a preferred learning method, especially in the health sciences (Virk *et al.*, 2022; Wondie *et al.*, 2022). Thus, over time, several dimensions and/or typologies have been created around the design of case study “problems” for learning (Sun *et al.*, 2022). The most used dimensions in the design of PBL “problem” case studies are concentrated in three main groups:

1) Based on constructivist educational and learning principles.

2) Founded on philosophical bases of the unstructured or Brunerian type (Lara *et al.*, 2017), and, vice versa, of the structured or non-Brunerian type; and

3) They consist of a series of recommendations or general principles for their elaboration in the form of a checklist.

The 1st dimension designs PBL "problem" case studies based on the learning objectives set out in the course (Lang and Parkinson, 2023). These objectives are derived from the professional competencies that the students should achieve in a given subject or educational program (Sharma *et al.*, 2023). To make PBL "problem" case studies more appealing to students, Schmeltz and Ganesh (2022) suggest that, in addition to ensuring professional competencies, the "problems" should be related to real-life situations, so that students find more meaning in the work they are assigned.

The 2nd dimension designs PBL "problem" case studies based on structured and unstructured philosophical questions (Virk *et al.*, 2022)-that is to say-, structured "problems" with a high degree of detail can be encountered (Sarmiento *et al.*, 2022), including open "problems" that do not present central data (Bai *et al.*, 2023). Therefore, it is up to the students to identify the IA "problem" and, to a certain extent, define it (Trullas *et al.*, 2022; Tsai *et al.*, 2022).

The 3rd dimension designs PBL "problem" case studies based on a list of recommendations for the search of information (Tadesse *et al.*, 2022). Therefore, the structuring of such a "problem" should ensure the motivation of the student body (Zhang *et al.*, 2023) and lead them to make their own judgments (Alduraibi *et al.*, 2022), based on facts (Ali *et al.*, 2022a), which combine prior knowledge with new knowledge (Ali *et al.*, 2022b), thus promoting discussion (Allert *et al.*, 2022) and development of collaborative work (Almulhem and Almulhem, 2022).

The typologies around the design of PBL case study "problems" described above indicate that there is no single execution in the structuring/construction of such educational resources (Alt *et al.*, 2022; Álvarez *et al.*, 2022). Thus, the development of the method and its implementation under an educational context is made more difficult (Chan *et al.*, 2022). When striking a balance, there is a theoretical and practical difficulty in designing PBL "problem" case studies, especially when they must be adjusted to the didactic needs of a particular discipline (Brown, 2022; Bukumiric *et al.*, 2022; Chan *et al.*, 2022; Chi *et al.*, 2022).

PBL and the teaching of Veterinary Medicine and Animal Husbandry

Designing PBL "problem" case studies to be applied in VMAH teaching involves specialized work in two areas: i) a pedagogical mediation, and ii) a disciplinary guideline (Álvarez *et al.*, 2022; Micieli *et al.*, 2022). Both directions must find a point of connection that allows the correct structure of the phenomenon (Virk *et al.*, 2022) and, as a consequence, the success of the cognitive impact of the method (Tsai *et al.*, 2022). Thanks to the experience gained in the use of PBL as a teaching strategy in VMAH (Farnsworth, 1997; Rand and Baglioni, 1997; Rivarola and García, 2000; Cox, 2001; Howell *et al.*, 2002; Schoenfeld-Tacher *et al.*, 2005), the design of case studies has been identified as "problems", based on empirical knowledge of the profession (Lane, 2008; Schmidt *et al.*, 2008), and "problem" case study design, based on good practices of contextualized teaching (David and Irizarry, 2009; Tarlinton *et al.*, 2011; Putra *et al.*, 2016) as the correct structure to address the phenomenon. In this regard, it should be noted that the professional training of VMAH is influenced by two study paradigms: i) the Clinical and Biosecurity vision of animal medicine (Schmidt *et al.*, 2008), and ii) the Animal Husbandry production of productive species in each region (Lane, 2008). Therefore, it is necessary to reflect on how the integrative teaching of VMAH implicit in real scenarios and contexts should be. This brings necessities that connect the Clinical with Animal Husbandry (Álvarez *et al.*, 2022). The professionalizing areas of the educational programs should be conceived in such a way that a homogeneous teaching of the profession is performed (Lane, 2008; Schmidt *et al.*, 2008). Finally, several authors Chan *et al.* (2022); Ma (2022); Bai *et al.* (2023); Fung *et al.* (2023) have illustrated how PBL can transform the social and cultural environment of each curriculum. Central to this approach is the importance of the design of learning "problems" as the core around which educational resources that adequately integrate, define, and describe the teaching-learning needs within the context in which they are to be implemented.

Design of a PBL "problem" case study at the Faculty of Veterinary Medicine and Animal Husbandry of the University of Colima

In the case of FVMAH at the University of Colima (**Figure 2**), this is a curricular challenge that seeks to increase good educational and training practices in vital areas of the profession. PBL is an efficient teaching-learning process, where the faculty's students can appropriate the curricular content necessary to perform effectively in the labor field.

Box 2

Figure 2

Faculty of Veterinary Medicine and Animal Husbandry of the University of Colima

Source personal photo

The following is presented as an example: **Case. Campaign diseases and mandatory reporting in poultry for meat and egg production** (as a conceptual approach; **Figure 3**).

Frame of reference and key words of the case

The eradication of hunger represents a challenge that extends beyond the capacity of the **Food and Agriculture Organization** alone. Therefore, animal production professionals must understand the different **poultry production systems**, ensure the **five freedoms of animal welfare,** and consider many other aspects before starting the construction of a livestock production facility (e.g., **ecological components**, **biological components**, **host susceptibility**, **agent-host-environment interaction,** and **disease control programs**).

Box 3

Figure 3

Case: Campaign diseases and mandatory reporting in poultry for meat and egg production

Source personal photo

The **poultry sector** is pivotal in supplying animal protein to humans. Proper **record-keeping** in poultry production systems is necessary to facilitate quick and effective decision making. Professionals should attend continuing education courses (held in the country) to be up to date with the latest recommendation in antibiotic resistance, food safety, animal welfare, ethology, as well as **product traceability**. The latter is the field of professional practice where the owner of a livestock production center is entrusted to a VMAH, in order to track the production and distribution of the animal products in the market.

The VMAH in question receives the production records from his/her digital device through the application (*Chicken-App*); the livestock production center is located in an area with a high density of poultry. According to the **Mexican Official Standards (NOM) for domestic poultry**, the **biosecurity** criteria in the livestock production center have become a challenge, due to the proximity to other farms. The Chicken-App issues an alert when the reference parameters indicated by the company are exceeded (Ross®, Aviagen Group, Huntsville, AL, USA).

Problem-Oriented Medical Record of the case

Because mortality is apparently above average, the VMAH requests necropsy records from the person in charge, noting the following clinic pathological findings:

1. Sneezing, tracheal rales, conjunctivitis, nasal discharge, green diarrhea, incoordination, and torticollis in live birds; and
2. Hemorrhages in coronary fat, proventriculus, caecum in the small intestine and in the isthmus, facial edema, and button-like ulcers in the intestine in 80% of the birds inspected at necropsy.

Samples were taken for histopathological study, and the following lesions were found:

1. Nervous system: non-purulent encephalomyelitis with neuronal degeneration, glial cell foci, perivascular lymphocyte infiltration, and endothelial cell proliferation in cerebellum, medulla, midbrain, brain stem, and spinal cord;

2. Vascular system: myocarditis, focal myofiber necrosis, and mononuclear cell infiltration;

3. Respiratory system: tracheal and air sac edema, epithelial necrosis and desquamation, heterophilic infiltration, followed by hyperplasia of the epithelium and infiltration of lymphocytes and mononuclear cells;

4. Intestinal apparatus: necrosis and hemorrhages in lymphoid tissue and intestine, as well as hemorrhages in proventriculus associated with necrosis; and

5. Serology: the hemagglutination inhibition test was used, and a red button was formed at the bottom of the cell, as a consequence of the sedimentation of the non-agglutinated erythrocytes, due to the fact that the immunoglobulins in the serum reacted with the antigen inhibiting its capacity to agglutinate erythrocytes.

General objective of the case

To understand the different poultry production systems and their production parameters; to identify the most common diseases in broilers during development/finishing, with special attention to their clinical diagnosis.

Specific objectives of the case

- To understand the objectives and production systems of the Food and Agriculture Organization;

- To understand the five freedoms of animal welfare, good production practices, and the components that make up biosecurity;

- To identify the main epizootiological components to establish a differential and definitive diagnosis;

- To manage the different records used in livestock enterprises; and

- To create an immediate clinical history, as well as the description of the necropsy technique in the species, including the collection and sending of samples for complementary tests.

Curriculum of the case

On Table 1 shows the curriculum of the case.

Box 4

Table 1

Curriculum case: Campaign diseases and mandatory reporting in meat and egg production poultry

Module III Poultry instead: Problem-Based Learning (PBL) Faculty of Veterinary Medicine and Animal Husbandry of the University of Colima	
Knowledge (Animal Husbandry Components)	**Knowledge** (Clinical Components)
Know the origin, breeds, lines, current situation, and importance of poultry production and feeding systems in the national and international context.	Know the procedures for the diagnosis, treatment, control, nd prevention of the primary diseases of domestic fowl.
Know the technical specifications, as well as the biosecurity measures that must be complied with in poultry production facilities.	Recognize the clinical manifestations of birds with respiratory and digestive tract diseases.
Understand the guidelines for the husbandry and processing of meat and egg producing poultry.	Recognize the clinical manifestations of birds with nervous system disorders.
Identify factors affecting poultry health and disease, which serves as a rationale for the implementation of comprehensive health programs.	Recognize the clinical manifestations of birds with immune system disorders.

Case teaching activities: i) discussion and ii) research

1st block of activities

Activities for Discussion

- What are the objectives of the Food and Agriculture Organization?
- Identify the five freedoms of animal welfare and outline good production practices.
- Describe the different production systems, with reference to the Food and Agriculture Organization.
- Explain each of the different epizootiological components.
- What is the *per capita* consumption of eggs, chicken, and turkey meat?
- What is the volume of the national flock of broilers, layers, and turkeys?
- Discuss the locations, production cycles, and strains of Mexican poultry broiler, egg, and turkey production companies.
- Outline the different types of records that should be implemented in poultry companies, and provide an example for each one.
- Identify the names of different poultry scientific forums held in Mexico.
- Define traceability.
- Discuss the requirements for transportation of poultry products and by-products, according to NOM.
- How many countries are members of the World Organization for Animal Health. Is Mexico a member? Where is the permanent headquarters?
- List and describe the website of the global scientific network for Avian Influenza control; and
- What is the World Animal Health Information System?

Research Activities

- Design a comparative chart based on the official NOM for poultry, detailing the minimum required distances between production centers in different categories (parent stock, breeders, broilers, and hatcheries) from one farm to another.
- Create an epizootiological map of Mexico for field diseases, delineating the various animal health statuses by color coding.
- Profile a register of Poultry Production Unit under vaccination scheme for Avian Influenza;
- Prepare a Poultry Production Unit form.
- Using the World Organization for Animal Health website, identify the geographical areas with outbreaks of Highly Pathogenic Avian Influenza in the world, color, in red, the geographical areas of the world where outbreaks are occurring; and
- List the infectious diseases and infestations currently recognized by the World Organization for Animal Health.

2nd block of activities

- The diagnostic methodology for bird diseases is an orderly and systematic process that includes the following steps:

- Clinical history of the farm: Establish a clinical history that is divided into mediate and immediate.
- Clinical examination of the flock: Perform a clinical examination.
- Necropsy examination: Perform a necropsy technique on birds.
- Presumptive clinical diagnosis: Prepare a comparative table including: disease, affected system(s), dissemination, period, etiology, synonymies, signs, lesions, and productive effects; and
- Selection, conservation, and shipment of samples for Newcastle and Avian Influenza: Describe the criteria for selecting live birds for sample collection, and document examples of sample collection and conservation methods for different studies, including the official diagnostic techniques for Newcastle and Avian Influenza.

- Subsequently, as a complement:

- Diagnostic Techniques: What are the most commonly used diagnostic techniques for pathogen identification, including their immunological/biochemical principles?
- Euthanasia Techniques: Identify the main euthanasia techniques used in birds.
- Sample Size Determination: Based on the size of the flock and the NOM for poultry, determine the sample size required to be statistically representative.

Methods, criteria, and instruments for case evaluation

Table 2 shows the methods, criteria, and instruments for case evaluation.

Box 5

Table 2

Evaluation methods, criteria, and instruments. Case: Campaign diseases and mandatory reporting in poultry for meat and egg production

Methodology	**Criteria**	**Instrument**	**Value** (%)
Discussion	Reasoning, independent study, and interaction skills. From discussion activities.	Estimated scale.	10
Portfolio of Evidence	Evidence of introductory activities. Evidence of research activities.	Activity guide with description and value.	40
Integrating Product	Development of a biosafety program. Design of a table of recommendations with prevention, control, and treatment measures, as well as a guide of measures in cases of contingency, in the event of the presence of campaign diseases.	Heading.	30
Examination	Single exam type: National Evaluation Center for Higher Education (CENEVAL), objective, collegiate, sanctioned, and verified by the academy.	Examination questions.	20
		Total	100

About the method used

Examining the tutors' knowledge, based on their experience in teaching PBL to propose and exemplify the design of a "problem" case studies, along with analyzing the context of the profession implied an IA process. This is because the participants reflected on their own educational practice (Tsai *et al.*, 2022; Wang *et al.*, 2023). In addition, this activity was complemented with the application of a focus group guided by a semi-structured survey with the intention of obtaining more in-depth narrative data (Virk *et al.*, 2022; Wondie *et al.*, 2022). Due to the type of study, of a qualitative nature, an intentional and non-probabilistic sample was considered (Chan *et al.*, 2022), made up of 10 tutors representing 90% of teachers who develop PBL on campus and complied with the following inclusion criteria:

- They had more than three years of experience with PBL.

- They participated in the elaboration of cases for the development of the method in the last three years.
- The subjects were VMAH of initial training.
- They had professional and work experience in the academic dimensions of Clinical and Animal Husbandry; and
- Give your informed consent to be recorded from a personal interview.

The research was carried out in July 2022, the focus group was organized, in which the design process of the PBL “problem” case studies that were available was analyzed, subsequently, the knowledge of each tutor was reflected on based on their experience in teaching PBL on campus, to reflect and propose a design structure for these educational resources that would respond to the requirement of teaching the profession (David and Irizarry, 2009; Tarlinton *et al.*, 2011; Putra *et al.*, 2016).

The empirical information that resulted from the implementation of the focus group was systematized through a field diary, this activity gave meaning to the objective of the investigation and helped to build new meanings around the elaboration of PBL “problem” case studies from the experience on the teaching practice of each tutor and the analysis of the context of teaching the profession (Putra *et al*., 2016). Finally, from a narrative that valued the experience of the tutors and that sought to understand their ways of knowing, proposing and suggesting a methodology for the design of PBL “problem” case studies (Virk *et al.*, 2022; Wondie *et al.*, 2022), topics were outlined, related to this phenomenon, to the extent that the information collected was investigated and adjusted, which allowed us to approach a prototype for the elaboration of educational resources for the development of the PBL method.

Discussion and results

Table 3 presents a structure of PBL "problem" case studies as a methodological suggestion for its design, that emerged from the tutors’ reflections during the focus group.

Box 6

Table 3

Structure of PBL "problem" case studies as a methodological suggestion for its design

No.	Structure	Design, writing and content
1	Title of the "problem" case	Name of the disease or definitive diagnosis.
2	General context	Reference framework with key concepts for the development of the case. General ideas as a clinical record. Keywords of the theoretical contents of the case.
3	Animal Husbandry context	Description of Animal Husbandry and/or Animal Management elements e.g., housing conditions, pasture management, genetics of biological material, animal health measures, prophylaxis, productive parameters, etc.
4	Clinical context	Description of Clinical and Pathological elements e.g., general signology, necropsy, complementary laboratory tests, physiological constants, auscultation, forms and types of respiration, diarrhea, psychomotor imbalances, etc.
5	General objective	Statement that indicates the learning, skills or knowledge that the development of the case-problem is intended to achieve in accordance with the curriculum.
6	Specific objectives	Short statements that allow the fulfillment of the general objective.
7	Guiding questions	Questions whose purpose is to guide the construction of learning objectives and the training route in the search for information and construction of learning.
8	Supplementary tests	Cabinet tests and laboratory tests e.g., complete blood counts, blood chemistry, general urinalysis, blood smear, skin scraping, impressions, coproparasitology, necropsy, biopsy, histopathology, PCR, immunofluorescence, immunohistology, etc.
9	Curriculum	You must point out the curricular contents that it includes.
10	Activity system	Learning activities: teaching and research that will be developed during the case and that will give evaluable results or products.
11	Evaluation system	Set of methods, criteria, instruments (qualitative and quantitative) and percentages to achieve a numerical evaluation.
12	Bibliography	Basic and complementary reference literature, as well as web pages and specialized magazines.

The information collected through the focus group allowed us to analyze the tutor's practice in relation to their experience in the preparation of PBL "problem" case studies.

This process mobilized a spectrum of their empirical and conceptual knowledge around the development of this didactic strategy? Achieving with this, an innovative, practical and instrumental design, structured from didactic elements inherent to the two training areas of the VMAH, the Clinical and Animal Husbandry.

Three central findings that must be present in the structuring and design of a PBL "problem" case studies were identified:

i) The Animal Husbandry context must contain descriptive elements of the immediate regional environment e.g., geography, climate, location and the species(s) involved in the case e.g., breed, genetics, production parameters, management, housing conditions (Howell *et al*., 2002; Schoenfeld-Tacher *et al*., 2005). In order to address animal health from an approach that links the environment with the medical perspective;

ii) The Clinical context must include adequate pathological elements and circumscribed to the PBL "problem" case studies to clearly define the disease (Lane, 2008; Schmidt *et al*., 2008). This guiding information will also make it possible to prepare presumptive and differential diagnoses to accurately reach the definitive diagnosis and propose the correct treatment; and

iii) The design of PBL "problem" case studies must be accompanied by a didactic system that clearly shows the formative spectrum of the discipline, the curricular contents, the learning activities and the evaluation criteria (Tarlinton *et al*., 2011; Putra *et al*., 2016). These elements must be inserted in the pedagogical framework of the needs of the profession and the school context, to ensure the achievement of the teaching-learning objectives.

Assess the design of PBL "problem" case studies

In Veterinary education, PBL represents one of the most popular and flexible teaching systems, which cultivates student self-direction skills (Micieli *et al.*, 2022). Its proper application replicates real-life experiences (Wang *et al.*, 2023), that stimulate the integration of knowledge and learning skills required for a Veterinary medical education (Álvarez *et al.*, 2022).

The PBL process has been described as: fun, interesting, motivating, and stimulating by the student body (Alduraibi *et al.*, 2022; Ali *et al.*, 2022a; Ardoin *et al.*, 2022). Its success depends on the careful selection of PBL "problem" case studies (Bains *et al.*, 2022). On the integration of knowledge acquired by students throughout the curriculum (Bisbee *et al.*, 2022), it is said to awaken in students: i) critical thinking, ii) the ability to problem-solve, iii) independent learning, and iv) a holistic approach to a case (Brown, 2022; Bukumiric *et al.*, 2022; Chan *et al.*, 2022).

PBL has long been highlighted as an attractive curricular alternative for Veterinary education (Virk *et al.*, 2022), which is why several Veterinary schools worldwide have integrated PBL into their curricula on a permanent basis (Rivarola and García, 2000; Cox, 2001; Howell *et al.*, 2002; Schoenfeld-Tacher *et al.*, 2005; Lane, 2008; Schmidt *et al.*, 2008; David and Irizarry, 2009; Tarlinton *et al.*, 2011; Putra *et al.*, 2016).

A curriculum based almost entirely on PBL in medical education schools is feasible and could encourage students to improve their autonomous learning skills, acquire adequate knowledge in basic sciences, and experience positive effects on learning clinical medicine (Bai *et al.*, 2023; Sharma *et al.*, 2023; Zhang *et al.*, 2023). However, better preparation of the student body for integrated learning of basic and clinical sciences, and further training of PBL tutors, are still needed to improve the effectiveness of tutorial discussions.

Conclusions

The purpose of this paper was to describe and exemplify a theoretical-methodological proposal for designing case studies used in PBL.

We analyzed the profession and the empirical knowledge of teachers applying this proposal. From this perspective, the structure of the case studies' "problems" was identified as the central characteristic of PBL. The educational context of Veterinary Medicine and Animal Husbandry was examined, highlighting the importance of correctly designing "problems" that reflect real-world contexts in teaching. The primary result described a methodological proposal for the design as an example of case “Campaign diseases and mandatory reporting in poultry for meat and egg production”. With this conceptual approach, it is feasible that the proposal will provide success in other settings, and according to the educational context of the school. It allows teachers to reconsider the didactic system of the method, ultimately enabling the adaptation of the implementation to each specific teaching situation. In conclusion, the design of carefully selected "problem" cases is valued for its role as an active methodology. This approach aims to ensure an efficient process whereby students can engage with the curriculum in a manner that prepares them effectively for their future careers.

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence in this chapter.

Author contribution

Lozano-Salmorán, Edgar Fidel: Writing original draft.
Hernández-Rivera, Juan Augusto: Review and correction.
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Availability of data and materials

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Abbreviations

FVMAH	Faculty of Veterinary Medicine and Animal Husbandry
IA	Investigation-Action
PBL	Problem-Based Learning
VMAH	Veterinary Medicine and Animal Husbandry

References

Antecedents

Chan, S. C. C., Gondhalekar, A. R., Choa, G., and Rashid, M. A. [2022]. Adoption of Problem-Based Learning in medical schools in non-western countries: a systematic review. Teaching and Learning in Medicine. 1-12.

Sharma, S., Saragih, I. D., Tarihoran, D., and Chou, F. H. [2023]. Outcomes of Problem-Based Learning in nurse education: a systematic review and meta-analysis. Nurse Education Today. 105631.

Trullas, J. C., Blay, C., Sarri, E., and Pujol, R. [2022]. Effectiveness of Problem-Based Learning methodology in undergraduate medical education: a scoping review. BMC Medical Education. 104-109.

Basics

Alduraibi, S. K., Sadik, A. E., Elzainy, A., Alsolai, A., and Alduraibi, A. [2022]. Medical imaging in Problem-Based Learning and impact on the students: a cross-sectional study. Journal of the Pakistan Medical Association. 1731-1735.

Ali, K., Daud, A., Ba Hattab, R., Philip, N., Matoug-Elwerfelli, M., Anweigi, L., Al Khabuli, J., and Du, X. [2022a]. Development of self-regulation amongst dental students in Problem-Based Learning curricula: a qualitative study. European Journal of Dental Education. 1-10.

Ali, K., Du, X., and Lundberg, A. [2022b]. Does Problem-Based Learning facilitate enactment of learner agency in undergraduate dental curricula? a Q study. European Journal of Dental Education. 7-11.

Allert, C., Dellkvist, H., Hjelm, M., and Andersson, E. K. [2022]. Nursing students' experiences of applying Problem-Based Learning to train the core competence teamwork and collaboration: an interview study. Nursing Open. 569-577.

Almulhem, M. A., and Almulhem, J. A. [2022]. Evaluation of Problem-Based Learning implementation in a College of Medicine, Kingdom of Saudi Arabia: a cross sectional comparative study. BMC Medical Education. 311-320.

Alt, D., Weinberger, A., Heinrichs, K., and Naamati-Schneider, L. [2022]. The role of goal orientations and learning approaches in explaining digital concept mapping utilization in Problem-Based Learning. Current Psychology. 1-16.

Álvarez, E., Nichelason, A., Lygo-Baker, S., Olin, S., Whittemore, J., and Ng, Z. [2022]. Virtual clinics: a student-led, Problem-Based Learning approach to supplement veterinary clinical experiences. Journal of Veterinary Medical Education. e202101444.

Ardoin, T. W., Hamer, D., Stumpf, M., and Miles, L. [2022]. Integrating Problem-Based Learning into an internal medicine residency curriculum. Ochsner Journal. 324-343.

Bai, S., Zhang, L., Ye, Z., Yang, D., Wang, T., and Zhang, Y. [2023]. The benefits of using atypical presentations and rare diseases in Problem-Based Learning in undergraduate medical education. BMC Medical Education. 93-104.

Bains, M., Kaliski, D. Z., and Goei, K. A. [2022]. Effect of self-regulated learning and technology-enhanced activities on anatomy learning, engagement, and course outcomes in a Problem-Based Learning program. Advances in Physiology Education. 219-227.

Bisbee, C. A., Vaccaro, M. J., and Awan, O. A. [2022]. Problem-Based Learning in radiology education: benefits and applications. Academic Radiology. 45-52.

Brown, G. [2022]. Proposing Problem-Based Learning for teaching future forensic speech scientists. Science & Justice. 669-675.

Bukumiric, Z., Ilic, A., Pajcin, M., Srebro, D., Milicevic, S., Spaic, D., Markovic, N., and Corac, A. [2022]. Effects of Problem-Based Learning modules within blended learning courses in medical statistics - a randomized controlled pilot study. PLoS One. e0263015.

Chi, M., Wang, N., Wu, Q., Cheng, M., Zhu, C., Wang, X., and Hou, Y. [2022]. Implementation of the Flipped Classroom combined with Problem-Based Learning in a medical nursing course: a quasi-experimental design. Healthcare. 1-10.

Cox, J. E. [2001]. Veterinary education and Problem-Based Learning. The Veterinary Journal. 84-87.

David, J., and Irizarry, K. J. [2009]. Using the PubMatrix literature-mining resource to accelerate student-centered learning in a veterinary Problem-Based Learning curriculum. Journal of Veterinary Medical Education. 202-208.

Farnsworth, C. C. [1997]. Measuring the effects of Problem-Based Learning on the development of veterinary students' clinical expertise. Academic Medicine. 552-554.

Fung, J. T. C., Chan, S. L., Takemura, N., Chiu, H. Y., Huang, H. C., Lee, J. E., Preechawong, S., Hyun, M. Y., Sun, M., Xia, W., Xiao, J., and Lin, C. C. [2023]. Virtual simulation and Problem-Based Learning enhance perceived clinical and cultural competence of nursing students in Asia: a randomized controlled cross-over study. Nurse Education Today. 105721.

Howell, N. E., Lane, I. F., Brace, J. J., and Shull, R. M. [2002]. Integration of Problem-Based Learning in a veterinary medical curriculum: first-year experiences with application-based learning exercises at the University of Tennessee College of Veterinary Medicine. Journal of Veterinary Medical Education. 169-175.

Lane, E. A. [2008]. Problem-Based Learning in veterinary education. Journal of Veterinary Medical Education. 631-636.

Lang, K., and Parkinson, B. [2023]. Problem-Based Learning in nurse education. Evidence-Based Nursing. 10-16.

Lara, V., Ávila, J. and Olivares, S. [2017]. Critical thinking development through the implementation of problem-based learning. Psicologia Escolar e Educacional. 65-77.

Ma, C. W. [2022]. How to advance medical education using journal articles? Insight from Problem-Based Learning. GMS Journal for Medical Education. Doc48.

Micieli, F., Valle, G. D., Del Prete, C., Ciaramella, P., and Guccione, J. [2022]. The use of virtual Problem-Based Learning during COVID-19 pandemic emergency: veterinary students' perception. Veterinary Sciences. 1-12.

Nomura, O., Soma, Y., Kijima, H., and Matsuyama, Y. [2023]. Adapting the motivated strategies for learning questionnaire to the Japanese Problem-Based Learning context: a validation study. Children. 14-21.

Putra, T. A., Hezmee, M. N., Farhana, N. B., Hassim, H. A., Intan, S. A. R., Lokman, I. H., Hamali, A. Y., Salisi, M. S., Ghani, A. A., Shahudin, M. S., Qayyum, M. A., Hafandi, A., Speare, R., and Fenwick, S. G. [2016]. The application of One Health concept to an outdoor Problem-Based Learning activity for veterinary students. Veterinary World. 955-959.

Rand, J. S., and Baglioni, A. J., Jr. [1997]. Subject-based Problem-Based Learning in the veterinary science course at the University of Queensland. Australian Veterinary Journal. 120-125.

Rivarola, V. A., and García, M. B. [2000]. Problem-Based Learning in veterinary medicine: protein metabolism. Biochemical Education. 30-31.

Sarmiento, R. J., Aya, P. P. A., and Perdomo, O. J. [2022]. Proposal of design and innovation in the creation of the Internet of medical things based on the CDIO model through the methodology of Problem-Based Learning. Sensors. 12-22.

Schmeltz, M. T., and Ganesh, C. [2022]. Improving the capacity and diversity of local public health workforce to address climate impacts to health through community partnerships and Problem-Based Learning. Frontiers in Public Health. 1090129.

Schmidt, P. L., Trevejo, R. T., and Tkalcic, S. [2008]. Veterinary public health in a Problem-Based Learning curriculum at the Western University of Health Sciences. Journal of Veterinary Medical Education. 212-218.

Schoenfeld-Tacher, R., Bright, J. M., McConnell, S. L., Marley, W. S., and Kogan, L. R. [2005]. Web-based technology: its effects on small group “Problem-Based Learning" interactions in a professional veterinary medical program. Journal of Veterinary Medical Education. 86-92.

Servos, U., Reiss, B., Stosch, C., Karay, Y., and Matthes, J. [2023]. A simple approach of applying blended learning to Problem-Based Learning is feasible, accepted and does not affect evaluation and exam results-a just pre-pandemic randomised controlled mixed-method study. Naunyn-Schmiedeberg's Archives of Pharmacology. 139-148.

Shad, M. U., Onwuameze, O., Sioson, K., Khan, A. H., Khalid, K., and Glick, I. [2023]. Problem-Based Learning in Psychopharmacology. Academic Psychiatry. 111-112.

Showstark, M., Joosten-Hagye, D., Wiss, A., Resnik, C., Embry, E., Zschaebitz, E., Symoniak, M. R., Maxwell, B., Simmons, A., and Fieten, J. [2023]. Results and lessons learned from a virtual multi-institutional Problem-Based interprofessional Learning approach: The VIPE program. Journal of Interprofessional Care. 164-167.

Staff, P. O. [2023]. Correction: assessing the attitude and Problem-Based Learning in mathematics through PLS-SEM modeling. PLoS One. e0280909.

Sun, M., Chu, F., Gao, C., and Yuan, F. [2022]. Application of the combination of three-dimensional visualization with a Problem-Based Learning mode of teaching to spinal surgery teaching. BMC Medical Education. 840-850.

Tadesse, S. G., Tadesse, D. G., and Dagnaw, E. H. [2022]. Problem-Based Learning approach increases the academic satisfaction of health science students in Ethiopian universities: a comparative cross-sectional study. BMC Medical Education. 334-340.

Tarlinton, R. E., Yon, L., Klisch, K., Totemeyer, S., and Gough, K. C. [2011]. Confidence as a barrier to the use of Problem-Based Learning in veterinary undergraduate students. Journal of Veterinary Medical Education. 305-310.

Tsai, C. L., Chiu, Y. L., Chao, C. T., Lin, M. W., Ho, C. C., Chen, H. L., Sheu, B. C., Hsu, C., and Yang, C. W. [2022]. Effectiveness of tutor shadowing on faculty development in Problem-Based Learning. BMC Medical Education. 564-570.

Virk, A., Mahajan, R., and Singh, T. [2022]. Conceptualizing Problem-Based Learning: an overview. International Journal of Applied and Basic Medical Research. 1-3.

Wang, A., Xiao, R., Zhang, C., Yuan, L., Lin, N., Yan, L., Wang, Y., Yu, J., Huang, Q., Gan, P., Xiong, C., Xu, Q., and Liao, H. [2022]. Effectiveness of a combined Problem-Based Learning and flipped classroom teaching method in ophthalmic clinical skill training. BMC Medical Education. 487-493.

Wang, X., Sun, D., Cheng, G., and Luo, H. [2023]. Key factors predicting Problem-Based Learning in online environments: Evidence from multimodal learning analytics. Frontiers in Psychology. 1080294.

Webster, A., Metcalf, A., Kelly, L., Bisesi, A., Marnik-Said, M., Colbeck, C., Marine, R., Vinces, M., Campbell, A., and Allen, T. [2022]. Undergraduates' lived experience of Project-Problem-based Learning in introductory Biology. Advances in Physiology Education. 162-178.

Wondie, K. Y., Endale, Z. M., Abrahim, A. H., Asefa, A. A., Alamneh, A. A., Berihun, B. K., Adamu, B. K., Selamsew, B. A., Kebede, A. A., and Tsega, N. T. [2022]. Factors affecting knowledge and attitude towards hybrid Problem-Based Learning curriculum among academicians of the University of Gondar, Northwest Ethiopia. Advances in Medical Education and Practice. 685-695.

Wong, F. M. F., and Kan, C. W. Y. [2022]. Online Problem-Based Learning intervention on self-directed learning and problem-solving through group work: a waitlist controlled trial. International Journal of Environmental Research and Public Health. 23-30.

Wormley, M. E., Romney, W., Veneri, D., and Oberlander, A. [2022]. Doctoral physical therapy students' increased confidence following exploration of active video gaming systems in a Problem-Based Learning curriculum in the United States: a pre- and post-intervention study. Journal of Educational Evaluation for Health Professions. 7-16.

Xie, H., Wang, L., Pang, Z., Chen, S., Xu, G., and Wang, S. [2022]. Application of Problem-Based Learning combined with a virtual simulation training platform in clinical biochemistry teaching during the COVID-19 pandemic. Frontiers in Medicine. 985128.

Xu, X., Wang, Y., Zhang, S., and Liu, F. [2022]. Performance of Problem-Based Learning based image teaching in clinical emergency teaching. Frontiers in Genetics. 931640.

Zamir, S., Yang, Z., Wenwu, H., and Sarwar, U. [2022]. Assessing the attitude and Problem-Based Learning in mathematics through PLS-SEM modeling. PLoS One, 17(5), e0266363.

Zhang, F., Wang, H., Bai, Y., and Zhang, H. [2022]. A bibliometric analysis of the landscape of Problem-Based Learning research (1981-2021). Frontiers in Psychology. 828390.

Zhang, X., Zhang, G., Liu, J., Song, X., Li, M., Zhang, Y., Hao, J., Wang, C., and Li, H. [2023]. Cross-sectional study of the quality of randomized control trials on Problem-Based Learning in medical education. Clinical Anatomy. 151-160.

Zheng, B., and Wang, Z. [2022]. Near-peer teaching in Problem-Based Learning: perspectives from tutors and tutees. PLoS One. e0278256.

Zhu, M., and Zhang, K. [2022]. Promote collaborations in online Problem-Based Learning in a user experience design course: educational design research. Education and Information Technologies. 1-19.