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Review

Teaching Clinical Reasoning to Veterinary Medical Learners with a Case Example

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Abstract: Clinical reasoning is an essential competence of veterinary graduands. It is a complex competence with cognitive, metacognitive, social, and situational activities. The literature on clinical reasoning in veterinary medical education is relatively scarce or focused on theoretical rather than practical applications. In this review, we address the practicality of teaching clinical reasoning to veterinary learners utilizing a practical example of a cow with allergic rhinitis. Learners should be guided through all the domains of clinical reasoning, including concepts, data collection and analysis, take action, and reflection on an encounter. Each of these domains needs to be clearly but concisely explained and practiced repeatedly by learners throughout the veterinary curricula. The teaching of clinical reasoning should start as early in the curriculum as possible, preferably in the pre-clinical years, with a gradual scaffolding and building of complexity before work-based learning begins, with an increase in demanding for advanced clinical reasoning competence. The teaching of clinical reasoning is best performed in specialized sessions and continued as a horizontally and vertically integrated activity.

Keywords: clinical teaching; veterinary learners; instructors; clinical encounter; deep learning

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1. Introduction

Accurate diagnosis and appropriate management of the clinical encounter are essential to the provision of quality veterinary medical services. Diagnostic accuracy is heavily reliant on the ability to reason based on the clinical presentation of the patient [1]. Most clinical reasoning errors are not the result of a lack of knowledge but rather reflect the complexity of the clinical presentation coupled with minor to major faults in cognition or contextualization of the clinical encounter, and the defective synthesis of information [1–11]. Errors in clinical reasoning, particularly in diagnosis, in human medicine range between 4% and 25% [3,12–14], with errors in adherence to best practice reaching up to 45% [3]. Some 30–70% of these errors are preventable [6,13]. These error proportions are probably similar in veterinary medical practice [15], emphasizing the importance of learning the clinical reasoning process for veterinary learners [16–22]. Clinical reasoning is also considered an essential requirement by many accreditation bodies of veterinary medical educators [23–25].

The learning and teaching of clinical reasoning has been an area of significant importance in other medical fields [26], starting with the pioneering work of Ledley and Lusted in the 1950s [27], followed by the seminal work of Elstein in the 1970s [28]. Instructors and learners in various medical fields, including veterinary medicine, have stated that the learning and teaching of clinical reasoning are challenging (Table 1). The challenge derives from the complexity of what the clinical reasoning process entails [9,10,29,30]. However, the process can be simplified into three basic concepts—clinical reasoning as a (1) cognitive and metacognitive activity; (2) contextually situated activity; and (3) socially mediated activity [12,31,32].

Table 1. Reasons for finding teaching or learning clinical reasoning challenging.

Instructors	Learners
Ambiguity and complexity of the process [22,30,33–35] Being at level of educator in (O)RIME and using a lot of intuitive types of clinical reasoning [36] Curriculum design lacking stimulation of storage of knowledge in clinically relevant manner [30,36–38] Difficulty in explanation of cognitive processing of information to learner/s [34,36,37] Lack of awareness of clinical reasoning concepts [35] Lack of consideration of the clinical reasoning process when dealing with clinical encounters [39] Lack of training in teaching clinical reasoning [30,34,35,37] Relative lack of literature in journals frequently read by instructors involved with clinical teaching that are not directly employed in academia [34,36]	Ambiguity and complexity of the process [22,30,33,35] Being at levels lower than educator and using a lot the analytical type of clinical reasoning [36] Being unfamiliar with the work-based learning context Belief that clinical reasoning is 'an art' [36] Content-loaded curriculum [38] Curriculum design lacking stimulation of storage of knowledge in clinically relevant manner [30,36–38] Lack of 'real-life' situations training during theoretical portion of the curriculum [40] Lack of awareness of clinical reasoning concepts [35] Lack of confidence [38] Lack of explanation of cognitive processing of information by instructor/s [37,39,41] Lack of opportunities to practice clinical reasoning in safe environment [37,38] Lack of qualified instructors in teaching clinical reasoning [37,38] Lack of specific teaching of clinical reasoning processes [30,38,40] Late introduction of clinical reasoning into the curriculum [40]

We found scarce literature related to teaching clinical reasoning related to veterinary medical education and, as such, the statements used will be predominantly evidence-based literature related to medical professions. The clinical instructor (instructor hereafter) plays a double role in the teaching of clinical reasoning, a clinician and a pedagogist [35]. We would like to stress that our recommendations in teaching clinical reasoning are dependent on the appropriate training of these instructors in clinical teaching, and, in particular, clinical reasoning.

2. Background of Clinical Reasoning

Each clinical encounter is solved by following the clinical reasoning cycle presented in Figure 1 (information from [5,33,42]). The cycle is composed of eight didactically distinct stages. In clinical practice, the eight stages are not exclusive and may occur in any combination concurrently, and, until a decision is made, a learner may move back and forth between them.

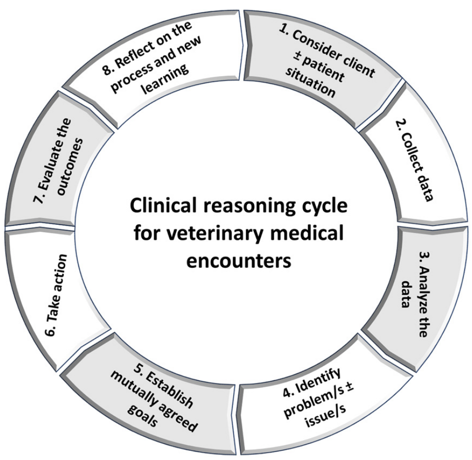

Figure 1. Clinical reasoning cycle (8 stages) modified to suit veterinary medical encounters (adapted from [43]). Stage 1 should allow the veterinary medical learner to gain an initial impression about the

encounter. This will allow hypothesis-driven data collection and analysis (stages 2 and 3). Information gathered and analyzed in the first 3 stages should allow for the identification of key features and issues (stage 4) that will be used in the generation of mutually agreed goals (stage 5) and managing the encounter (stage 6). When an action has been completed, the success of the overall measurable outputs of the encounter should be evaluated (stage 7). Each stage should stimulate self-reflection and learning issues (as applicable; stage 8), completing the clinical reasoning cycle.

To explain the stages of the clinical reasoning cycle as applicable to veterinary medical education, hereafter, an example of a bovine clinical encounter will be used (Table 2). In this table and hereafter, italicized text will mean a verbal communication statement.

Table 2. Stages of clinical reasoning applicable to veterinary medical education using a clinical encounter of a cow with allergic rhinitis.

Stage	Activity/Element	Example of Veterinary Medical Learner's Synthesis of Information
Consider client ± patient situation	NA	Mr John Do is an experienced dairy farmer and has presented Daisy, a 4-year-old Jersey cow, that has been snorting and making noise on taking air though the nose for over 3 weeks, with both nostrils being affected. Daisy is otherwise 'healthy'. Mr. Do just came back from holidays and she is still the same.
Collect data	Presenting problem	Snorting for over 3 weeks
	Health interview	Immunized against common bovine respiratory disease (BRD) pathogens. Member of 450 cow herd (no other sick cows).
	Various examination steps	Hot summer. Environment and husbandry—no abnormalities detected (NAD). Bright and alert. Temperature, pulse, and respiration (TRP) + rumination—NAD. Inspiratory stridor. Increased respiratory effort. Air flow into nostrils decreased. Nasal flaring. Copious orange nasal discharge. No signs of pain. Capillary refill time (CRT) < 2 s.
	Ancillary examination techniques/tests	Swab taken from the nasal discharge, negative on culture.
Analyze the data	Review data/problem representation	Mr. John Do is an experienced dairy farmer and has presented Daisy, a 4-year-old valuable Jersey cow, with chronic inspiratory dyspnea associated with bilateral, sterile, copious, mucoid, and non-purulent rhinorrhea. No other abnormalities detected in her, the other herd members, or the environment and management.
	Review context	Client concerned about Daisy's animal welfare. Valuable cow for the client.
	Problem identification	Copious nasal discharge that results in a partial blockage of the nasal cavity/upper airway.
	Recall knowledge	Exemplars/illness scripts/prototypes/semantic qualifiers Inspiratory dyspnea is common with partial or complete blockage of the upper airway.
	Interpretation	Upper airway blockage resulting in inspiratory dyspnea.
	Discrimination	Daisy is not febrile and does not appear to have generalized malaise. However, her respiratory effort is increased.
	Relating	Although Daisy has inspiratory dyspnea, her overall oxygenation does not seem to be affected. CRT < 2 s
	Inferring	Daisy's oxygenation is probably OK whilst at rest, as she takes air through the mouth. It is likely to be compromised with increased level of activity.
	Matching	Non-purulent, copious rhinorrhea in cattle is often of allergic nature.
	Predicting	Even without treatment, Daisy seems not to be affected, and allergic conditions are likely to self-cure when the allergens disappear.

Table 2. *Cont.*

Stage	Activity/Element	Example of Veterinary Medical Learner's Synthesis of Information
Establish mutually agreed goals	NA	Daisy's wellbeing is marginally affected. The most likely diagnosis is allergic rhinitis, which is not easily treated. We agree that the best course of action is to continue monitoring Daisy at every milking and with any sign of discomfort, you will contact us. If Daisy's discomfort increases, we may consider prolonged administration of corticosteroids. Are we all on the same page?
Take action	NA	In this encounter, the best course of action is regular monitoring by the client.
Evaluate	NA	Daisy significantly improved a month later. As her condition is likely to recur in future years, the client may consider culling at the end of the milking season. Additionally, the disorder is characterized by suspected familial predisposition.
Reflection and new learning	NA	It would be good to be more confident in the diagnosis of allergic rhinitis by checking for eosinophilia and/or cytologic examination of the nasal discharge for eosinophils. Regular monitoring without a treatment intervention may be suitable in encounters where animal welfare or the image of the industry are not affected. Heredity of disorders in production animals may be important for the client.

2.1. Types of Clinical Reasoning

In the opinion of the authors of this article, clinical reasoning within the cognitive and metacognitive concept may be presented as a scale from completely intuitive to completely analytical. The **intuitive type of clinical reasoning** is based more on cognitive short-cuts (e.g., heuristics) [44,45] than real intuitive (gestalt effect) processes. Therefore, even the intuitive type of clinical reasoning is not really equal to the real meaning of intuitive ('judgment made quickly and without apparent effort'). Common synonyms for the intuitive type of reasoning include experiential, 'gut feeling', non-analytical, inductive, tacit, or system/type 1 clinical reasoning.

The **analytical type of clinical reasoning** is more deliberate, explicit, purposeful, rational, and slow and focusses on hypotheses generation and deductive reasoning that is closer to the cognitive processes associated with problem solving. In the past, it was believed that this type of clinical reasoning was less prone to errors [9], but nowadays it is accepted that the proportion of errors using this type of clinical reasoning are associated with the expertise of the learner, the context, and the stages involved in the clinical reasoning cycle. Common synonyms for the analytical type of clinical reasoning include deductive, deliberate, rational, rule-governed, or system/type 2 clinical reasoning.

In clinical practice, most of the clinical reasoning happens somewhere between the two types of clinical reasoning, being referred to as **dual type of clinical reasoning**. Common synonyms for the dual type of clinical reasoning include dual-/mixed-process clinical reasoning/theory.

Our presentation hereafter (Figure 2; [5,6,13,14,17,18,26,30,31,36–38,42,45–53]) will reflect the universal clinical reasoning theory [26] and the dual-process theory [42,44,45]. In our opinion, clinical reasoning types are not dichotomous (e.g., analytical or intuitive/novice or expert) but, in fact, related to the type of changes with exposure to work-based practice and/or additional education [5,29,42,48]. There are several other factors that affect the choice of clinical reasoning used by the learner, and these will be discussed below.

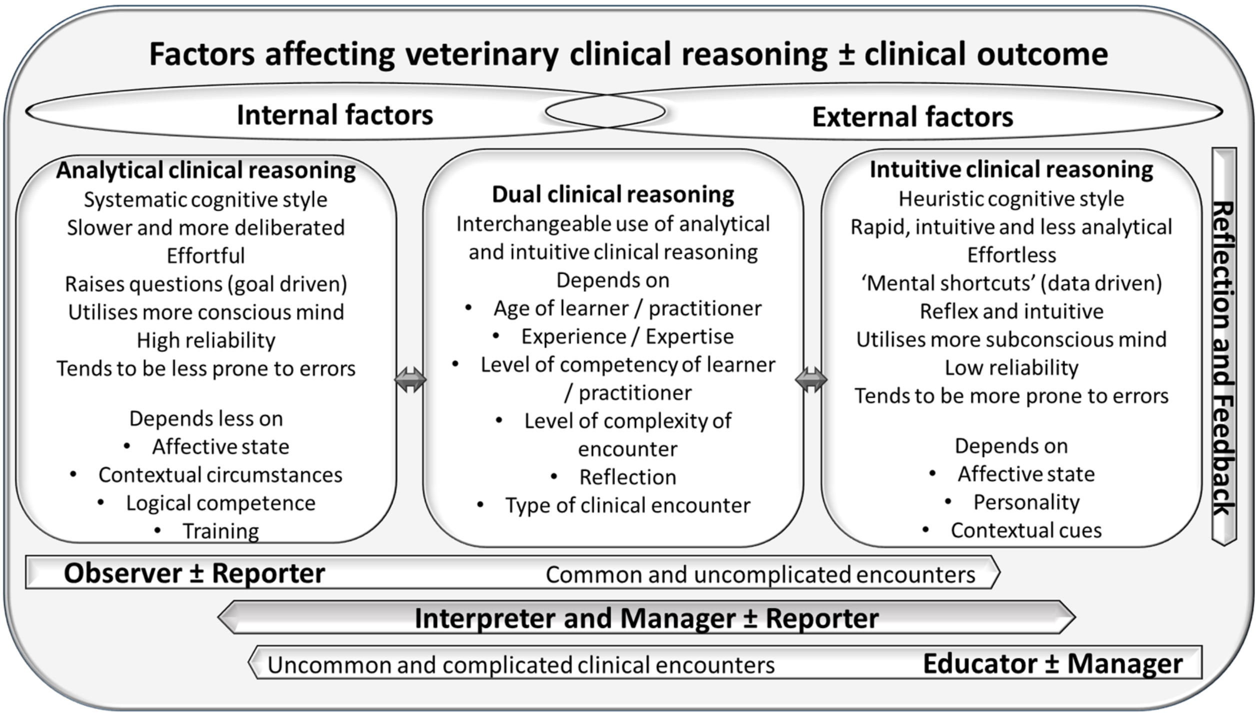

Figure 2. Types of clinical reasoning and factors affecting the type used in a particular clinical encounter in veterinary medicine. Switching between the types of clinical reasoning depends on the variety of factors applicable to the encounter (e.g., external/internal factors, level of development of the learner, relative complexity/frequency of the encounter, and the use of reflective practice or receiving effective feedback).

In education practice, as clinical reasoning requires some understanding of 'normality' and 'abnormality' in the morphology and function of the body, it is most likely that the scale moves from analytical in observers and reporters to intuitive in managers and educators [32,54–56]. However, in veterinary medical science, nothing is absolute, and this also applies to the type of clinical reasoning. The level of the development of the learner is not the only factor affecting the choice of the type of clinical reasoning.

For the analytical type of clinical reasoning, collected information should be synthesized in a format that follows some logical rules (e.g., causal relationship, hypothetico-deductive model, pathophysiological principles, relative frequency, and threshold concept) [26,27,37,42,45,46,48,49,55–57]. The retrieval of mental representation is highly dependent on the capacity of the working memory of the learner [53]. It is usually quite an effortful process and significantly reliant on metacognitive skills by the learner. Scans of brains of people undertaking the analytical type of reasoning have shown differences in the areas activated compared to the intuitive types [11]. Additionally, the analytical type is time-demanding. If all clinical encounters were to be carried out using the hypothetico-deductive model only, it would be difficult to go through more than 1–2 encounters per day (sometimes week) [11,56]. Therefore, the analytical type as the only approach to clinical reasoning is not sustainable. The analytical type of clinical reasoning is usually used in higher complexity, non-typical presentations and uncommon encounters. Early development learners (observer and reporter), and less experienced practitioners, or experts when working out of their usual field, frequently use the analytical type of clinical reasoning [3,17,26,32,42,45,48,54,57]. It is also often applied to clinical encounters with comorbidities or rapidly evolving cases [58,59].

For the intuitive type of clinical reasoning, there must be a direct association between information collected during the encounter and a same/similar mental representation in the mind of the learner [26,37,45,48,50,53]. The likelihood of the retrieval of the mental representation is proportional to the strength of the association (e.g., complexity and frequency of the encounter, field of work, polymorphism of disorders, and prior experience) and the strength of the context [17,45,53,54]. It is usually relatively effortless and dependent on the heuristic recall of mental representation for the disorder/issue/problem by the learner. The intuitive type of clinical reasoning is usually used in common, lower complexity, and typical presentation encounters. Advanced development learners (manager and educator), and experienced practitioners, or experts when working within their usual field, frequently use the intuitive type of clinical reasoning. Usually, 'simple' encounters are presented with pathognomonic or typical signs and syndromes, whilst more 'complex' encounters lack them [26].

Using the dual type of clinical reasoning and switching from intuitive to analytical or analytical to intuitive is usually more easily achieved by 'experts', being manager and educator levels in learners or practitioners experienced in a particular field [5,17,42,57,60]. This capacity of switching between types of clinical reasoning allows for the continuous adaptation and application of knowledge in solving novel and complex encounters [17,26,55].

2.2. The Role of Context in Clinical Reasoning

Clinical reasoning competence of the learner is influenced by external and internal context (the so-called 'situated cognition theory'; Table 3). External factors are related to the client, encounter, patient, and others, whilst internal factors are related to the learner [12,61,62]. In real-life, these context are inextricably networked and difficult to separate [53] and even recognize. We would like to point out that the social environment is included as a context in Table 3 but is discussed separately.

Table 3. External and internal contexts that may affect the type of clinical reasoning during veterinary clinical encounters.

External	Internal
Client ± patient-related	Age, due to general problem-solving competence
Challenging learners/practitioner's credentials [12,62,63]	Awareness of biases and/or errors in clinical reasoning [10,65,67]
Client's ± patient's characteristics [12,13,26,32,42,62,64,65]	Cognitive indolence [26,62]
Client's wish/es and perceptions [32,62,66]	Cognitive overload [12,56,67]
Incorrect hypothesis suggestions [12,61,63,66]	Communication skills [61–63,66,68,69]
Language and vocabulary [12]	Experience [12,26,37,45,48,50,61,62,65]
Understanding of the problem [61,62]	Expertise/level of development [12,14,57]
Encounter-related	Language and vocabulary [62]
Available resources [3,12,13,26,66]	Level of knowledge in the field [42,61]
Available versus required time for the encounter [3,12,13,42,52]	Multitasking [12,26,42,52]
Clinical encounter (e.g., urgency) [26,62]	Organization of mental representation [9]
Clinical settings [26,30,64,66]	Personal affective state (e.g., emotional state) [3,13,26,30,42,48,52,53,61–63,67]
Cultural environment [66]	Personal attitude (e.g., beliefs, confidence, contemplation, creativity, curiosity, flexibility, inquisitiveness, intellectual integrity, intuition, motivation, open-mindedness, perseverance, prejudices, and values) [3,32,42,44,52,62,64]
Distractors (e.g., noise) [26,42,52]	Personal psychomotor state (e.g., fatigues, sleep deprivation, and stress) [3,12,13,26,42,48,52,56,61,62,67]
Frequency of encounter	Philosophical preconceptions [42,62,64]
Environment [52,62]	Philosophical perspective [13,64]
Level of complexity	Reflection [9,51,70]
Team dynamics [52]	
System-related	
Client–learner/practitioner relationship [32,61–63]	
Ethical issues [26,66]	
Financial constraints [3,66]	
Industry-related factors and issues [66]	
Legal factors and issues [66]	
Social environment [3,12,13,17,29,31,38,47,48,51,55,71]	
Support from the team [13]	

2.3. The Role of the Social Environment in Clinical Reasoning

In addition to the professional and social identity of the learner, social and local industry/work-based learning environment beliefs, customs, language, norms, traditions, and/or values also infuse the learning environment [17,18,31,48]. High- versus low-stake encounters will differ in the type of clinical reasoning, with low-stake encounters being usually solved using the intuitive type [42]. Due to regret, after being publicly criticized on their previous predominantly intuitive-based clinical reasoning (e.g., unexpected outcome, regulatory complaint, or social media posting), even experienced practitioners or advanced learners may be reluctant to use an intuitive type of clinical reasoning [55]. Additionally, clinical encounters involving clients from medical fields usually favor the analytical type of reasoning [47,71]. Therefore, social environment will affect the type of clinical reasoning. The effect of the social environment on learning is often ignored by instructors and teaching organizations [29]. Each change in the social environment needs an adjustment in clinical reasoning [31,42,51,52]. This is a reason for advocating for longer clinical rotations and concurrently having learners with different exposures to the particular work-based learning environment.

3. Teaching Clinical Reasoning

Clinical reasoning is a competence and should be treated as one [39,72]. It requires meta-cognitive capacity [52]. A good analogy would be learning to drive between two towns. Theoretical learning of the route would be completely useless without attempting to drive the distance, or, at least, driving on a simulated route. The first drive of the route is usually the hardest, but each additional drive becomes easier. Yet even two to three attempts at driving the distance, when all under similar weather conditions, are insufficient to provide a guarantee that the driver will be comfortable on the road in variable weather conditions. Hence, becoming a proficient driver on the route between two towns requires repeated practice and following the traffic rules. Driving safely also requires other drivers to be proficient and follow the traffic rules. Finally, there may be an alternate route between the two towns that could be taken. What is important is the outcome, namely driving from town one and arriving safely at town two. How does this relate to clinical reasoning? Theoretically learning the route is the same as learning clinical reasoning; without practice, it is nearly useless. The first attempt at driving and at clinical reasoning is the hardest, but it becomes easier with repeated practice. Even if the learner is proficient and safe when driving between the two towns, it will be inefficient if other drivers interfere with the driving. This is in parallel to distractors in clinical reasoning. Variable weather conditions and the need to adjust to these are parallel to considering the context. Hence, the teaching of clinical reasoning should include both theoretical and practical aspects. As the learner becomes familiar with clinical reasoning, the teaching aspect must be repetitive and progressively more complicated. Following traffic rules allows for ensuring safety when driving. In parallel, following clinical reasoning rules makes the process easier and safer. Finally, taking alternative driving routes is possible, as are alternative ways of clinical reasoning. The outcome of arriving at town two would be parallel to arriving at the expected clinical outcome (e.g., selection of diagnosis or a management approach).

The role of the instructor in teaching clinical reasoning should not be to teach learners clinical reasoning per se but rather to concentrate on the facilitation of deep learning and encouraging leaner-initiated enquiries [45]. The biggest challenge areas in learning and teaching of the clinical reasoning include the learner's following qualities: (1) organization of their knowledge and interpretation of clinical information; (2) data synthesis and development of problem representation; (3) formation and prioritization of test hypotheses; and (4) awareness and remediation of common biases, difficulties, and errors in clinical reasoning.

A simplified presentation of the clinical reasoning process applicable to veterinary clinical encounters is presented in Figure 3. The instructor should assist learners to progress with the encounters by utilizing various models of clinical teaching (e.g., the Five microskills: 1. get a commitment, 2. probe for supportive evidence, 3. teach general rules, 4. re-enforce what was done well, and 5. correct errors and mistakes, coupled with debriefing [73]). Initial impressions should be formed from the presenting problem (e.g., Daisy, 4-year-old Jersey cow that has been snorting and making noise on taking air though the nose for over 3 weeks, with both nostrils being affected; otherwise 'healthy'), and hypotheses generation may have begun (e.g., microskill 1: get a commitment). Hypotheses should be generated based on the detected problems or issues and the list of differential hypotheses (meaning in this paper: differential diagnosis, further data collection, or management of the encounter) that are related to that particular problem or issue (e.g., inspiratory dyspnea and copious, sterile rhinorrhea indicating upper respiratory tract disorders, such as rhinitis of some other type). As new information is acquired (e.g., feverish, or non-feverish disorder), these hypotheses should be tested further down the data collection process and accepted (rule-in) or rejected (rule-out). The list of tested hypotheses at any given time should be at a maximum of three or four. As the encounter continues, a prioritized list of differential diagnoses for each hypothesis should be created, followed by a working and, eventually, a final diagnosis within a re-iterative process or acquisition of new information, consideration of the additional information, additional hypotheses being included in the list of differentials, and unlikely ones being excluded from the list. The final diagnosis should be generated when learners are satisfied that there is enough certainty, with the most likely diagnosis being one presented as a final diagnosis. Even then, some uncertainty may need to be accepted. This step, making learners aware of the uncertainty, is very important and should be facilitated to become a 'usual practice' by learners (e.g., microskills 2: probe for supporting evidence and 3: teach general rules).

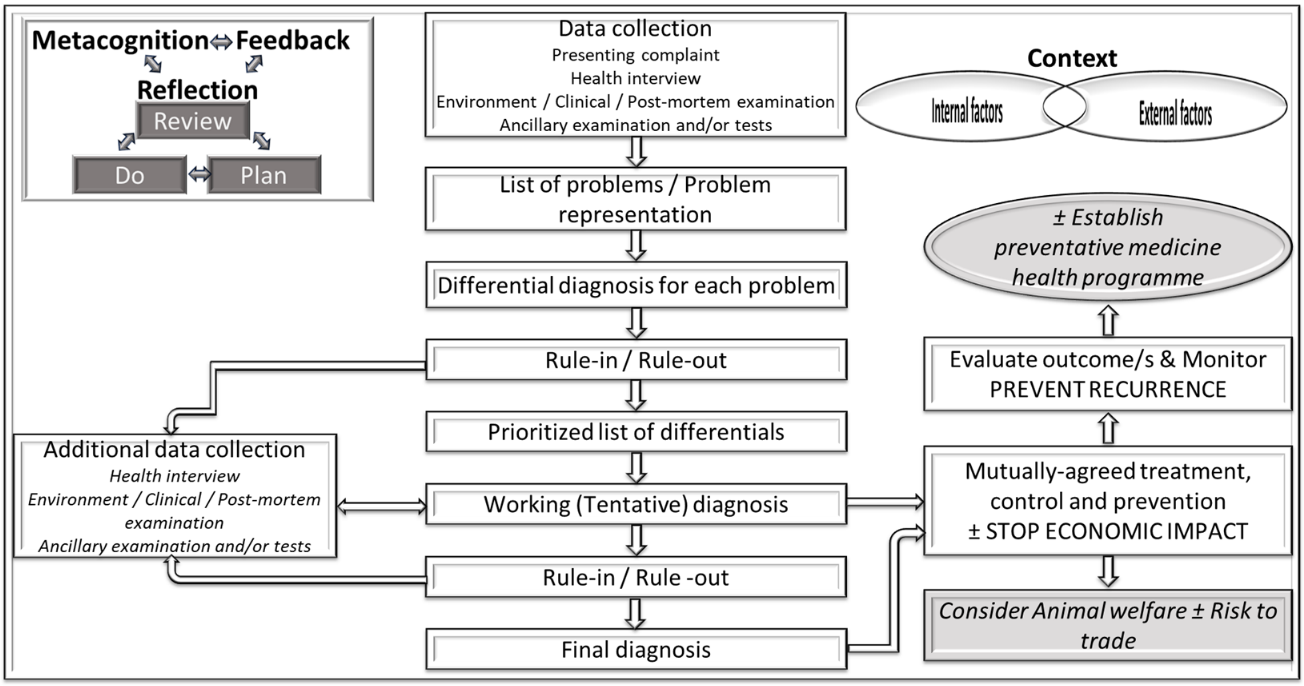

Figure 3. Simplified presentation of the clinical reasoning process in veterinary medical encounters.

Based on the final or working diagnosis, the mutually agreed goals for the encounter should be re-discussed, and options for further testing/management should be chosen. The agreed goals must, at a minimum, adhere to the principles of animal welfare, and that relief of pain and suffering should take priority over any other consideration. After the action has been taken, outcomes should be evaluated, and adjustments should be made as needed. Throughout the encounter, reflection should be used to re-check the steps taken, considering possible enhancements and a re-evaluation of the decision-making process. The role of the instructor is to facilitate the development of self-reflective practice, where reflection acts as a self-monitor (e.g., microskills 4: re-enforce what was done well and 5: correct mistakes).

Additionally, in population animal settings, the prevention of future cases and regular monitoring for early detection of the future recurrence of the problem are essential. The risk to trade must also be considered, even if the presented patient is unlikely to finish as part of the human food chain (e.g., a pet animal). Furthermore, every clinical encounter in any population animal settings should be used as an opportunity to advocate for preventative health management.

There is a complete lack of a standardized framework for teaching clinical reasoning in veterinary medical learners. However, there are some suggestions in other medical educational fields [5,9,10,74]. We will use the basic framework as proposed by Cohen and others (2020) [10], Cooper and others (2021) [74], Amey and others (2017) [5], Weinstein and others (2016) [41], and, although a little bit dated, Cutrer and others (2013) [9], but we will expand it to include reflection, which is important for deep learning and strongly supported by some authors [21,65,75,76]. Additionally, in our opinion, ancillary examination techniques and tests are part of the data collection, whilst management should be a separate domain from the analyzed data. Therefore, for improving the teaching of clinical reasoning in veterinary learners, all the proposed domains presented in Figure 4 should be covered.

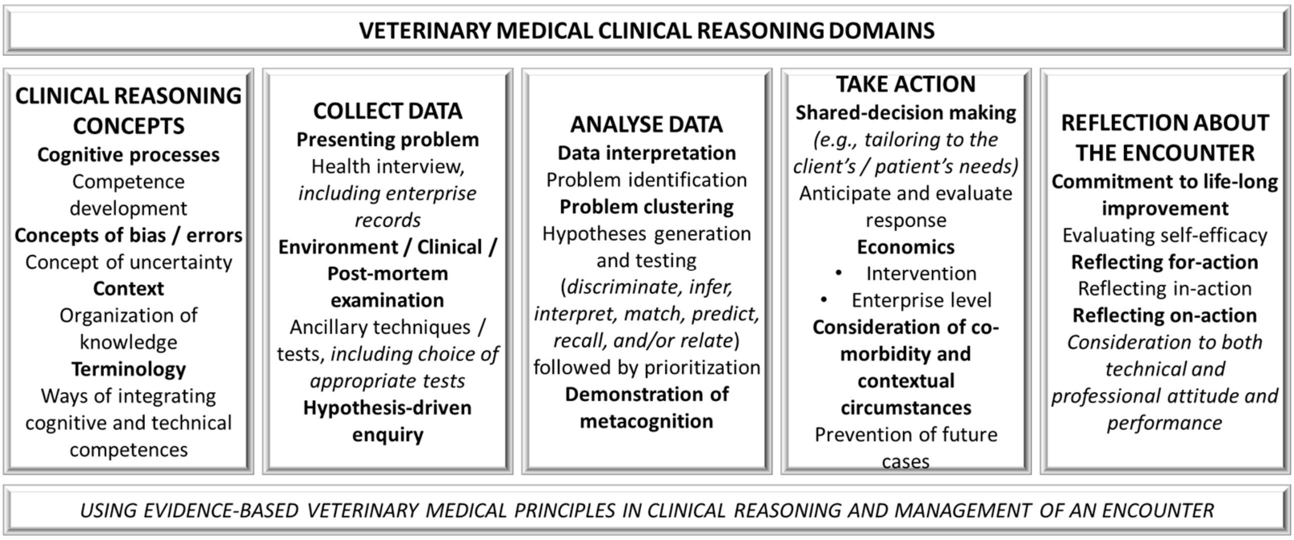

Figure 4. Veterinary medical clinical reasoning domains that instructors should be aware of and that should be taught to veterinary medical learners, mainly using facilitation rather than traditional teaching techniques.

Teaching clinical reasoning should occur in specialized sessions, either as a horizontally or vertically integrated course, or a separate course [5,11,33,37,74]. Teaching in specialized sessions is more beneficial [1,40,42,74,77,78] as both learners and instructors have realized that the teaching or learning has occurred [19,41]. Excluding specialized sessions facilitates the implicit learning of clinical reasoning that is often assumed to be less important than the acquisition of competences and knowledge [42]. The implicit learning of clinical reasoning is based on the acquisition of knowledge through apprenticeship and experience ('pick it up as you go' approach) [5,39,41,42,51,65,74]. The belief that the observation of instructors and practitioners will develop clinical reasoning in learners is utopian, resulting in passive, inefficient learning [5,9].

It is important to introduce the teaching of clinical reasoning as early in the curriculum as possible, preferably during the pre-clinical portion of the curriculum [5,18,35,37,42,45,78,79], and continual teaching is required in a developmental fashion from a low level going up in complexity [41,74]. It is important to teach clinical reasoning into as many disciplines as possible, using different approaches to teaching and types of clinical reasoning [17,29,55,65,77]. Teaching into a variety of disciplines is required due to the content- and context-specificity of the processes (often referred to as 'departmental disjunction') [17,30]. A good clinical reasoning performance in one discipline does not guarantee performance in other [30]. The basic clinical reasoning process is common between disciplines, but as it is influenced by the expertise and context, it is not a completely generalizable competence. The early introduction of clinical reasoning should allow learners to practice it and utilize basic concepts before entering into work-based learning [5,78].

To stimulate the development of intuitive clinical reasoning in learners, they should be asked as early in the encounter as possible to propose their hypothesis/hypotheses (e.g., as soon as the presenting problem is mentioned by the client, an instructor should ask something similar to "What is your first impression regarding this client ± patient?") [80]. For this to be achieved, instructors should directly supervise the learners' approach [42], and as previously mentioned, various models of clinical teaching (e.g., the five microskills [73] or the SNAPPS: 1. summarize briefly the history and findings; 2. narrow the differential to two or three relevant possibilities; 3. analyze the differential by comparing and contrasting the possibilities; 4. probe the preceptor by asking questions about uncertainties, difficulties, or alternative approaches; 5. plan management for the patient's medical issues; and 6. select a case-related issue for self-directed learning [81]). In case-based discussions, in levels of the development of learners of reporters and above, it is preferred to provide the clinical data simulating the encounter, starting with the presenting complaint and followed by the appropriate information as requested by the learners (the so-called 'serial cue approach') [41,65].

We would like to note that the discussion on teaching clinical reasoning to veterinary medical learners by domains does not address in detail veterinary medical cognition. The instructor should be aware of the cognitive level of the learners and choose encounters that are appropriate to the level of the learners' development. Additionally, expectations for clinical reasoning competence from learners with different levels of development should differ.

3.1. Consider Client ± Patient Situation

Importantly, learners must be aware that the veterinary clinical encounter must consider the client ± patient situation (stage 1 in the clinical reasoning cycle), including various context external factors (client-, encounter-, or system-related; Table 3). The role of the instructor should be to facilitate client–learner communication and the elicitation of the client's perspective.

3.2. Collect Data

The role of data collection is to identify clinical abnormalities, risk factors, and context applicable to the encounter. In earlier levels of (O)RIME, learners (observer up to interpreter), data collection is often mechanical, comprehensive, and complete (general collection of data). In later development levels of learners (manager and educator, ± interpreter) and for experienced practitioners, data collection is often guided by the hypotheses' generation (problem-based or hypothesis-driven data collection). This means that the more data that are collected are not always equal to a correct diagnosis/management approach (Figure 5). The complete data collection approach is associated with a higher likelihood of false-positive information that complicates the decision-making process. Hence, data collection should be as comprehensive as possible, yet focused and purposeful [8].

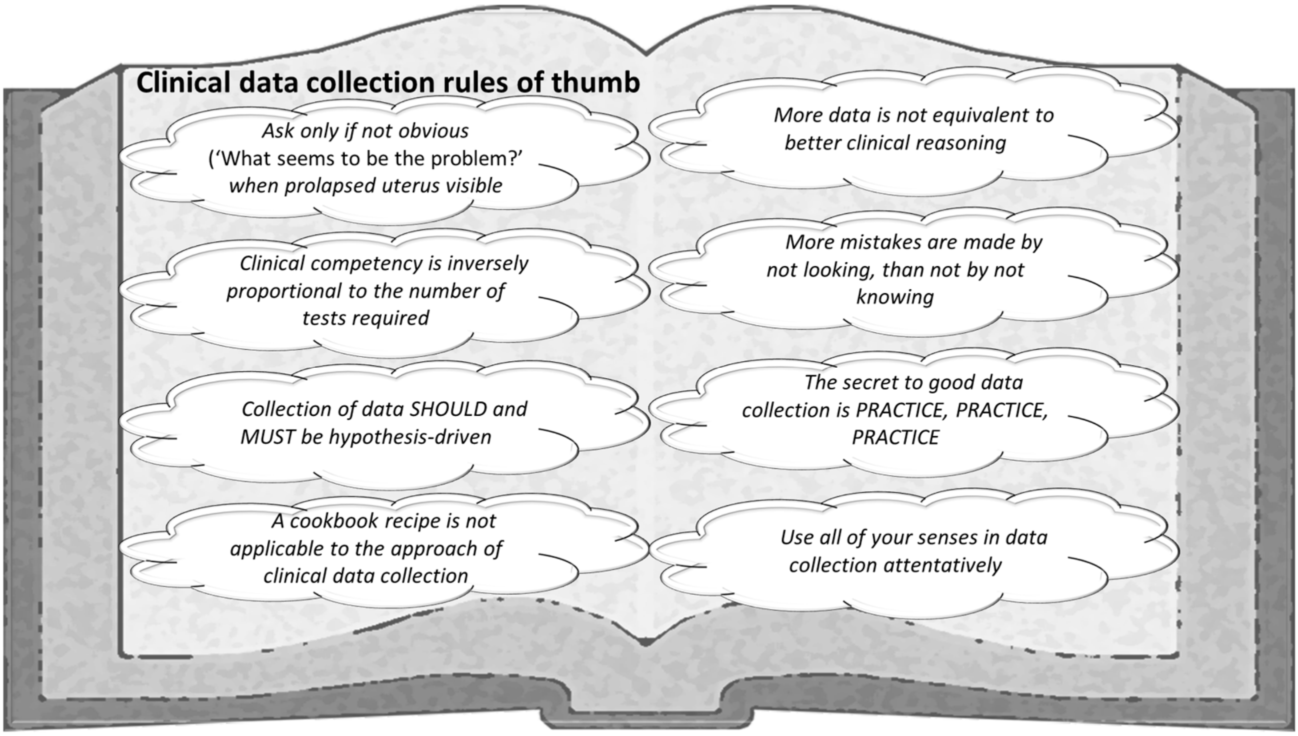

Figure 5. Common rules of thumb related to collection of data during clinical encounters.

As the learner progresses from an observer toward an educator, the collection of data should be gradually narrowing, from a 'cookbook recipe' approach in early level learners to hypothesis-driven information gathering in interpreter levels and above [5,54,82]. This should reflect the change in the organization of knowledge, becoming a comprehension rather than pure recall [83].

Therefore, instructors should assist learners in data collection and facilitate them to identify key features, both inclusive and exclusive (positive and negative). This should allow for hypothesis-driven data collection. Instructors should facilitate data collection that will result in no 'must not forget' hypotheses being left out (e.g., exotic diagnosis that may have catastrophic results if missed).

Initially, particularly for learners in earlier levels of development, a plan of data collection should be discussed with learners before contact with the client. Attention should be paid to keeping the learner on track, preventing straying, and exploring minor points or preventing major omissions. There may be a need to prevent learners inadvertently closing the encounter prematurely without completing the data collection process. Finally, as the learners progress, the instructor should stimulate them to use hypothesis-driven data collection yet allowing for the exclusion/inclusion of new hypotheses [9,82].

3.3. Analyze Data and Identify Problems ± Issues

In the intuitive type of clinical reasoning, an incomplete aspect of analysis is carried out. The collected data are used to confirm the approach/diagnosis. Therefore, most of the discussion under this heading will be related to the analytical type of clinical reasoning. On rare occasions, the problem identified would fit all signs/factors that are typical for the disorder/management approach. More commonly, only a few of the context factors that should be considered are present. In such cases, pathognomonic or typical information is used in the analysis. Rarely, a single, particularly pathognomonic, or typical sign/factor will be the only available piece of information to make the decision.

To be able to analyze the collected data, veterinary medical learners should be made aware of the rules used in the determination of how information ± context are shaped into a clinical decision (metacognitive competency; Table 4).

Table 4. Essential competences/skills required for clinical reasoning.

Competence/Skill	Examples
Acquiring	Cognitive and metacognitive competences; general problem-solving skills
Acting	Hypothesis-driven; purposefulness; tailoring
Adjusting/consideration to context	Tailoring
Analysis of information	Analyzing; applying; comparing; conceptualizing; contrasting; evaluating
Commitment to improvement	Self-directed learning; self-reflection
Communication	Non-verbal and verbal
Inquisitiveness and observation	Communicating; focused observation; information seeking; noticing
Integration/synthesis of information	Abstracting; aggregating; assimilating; activating neural networks
Interpretation of context/information	Interpreting; recognizing deviations from expected patterns; responding to analysis of information
Open-mindedness	Flexibility
Prioritization of context/information	Making sense; prioritizing information
Professional demeanor	
Recognition of self-limitations of knowledge/resources/skills	Reflecting; self-awareness
Reflective practice	Self-analysis/-evaluation/-monitoring; self-awareness/-esteem/-regulation; self-efficacy
Summarizing information	Abstracting; use of medical terminology

The role of the instructor should be to facilitate learners in the recognition of key/major issues/problems ± context and in the recognition of data clustering to prevent each sign/syndrome being addressed in isolation. A short discussion on the relationships between signs/syndromes may be required and should be, whenever possible, driven by learners.

3.3.1. Data Organization

The first step in the analysis of data by veterinary medical learners should be the detection of the key features from the encounter (identification of key problems ± context). For this purpose, the instructor should guide the learner to organize data for analysis. As the working memory of a person is restricted to 2–7 items at any given time, keeping all the collected data in the working memory would result in an information overload [44]. Hence, to assist with learning the process, data should be written down and organized in a manner that assists the analysis (hypothesis testing).

The ability to successfully sieve through the collected data improves with the development level of the learner, and it should be expected that, by the level of interpreter, learners would be able to select relevant from relatively irrelevant information from memory alone [13,48,54]. A major portion of the teaching and learning of clinical reasoning should be the explanation on how to identify and ignore redundant data. An example of data organization is presented in Table 5. A complete list of context/problems identified in the encounter with Daisy is presented in step 1. In step 2, data should be categorized as intrinsic to the encounter and other types. Some information in this step is crossed out as non-important (extraneous to the encounter). For the detection of key features, data should be organized into clusters that allow for their interpretation. This is presented in step 3.

Table 5. Data organization for analysis in veterinary clinical encounters using the example encounter of Daisy's upper respiratory tract problem.

Step 1	**Step 2**		**Step 3**	
List of Context/Clinical Data Collected	**Data Categorization**		**Data Clustering**	
	Information	**Category**	**Information**	**Indicative of**
Experienced dairy farmer	Experienced dairy farmer	Extraneous	Daisy, 4-year-old, Jersey cow	Signalment
Daisy, 4-year-old, Jersey cow	Daisy, 4-year-old, Jersey cow	Signalment	Daisy is valuable	
Snorting	Snorting	Specific		
Making noise on taking air through the nose	Making noise on taking air through the nose	Specific	Snorting	
Over 3 weeks	Over 3 weeks	Specific	Making noise on taking air through the nose	
Both nostrils affected air flow into nostrils decreased, nasal flaring.	Both nostrils affected, air flow into nostrils decreased, nasal flaring.	Specific	Inspiratory stridor	Involvement in the upper respiratory tract
Mr. Do just came back from holidays	Mr. Do just came back from holidays	Extraneous	Both nostrils affected air flow into nostrils decreased, nasal flaring.	
Immunized against common BRD pathogens	Immunized against common BRD pathogens	Non-specific	Copious orange nasal discharge	
Member of 450 cows' herd	Member of 450 cows' herd	Non-specific	Nasal discharge negative on culture	
No other sick cows	No other sick cows	Specific		
Hot summer	Hot summer	Extraneous	Over 3 weeks	Chronology
NAD environment	NAD environment	Extraneous		
NAD husbandry	NAD husbandry	Extraneous	Daisy bright and alert	
Daisy bright and alert	Daisy bright and alert	Non-specific	TPR + rumination NAD	
TPR + rumination NAD	TPR + rumination NAD	Non-specific	No signs of pain	No generalized malaise; no fever
Inspiratory stridor	Inspiratory stridor	Specific	Immunized against common BRD pathogens	
Copious orange nasal discharge	Copious orange nasal discharge	Specific		
No signs of pain	No signs of pain	Non-specific	Member of 450 cows' herd	Unlikely to be contagious
Nasal discharge negative on culture	Nasal discharge negative on culture	Specific	No other sick cows	
Mr. Do concerned for Daisy's animal welfare	Mr. Do concerned for Daisy's animal welfare	Extraneous		
Daisy is valuable	Daisy is valuable	Signalment		

3.3.2. Problem Representation

Detection of the key features should allow for the creation of succinct problem representation. The role of the instructor in the generation of the problem representation by the learner should be facilitation in using semantic qualifiers [13,45,80]. A simple way of achieving this is asking learners to summarize the case encounter into one single sentence or up to a maximum of 2–3 sentences (the **problem representation**). Learners who were good at problem representation were better at clinical reasoning than those who were not [9,13,48,80]. As problem representation is presented using semantic qualifiers that are always concrete and use the working memory, this methodology of data analysis is always associated with the analytical type of clinical reasoning [13,84]. Clinical information that should be included in the summary may include any/all of the information listed in Box 1.

Box 1. Clinical and context information that should be included in the problem representation for a veterinary medical encounter.

Patient's signalment + client data
Epidemiologic information
Important risk factors
Most likely cause
Key features
Key findings (key data clusters interpreted)
Important qualifying adjectives (sematic qualifiers)
Chronology
Location of the pathophysiological change/lesion
Pathophysiological process occurring
Organ/system involved
Severity of the disorder/problem
Type of pathophysiological change/lesion
Key context

Please note that the problem representation for the example case was previously mentioned in Table 2. As problem representation uses medical terminology, learners should be stimulated to use abstractions (e.g., 'orange nasal discharge' becomes 'rhinorrhea') and medical terminology (e.g., 'snorting and making noise on taking air' becomes 'inspiratory dyspnea'), predominantly using sematic qualifiers (e.g., 'for over 3 weeks' becomes 'chronic') [80,84]. Good problem representation should eliminate irrelevant findings (e.g., 'no generalized malaise').

The instructor's role should be ensuring the identification and grasping of the main features related to the encounter being addressed in the problem representation [80,82].

It is noteworthy to mention that as the learners' progress with their development and acquire more medical cognition and experience, they may skip the step of problem representation and, using an intuitive type of clinical reasoning, may immediately move to the differentials. Although the aim of the development of clinical reasoning is to stimulate, as much as possible, the intuitive type of clinical reasoning, instructors should try to facilitate problem representation being generated for each clinical encounter. This is essential for a deeper understanding of the clinical reasoning competence and for improvements in medical vocabulary. Additionally, the instructor should prevent the generation of an overly complex problem representation, interjected with irrelevant features, or skipping information not supportive of the preferred hypothesis.

3.3.3. Generation of List of Tested Hypotheses

The problem representation should allow for a solid approach to the generation of an appropriate and prioritized list of differentials for the tested hypotheses. Refinement of the hypotheses should be based on the existing data and, when necessary, the collection of further data. It is noteworthy to mention that as the learners' progress with their development and acquire more medical cognition and experience, they may skip the step of the generation of the list of the tested hypotheses and, using the intuitive type of clinical reasoning, may immediately move to the decision-making step.

The role of the instructor should be to 'probe for evidence', ensuring that the learners' way of thinking is based on a logical approach. In each encounter, the instructor should facilitate the consideration of alternative hypotheses, comparing and contrasting between the tested hypotheses, and the consideration of the context. Additionally, during the encounter or soon after, instructors should ensure a debrief discussion with learners where reflective practice should be facilitated. As previously mentioned, a model of clinical teaching (e.g., the five microskills [73] or the SNAPPS [81]) should be utilized by the instructor to facilitate this teaching.

For the example case used in this article, learners may come up with a list of differentials encompassing any of the following: allergic rhinitis, aspiration pneumonia, bovine respiratory disease complex (BRD; multiple disorders), rhinitis (unspecified), and sinusitis (unspecified). Further discussions using the example case will be limited to four differentials (allergic rhinitis, aspiration pneumonia, BRD, and sinusitis; Figure 6).

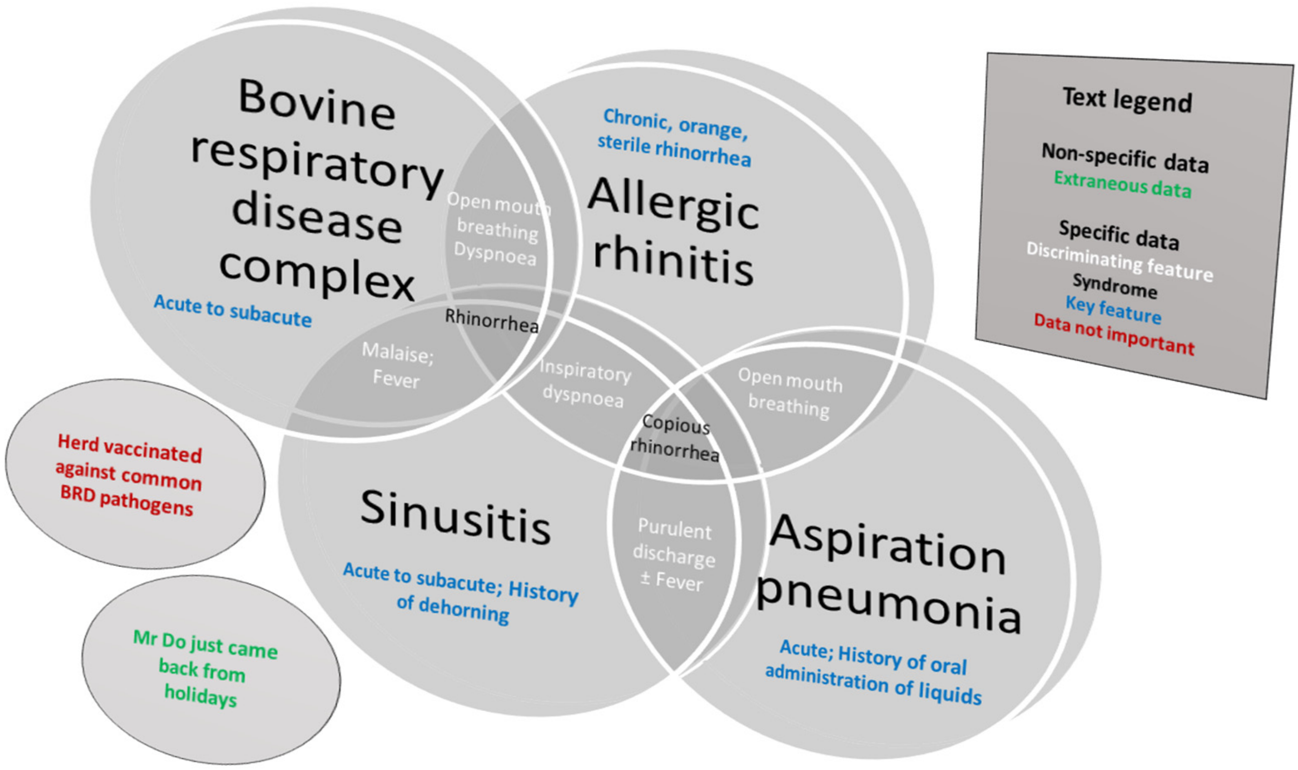

Figure 6. Types of data that can help in the development of problem representation and refining of differentials for the cow presented with copious rhinorrhea of 3 weeks duration. Clustering of data should assist refinement of the stated differentials for this encounter.

The role of the instructor should be the facilitation of the 'compare and contrast' approach between the stated differentials. The preferred approach when using compare and contrast is to consider only two differentials at a time [14,84]. During this process, learners should refine their illness scripts.

3.3.4. Refinement of Tested Hypotheses

Many hypotheses may be concurrently tested and ruled in or out until the final diagnosis is reached using arborization (branching approach; Figure 3) [55,56]. The rule in or out (successive scanning) is based on the assigned probabilities to each diagnosis/management approach/problem/syndrome using various mental representation models such as Bayesian analysis [17,45,49,52,55,56]. For improving probabilities, additional information may be sought (e.g., additional health interview information, ancillary examination techniques, cost–benefit analysis). The insecurity and risk aversity of the learner will be represented in the number of additional enquiries, with overconfidence being associated with a minimal, often insufficient, number of enquiries [55]. The appropriate choice of additional enquiries increases the capacity of rule in or out and shortens the time to decision making. In the process of the rule in or out of the hypotheses, the learner may use plenty of dichotomous answers (semantic qualifiers) [13,17,84]. Alternatively, a learner may use other mental representation models (e.g., illness scripts or prototypes) [17,48,84]. After reaching the workable diagnosis of the problem/syndrome (although not essentially the final diagnosis), the encounter moves to the management section.

In the example case, the learner's ability to recognize husbandry events such as dehorning and the oral administration of fluids that contribute to the diagnoses of sinusitis and aspiration pneumonia, respectively, allows for these differentials to be ruled out. The chronicity of the problem (>3 weeks) should direct the learner to allergic rhinitis rather than BRD. Non-purulent, copious rhinorrhea is often of allergic nature, strengthening the diagnosis of allergic rhinitis.

3.4. Establish Mutually Agreed Goals

As the modern teaching of clinical veterinary medicine is client-centered [66], learners should include the client in the decision-making process. This requires impeccable communication between learners and clients. Learners should also be able to support the decision making, considering the client's perspective and wishes, and valuing the contributions of others. The goals should be specific/suitable, measurable, achievable, relevant, and timely (SMART). The learner should also be aware that during this step, a level of uncertainty must be accepted.

The role of the instructor in the client-centered approach to the encounter should be the facilitation of the communication (both non-verbal and verbal), metacognitive, and reflective competencies in the learner. Learners may not recognize the effect of the proposed goal on the client. This may need to be tactfully addressed by the instructor. Instructors should ensure that the chosen goal is appropriate for the encounter. Additionally, instructors should facilitate the demonstration of ethical and professional veterinary medical practice.

In the example case, the client's concern for Daisy's welfare should be recognized by the learner and considered when discussing the goals of treatment with the client in the decision-making process. The learner should explain to the client that continued monitoring with no decrease in discomfort levels is an appropriate strategy for the diagnosis of allergic rhinitis. However, any increase in discomfort levels would require intervention (e.g., prolonged administration of corticosteroids). The instructor should facilitate the discussion of matching the client perspective with the available treatment options for allergic rhinitis, pointing out the connection to self-cure when the allergens disappear.

3.5. Take Action

The action taken may vary from the collection of additional information to the development of a management plan. The decision-making process should, again, follow the analysis of the data step. Self-monitoring should occur throughout the encounter, and any decision making should be followed by reflective practice. The role of the instructor in the client-centered approach to the encounter should be as a facilitator of clinical data analytical, communication, metacognitive, and reflective competencies in the learner.

It is outside of the scope of this article to discuss all the 'take action' possibilities. What we would like to mention is that the role of veterinary medical encounters has evolved, and the priority of 'planning health and animal welfare' should always be considered. For a successful veterinary medical practice, in any population level or any production animal clinical encounter, establishing monitoring and preventative strategies is imperative.

In the example case, the instructor should facilitate the learner's journey through providing a prolonged course of corticosteroids to continued monitoring without intervention, analyzing the epidemiological progression of allergic rhinitis, and reflecting on the use of medications in a milking cow and the impact on productivity and profitability, including a discussion on withholding periods. Facilitating this discussion will allow the learner to work through all the available management options for allergic rhinitis and establish the best course of action for the client in this particular encounter, reflecting that, in a different encounter, a different course of action may be required.

3.6. Evaluate the Outcomes

SMART goals should allow for measurable outcomes. Yet, learners often struggle to grasp the concept of objective evaluation and understanding the holistic approach to the expected and achieved outcomes (e.g., co-morbidity may have affected the outcome). Learners may also not be aware of the effect of compliance on the outcome.

The role of the instructor should be to facilitate follow-up and enquire of the outcomes from the encounter. Support in understanding uncertainty and holistic approaches may also be required. The facilitation of reflective practice may assist in teaching these items.

In the example case, the instructor facilitating the knowledge of the improvement in Daisy a month later with no change in her comfort level at any time during the month allows for learners to recognize the benefits of mutually agreed client-focused goals coupled with a management option without intervention as a suitable recommendation in some encounters.

3.7. Reflect on the Process and New Learning

The development and maturing of clinical reasoning competence in learners are only possible when engaged in effective reflective clinical practice [76,85] associated with deep learning/metacognition. Every encounter should be used to select a new area of further development of veterinary medical cognition, particularly in the earlier levels of development of the learner (at least up to the interpreter level). All levels of reflective practice should be employed, reflection-for-action, reflection-in-action, and reflection-on-action.

The role of the instructor should be to facilitate reflective practice. The following self-reflective skills should be stimulated: self-analysis (e.g., assessment of the performance versus goals for the encounter); self-awareness (e.g., accepting constructive criticism and/or recognition of self-limitations); self-confidence (e.g., speaking in an awkward situation); self-efficacy (e.g., spending time to self-reflect and avoid/change/enhance actions in ongoing and/or future encounters); self-esteem (e.g., believing in the self); self-evaluation/monitoring (e.g., recheck on every decision to be or already made with the aim of adjusting it); and self-regulation (e.g., controlling the expressions of the affective state). All of these skills can be used in verbal and/or written self-reflection. With the aim of preventing embarrassment, instructors should cautiously choose which self-reflective skills learners should express verbally and which in written form. An additional role of the instructor at this stage should be to facilitate a choice of an appropriate self-directed learning issue/s. In the early stages of learner development, most of these choices should be limited to improving veterinary medical cognition. As the learners' progress with their development, the choices should be transferred mainly to improving metacognitive and self-reflective competences. The learner should be facilitated to reflect on the need to arrive to the appropriate ancillary examination/tests (e.g., cytological examination of the nasal discharge for eosinophils), on the lack of awareness/knowledge of these ancillary diagnostic tests, and should assist the learner to identify learning issues from the encounter (confidence in diagnosis of allergic rhinitis). The instructor should also facilitate reflection on the mutually agreed recommendation to continue monitoring without intervention and the suitability of when this recommendation may be considered in other encounters (where the animal's welfare or image of the industry are not affected). The instructor should assist the learner with the identification of new areas of learning (e.g., the importance of heredity disorders) to progress the development of medical knowledge.

4. Instructors' Preparedness for Delivering Teaching in Clinical Reasoning

It is a common misconception that learners should learn clinical reasoning from experts in the field. However, there are beliefs that in the early stages of learner development, the instructors should also be relatively unfamiliar with the case [45]. In that way, the instructor undergoes the process of clinical reasoning in the same way as learners and provides an opportunity to learners to see that not all encounters are straightforward and that a level of uncertainty does exist [45]. Instructors should be aware of the main aims of clinical teaching, and particularly clinical reasoning, such as setting goals for each encounter, stimulating hypothesis-driven data collection, and guided reflection/facilitation of reflective practice [14,70,86]. As team work has evidence of improving clinical reasoning, another role of the instructor should be to facilitate and stimulate peer learning and peer supervision [86].

As part of the training of instructors in clinical teaching, the teaching of clinical reasoning should have a central role. However, this should not be a 'one off' opportunity, and continuing to support instructors is essential for their success. Instructors should be aware of all the cognitive processes involved in clinical reasoning [9,19,36–38,87,88]. Only with this support and awareness can instructors teach evidence-based clinical reasoning to veterinary medical learners.

The preparedness of instructors should allow for the effective teaching of clinical reasoning to learners. Instructors should be prepared for the teaching of clinical reasoning by specialized courses/sessions/workshops [10,34]. Some authors propose a simplified method for preparing instructors with only four domains covered, namely data collection, data analysis (with two components of problem representation and illness scripts recall and selection leading to diagnosis), and finally taking action [34]. We think that instructors should be aware of all the domains of veterinary clinical reasoning (Figure 4), and therefore, all domains should be included in the specialized courses/sessions/workshops. The highest achievements in improving the capacity of teaching clinical reasoning have been reported after instructors undergo specialized workshops. A significant benefit of workshops is team work rather than the individualized reading of terminology [7,34] and the five domains in veterinary clinical reasoning. In the preparation of the workshops, it is essential to have enough time for instructors to practice the teaching of clinical reasoning.

We propose 3 × 2 h workshops for teaching instructors clinical reasoning. The first workshop should concentrate on the first two domains (clinical reasoning concepts and data collection, and particularly the stimulation of the hypothesis-driven approach). Additionally, the first workshop should introduce strategies forcing cognition and metacognition in learners. The second workshop should address data analysis, take action, and debrief, with particular attention paid toward the reflection. The third workshop should address the prevention and remediation of biases, difficulties, and errors in clinical reasoning, as well as an opportunity to practice the entire process described in the three workshops.

5. Conclusions

Clinical reasoning is an essential competence of veterinary graduands. Learners should be guided through all the domains of clinical reasoning and allowed to practice repeatedly throughout the veterinary curricula. This paper provides a framework for teaching clinical reasoning, integrating the models of clinical teaching (e.g., five microskills), and uses a case example. It demonstrates the importance of scaffolding clinical reasoning within a work-based learning environment. This paper also highlights the importance of teaching clinical reasoning in specialized sessions, paying particular attention to the facilitation of reflective practice.

6. Glossary of Terms

Clinical encounter—Any physical or virtual contact with a veterinary patient and client (e.g., owner, employee of an enterprise) with a primary responsibility to carry out clinical assessment or activity.

Clinical instructor—In addition to the regular veterinary practitioner's duties, a clinical instructor should fulfil the roles of assessor, facilitator, mentor, preceptor, role model, supervisor, and teacher of veterinary learners in a clinical teaching environment. Apprentice/intern in the upper years, resident, veterinary educator/teacher, veterinary practitioner.

Clinical reasoning—The cognitive process interjected with unconscious operations during which a learner or practitioner collects information (clinical and context), processes it, comes to an understanding of the problem presented during a clinical encounter, and prepares a management plan, followed by the evaluation of the outcome and self-reflection. Common synonyms: clinical/diagnostic/medical: acumen/cognition/critical thinking/decision making/information processing/Judgment/problem solving/rationale/reasoning.

Clinical teaching—Form of interpersonal communication between a clinical instructor and a learner that involves a physical or virtual clinical encounter.

Complete data collection consists of checking for the presence of clinical abnormalities, risk factors, and context using a systematic and exhaustive approach.

Context—A complex interaction of factors (including, but not limited to, affective/physical state, client, encounter, environment, finances, patient, and social environment) having an effect on the clinical reasoning competence of the learner.

Deep learning—Aiming for the mastery of essential academic content; thinking critically and solving complex problems; working collaboratively and communicating effectively; having an academic mindset; and being empowered through self-directed learning.

General data collection consists of a broad search for the presence of clinical abnormalities, risk factors, and context with the identification of the particular organ/region/system involved and concentrating data collection in greater detail on that particular area, resulting in partially focused data collection.

Illness script—An organized mental summary of the knowledge of a disorder. Common synonyms: medical scripts and schema.

Problem-oriented data collection consists of a combination of data collection and clinical reasoning, resulting in the early generation of hypotheses, and resultant data collection is used to rank competing differentials/management approaches, resulting in limited but focused data collection.

Problem representation—A one-sentence summary that highlights the defining features of a clinical encounter. Common synonym is summary statement.

Reflection—Metacognitive process that may occur before, during, or after an encounter with a purpose of developing a deeper understanding of the encounter and self ± the team to inform the ongoing and/or future actions, behaviors, and encounters.

Reflection-for-action—A process of self-evaluation of the action to happen, including planning for action and performing the action, anticipating the unexpected, and planning and executing adjustments from before, during, and after the encounter.

Reflection-in-action—A process of self-evaluation of the action as it happens, resulting in ongoing adjustments during the encounter.

Reflection-on-action—A process of self-evaluation of the action after it has been completed, planning for adjustment in future encounters.

Safe environment—An environment in which a learner feels safe, relaxed, and willing to take risks in pursuing a goal; enhances self-esteem and encourages exploration.

Semantic qualifiers—Abstractions expressed using medical rather than lay terminology. Generally, they exist as divergent pairs that aid in comparing and contrasting the hypotheses. Examples of semantic qualifiers include acute or chronic, being affected by XX or previously healthy, bilateral, or unilateral, constant or exacerbated by XX, continuous or intermittent, copious or scant, dull or sharp, frequent or rare, generalized or localized, left or right, mild or severe, etc.

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