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Case-Based Teaching in Veterinary Parasitology: Changes in Knowledge and Student-Reported Engagement, Conceptual Understanding, and Clinical Reasoning

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Abstract

Background: Veterinary parasitology requires students to integrate biological concepts with epidemiological interpretation, diagnostic reasoning, and disease-control decision-making. Predominantly lecture-based instruction may provide fewer opportunities to apply theoretical knowledge to authentic clinical and field situations. This study examined the implementation of contextually relevant case-based teaching as an active-learning strategy in undergraduate veterinary parasitology and considered its contribution to broader STEM education.

Results: A classroom action research study using a one-group pre-test/post-test design was conducted among 18 third-year Doctor of Veterinary Medicine students in Ethiopia. Locally relevant clinical parasitology cases were integrated into teaching through a structured six-step process involving case presentation, collaborative analysis, theoretical integration, diagnostic and control planning, student presentation and discussion, and instructor synthesis and feedback. The mean knowledge-test score increased from 12.83 ± 4.27 before the intervention to 29.33 ± 6.35 after the intervention, a mean increase of 16.50 points and a 128.57% relative increase from baseline. The paired comparison was statistically significant, $t(17) = 9.33$, $p <$

0.001, with a very large effect size (Cohen's $d = 2.20$). The 20-item questionnaire demonstrated good internal consistency (Cronbach's $\alpha = 0.886$). Students reported favorable engagement (4.04/5), conceptual understanding (3.91/5), and clinical reasoning (3.98/5). All students agreed or strongly agreed that case-based teaching was better than traditional lectures (4.72/5). **Conclusions:** Contextually relevant case-based teaching was associated with substantial improvement in knowledge-test performance and favorable student-reported engagement, conceptual understanding, clinical reasoning, motivation, and satisfaction. The findings suggest that case-based teaching can provide a feasible way of complementing conventional instruction while connecting biological STEM knowledge with applied problem-solving and clinical decision-making. Because the study used a single cohort without a comparison group and relied on self-reported measures for several outcomes, the findings should be considered preliminary. Larger controlled and multi-institutional studies using objective measures of clinical reasoning, practical competence, and longer-term learning are warranted.

Keywords: Case-based teaching; STEM education; veterinary education; veterinary parasitology; clinical reasoning; active learning; student engagement; conceptual understanding

1. Introduction

STEM education increasingly emphasizes learning approaches in which students move beyond acquiring isolated disciplinary facts and develop the capacity to apply knowledge, solve authentic problems, analyze evidence, collaborate, communicate reasoning, and connect disciplinary concepts with real-world contexts. Contemporary STEM education research identifies inquiry-based, problem-based, project-based, and design-based approaches as important instructional designs for promoting active learning, STEM literacy, engagement, and

broader competencies (Halawa *et al.*, 2024). The *International Journal of STEM Education* has contributed to the development of STEM education as a distinct interdisciplinary research field and provides an international platform for empirical scholarship examining instructional design, learning processes, student outcomes, and emerging directions in STEM education (Li, 2025). These characteristics are particularly relevant to professional education in which learners must integrate disciplinary knowledge with applied problem-solving and evidence-based decision-making.

Veterinary education provides a particularly relevant context for such pedagogical approaches because veterinary practice requires learners to integrate biological and clinical knowledge with diagnostic interpretation, epidemiological reasoning, problem-solving, and clinical decision-making. Contemporary competency-based veterinary education also increasingly recognizes the importance of public health, interdisciplinary collaboration, and One Health competencies in preparing graduates for complex animal, human, and environmental health challenges (Baines *et al*., 2024). Thus, veterinary education requires instructional approaches that not only transmit foundational scientific knowledge but also provide opportunities for students to interpret information, evaluate alternatives, communicate reasoning, and apply knowledge to authentic professional problems.

Veterinary education has traditionally relied substantially on lecture-based instruction. Lectures can efficiently introduce foundational concepts and organize complex bodies of knowledge, but predominantly transmissive approaches may provide fewer opportunities for students to apply knowledge, discuss alternative explanations, solve problems collaboratively, and develop higher-order reasoning. Active-learning approaches create opportunities for students to retrieve, discuss, apply, and reorganize knowledge and have been associated with

improved student learning outcomes in STEM education (Freeman *et al*., 2014; Prince, 2004). In this regard, case-based and problem-based approaches are particularly relevant to health-professions education because authentic or contextually relevant problems can connect theoretical knowledge with practical decision-making and professional reasoning (Barrows, 1986; Dolmans *et al.*, 2005; Thistlethwaite *et al*., 2012).

Case-based teaching is also compatible with several characteristics of contemporary STEM pedagogy. Although case-based teaching is not inherently a formal integrated STEM intervention, cases can provide authentic problems through which students actively interpret evidence, integrate disciplinary knowledge, evaluate alternative explanations, collaborate with peers, and justify decisions. These features correspond closely with instructional approaches identified in STEM education research, particularly problem-based and inquiry-oriented learning (Halawa *et al*., 2024). In professional education, the value of such approaches lies not simply in increasing classroom activity but in creating opportunities for learners to transform disciplinary knowledge into applied reasoning and decision-making. Accordingly, case-based teaching can be considered a STEM-aligned pedagogical approach when cases require students to integrate scientific knowledge with evidence interpretation, quantitative or epidemiological reasoning, problem-solving, and authentic professional decisions.

Veterinary parasitology presents distinctive educational challenges because competent veterinary practice requires students to integrate parasite biology, life cycles, host–parasite interactions, epidemiology, pathogenesis, diagnosis, prevention, and control. Students therefore need to move beyond factual recall and interpret clinical and epidemiological information to make appropriate diagnostic and management decisions. These competencies are particularly relevant in pastoral livestock-production systems, where parasitic diseases can

affect animal health, productivity, and household livelihoods (Beyene & Hiko, 2019; Haile *et al*., 2018). For example, understanding gastrointestinal nematode infections requires students to relate parasite biology and life cycles to host susceptibility, environmental and management risk factors, clinical manifestations, diagnostic findings, and appropriate control strategies. Such interconnected reasoning is difficult to develop through memorization alone and requires opportunities for students to apply knowledge to realistic veterinary problems.

The development of clinical reasoning is therefore an important educational consideration in veterinary parasitology. Clinical reasoning involves gathering and interpreting relevant information, representing the problem, generating and evaluating possible explanations, selecting appropriate diagnostic or management actions, and reflecting on decisions. Evidence from veterinary education indicates that inductive, problem-based clinical reasoning can enhance diagnostic accuracy among final-year veterinary students, supporting the educational value of approaches that engage learners in authentic diagnostic reasoning rather than passive knowledge acquisition (Neill *et al*., 2020). Case-based learning can provide a practical context for such reasoning by presenting students with incomplete or interconnected clinical and epidemiological information and requiring them to identify relevant evidence, consider alternatives, and justify their conclusions.

Contemporary veterinary education consequently requires pedagogical approaches that support conceptual understanding, active participation, application of knowledge, problem-solving, and clinical reasoning. Veterinary education literature has highlighted the educational value of case-based and problem-based approaches and the need to adapt veterinary teaching to changing professional and educational contexts (Jabbar & Gasser, 2018; Lane, 2008; May, 2013; Strube *et al*., 2018). In addition, the increasing emphasis on competency-based

126 veterinary education and One Health reinforces the need for graduates who can integrate
127 scientific knowledge with professional reasoning and address complex health problems across
128 animal, human, and environmental interfaces (Baines *et al*., 2024). These educational priorities
129 provide a strong rationale for investigating pedagogical approaches that connect foundational
130 veterinary science with authentic clinical and epidemiological contexts.
131
132 The Ethiopian context provides an important setting for examining such approaches. Recent
133 research in Ethiopian health-sciences education has documented efforts to implement
134 competency-based curricula and problem-based learning, while also identifying challenges
135 associated with educator preparation, curriculum implementation, educational resources, and
136 institutional readiness (Gebremickael & Mulu, 2024; Mohammed *et al*., 2024). These findings
137 suggest that educational innovations need to be examined within their institutional and resource
138 contexts rather than assumed to transfer directly from better-resourced settings. This
139 consideration is particularly important for veterinary education in pastoral regions, where
140 students may encounter distinctive livestock-production systems, disease patterns, resource
141 constraints, and community-based animal-health practices.
142
143 **1.1 Conceptual and theoretical framework**
144
145 This study was informed by constructivist and active-learning perspectives, which view
146 learning as an active process through which students connect new information with existing
147 knowledge and develop understanding through interaction, application, discussion, and
148 reflection (Brooks & Brooks, 1999; Prince, 2004). The case-based approach also draws on
149 principles underlying problem-based and case-based learning, in which meaningful problems

provide a context for integrating disciplinary knowledge and developing reasoning processes (Barrows, 1986; Biggs & Tang, 2011; Dolmans *et al*., 2005; Thistlethwaite *et al*., 2012).

The STEM-aligned dimension of the intervention is reflected not in the formal integration of all four STEM disciplines, but in the use of authentic problems requiring students to apply scientific knowledge, interpret evidence, discuss alternative explanations, and develop defensible solutions. This distinction is important because the present intervention was designed primarily as case-based teaching within a veterinary parasitology course rather than as a formal interdisciplinary STEM curriculum. Nevertheless, the learning processes targeted by the intervention active engagement, contextualized problem solving, evidence-based reasoning, collaboration, and application of disciplinary knowledge are consistent with important characteristics identified in contemporary STEM education research (Halawa *et al*., 2024).

The conceptual framework used in this study proposes that contextually relevant cases provide an authentic learning stimulus that prompts active engagement and collaborative discussion. These activities create opportunities for students to retrieve and reorganize disciplinary knowledge, connect theoretical concepts with clinical and epidemiological information, and explain or defend their interpretations. This process is expected to support conceptual understanding and application, which in turn may facilitate problem-solving and clinical reasoning. Instructor feedback and synthesis provide an additional mechanism for correcting misconceptions and consolidating learning.

Accordingly, the framework can be represented as: Contextually relevant cases → active participation and collaborative discussion → conceptual integration and application → problem-solving and clinical reasoning → perceived engagement and learning

The framework does not assume that case-based teaching alone causes improvements in all of these outcomes. Rather, it provides a pedagogical explanation for why a case-based intervention may create opportunities for learning processes that are less prominent in predominantly lecture-based instruction. In the present study, knowledge-test performance was treated as the primary objective learning outcome, whereas engagement, conceptual understanding, clinical reasoning, motivation, enjoyment, and satisfaction were assessed as student-reported perceptions.

1.2 Educational gap and study purpose

Although case-based and active-learning approaches are well established in health-professions education, empirical evidence concerning classroom-based implementation in veterinary parasitology remains limited, particularly in resource-constrained pastoral settings. This gap is important because the effectiveness and feasibility of educational interventions may depend on local curricula, available teaching resources, student experience, instructor preparation, and opportunities for clinical and field exposure.

Case-based teaching may provide a practical strategy for addressing this gap because it can be integrated into an existing curriculum without requiring complete replacement of conventional instruction. In veterinary parasitology, locally relevant cases can enable students to connect parasite biology and epidemiology with clinical signs, diagnostic decisions, and prevention and control strategies. Such an approach also provides opportunities for students to engage in the

types of applied reasoning emphasized in contemporary STEM-aligned and competency-based education.

Despite the potential relevance of these approaches, there remains limited empirical evidence examining whether contextually relevant case-based teaching can improve objective knowledge while simultaneously supporting students' perceived engagement, conceptual understanding, and clinical reasoning in veterinary parasitology. This gap is particularly relevant in pastoral and resource-constrained educational settings, where locally contextualized teaching strategies may be more feasible and educationally meaningful than approaches that depend heavily on sophisticated infrastructure or extensive curricular restructuring.

The present study therefore examined the implementation of contextually relevant case-based teaching among third-year Doctor of Veterinary Medicine students enrolled in veterinary parasitology at Borana University, Ethiopia. The study examined changes in knowledge-test performance and explored students' self-reported engagement, conceptual understanding, clinical reasoning, and perceptions of and satisfaction with the intervention.

The study addressed four research questions:

1. What change occurs in students' veterinary parasitology knowledge-test scores following implementation of case-based teaching?
2. How do students perceive their classroom engagement during case-based teaching?
3. How do students perceive their clinical reasoning following participation in case-based teaching?
4. What are students' perceptions of and satisfaction with case-based teaching?

2. Materials and Methods

2.1 Study design and participants

A classroom action research design using a one-group pre-test/post-test approach was employed. The action research process followed four iterative phases: planning, action, observation, and reflection (Kemmis *et al*., 2014; McNiff & Whitehead, 2011). The study involved a census of all third-year Doctor of Veterinary Medicine (DVM) students enrolled in the Veterinary Parasitology course at the School of Veterinary Medicine, a university in Ethiopia, during the 2025/2026 academic year. The study was conducted over one semester. All 18 eligible students participated. Census sampling was used because the entire eligible cohort was included.

2.2 Case-based teaching intervention

The intervention supplemented conventional lecture-based instruction with locally relevant clinical parasitology cases. The pedagogical design was intended to promote active participation, application of theoretical knowledge, collaborative problem-solving, and clinical reasoning (Lane, 2008; May, 2013; Thistlethwaite *et al.*, 2012). Each case-based session followed a structured six-step sequence:

1. **Case presentation:** A clinical case was introduced using relevant history, epidemiological information, and diagnostic findings.
2. **Collaborative case analysis:** Students worked in small groups to identify key clinical, epidemiological, and parasitological problems.
3. **Theoretical integration:** Students connected the case with relevant concepts, including parasite life cycles, host–parasite interactions, pathogenesis, epidemiology, and diagnostic principles.

4. **Diagnostic and control planning:** Groups developed diagnostic, prevention, and parasite-control strategies.
5. **Presentation and discussion:** Groups presented their interpretations and defended proposed solutions through question-and-answer discussion.
6. **Instructor synthesis and feedback:** The instructor synthesized the major concepts, corrected misconceptions, and provided feedback intended to consolidate learning and strengthen diagnostic reasoning.

Cases were contextualized to livestock production systems and parasitological challenges encountered by pastoral communities. The contextualization was intended to strengthen the connection between classroom learning, local veterinary practice, and field-oriented disease-management decisions.

2.3 Instruments and data collection

Two complementary instruments were used. First, structured knowledge assessments were administered before and after the intervention. The assessments targeted the same broad learning domains but used different questions at the two time points to reduce potential familiarity, recall, and testing effects. Second, students completed a 20-item, five-point Likert-scale questionnaire assessing four domains: classroom engagement, conceptual understanding, clinical reasoning, and perceptions of and satisfaction with case-based teaching. Response options ranged from strongly disagree to strongly agree. Higher scores indicated more favorable perceptions.

The questionnaire was administered following the intervention. Item-level frequencies, percentages, and mean scores were calculated. Because engagement, conceptual

understanding, clinical reasoning, motivation, enjoyment, and satisfaction were assessed through self-report, these outcomes were interpreted as student perceptions rather than objective measures of behavioral engagement or clinical competence.

2.4 Data analysis

Quantitative data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize knowledge-test scores and questionnaire responses, consistent with standard approaches to educational research and classroom-based evaluation (Cohen *et al*., 2018). Pre- and post-intervention knowledge scores were compared using a paired-samples t-test because the same students contributed measurements at both time points. Statistical significance was assessed at $p < 0.05$. Cohen's d was used to estimate the magnitude of the pre–post difference. Internal consistency of the 20-item questionnaire was evaluated using Cronbach's alpha (Tavakol & Dennick, 2011). The relative increase in the knowledge score was calculated as: [(Post-test mean − Pre-test mean) / Pre-test mean] × 100. Thus, the reported 128.57% represents the relative increase from the pre-test mean and should not be interpreted as a percentage of the maximum possible test score.

3. Results

3.1 Knowledge-test performance

The mean knowledge-test score increased from 12.83 ± 4.27 before the intervention to 29.33 ± 6.35 after the intervention. The mean increase was 16.50 points, corresponding to a 128.57%

relative increase from the pre-test mean. The paired-samples analysis indicated a statistically significant difference between pre-test and post-test scores, $t(17) = 9.33$, $p < 0.001$. Cohen's $d = 2.20$, indicating a very large pre–post effect (Table 1).

Table 1. Pre- and post-intervention knowledge-test scores and paired-samples analysis

Assessment	Mean	SD	Mean difference	Relative increase	*t*	df	*p*	Cohen's *d*
Pre-test	12.83	4.27	—	—	—	—	—	—
Post-test	29.33	6.35	16.50	128.57%	9.33	17	<0.001	2.20

Note. The relative increase was calculated from the pre-test mean and should not be interpreted as a percentage of the maximum possible test score. Different questions were administered at pre-test and post-test while maintaining the same assessment framework and learning domains to minimize potential familiarity, recall, and testing effects. Some residual testing effects cannot, however, be completely excluded.

3.2 Classroom engagement

Students reported generally favorable classroom engagement during the intervention. Active participation during lessons received the highest engagement rating (mean = 4.28), followed by the extent to which the cases kept students interested (mean = 4.17) and discussion with classmates (mean = 4.11). Asking more questions during case-based teaching and perceiving the lessons as interactive each received a mean score of 3.83. The overall mean across the five engagement items was 4.04/5, indicating generally favorable self-reported engagement during the intervention (Table 2).

Table 2. Students' self-reported classroom engagement during case-based teaching

Engagement item	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)	Mean
I actively participated during the lesson	0 (0.0)	0 (0.0)	3 (16.7)	7 (38.9)	8 (44.4)	4.28
The cases kept me interested	0 (0.0)	0 (0.0)	2 (11.1)	11 (61.1)	5 (27.8)	4.17
I asked more questions during case-based teaching	0 (0.0)	2 (11.1)	4 (22.2)	7 (38.9)	5 (27.8)	3.83
I discussed more with classmates	0 (0.0)	2 (11.1)	3 (16.7)	4 (22.2)	9 (50.0)	4.11
The lesson felt interactive	0 (0.0)	1 (5.6)	5 (27.8)	8 (44.4)	4 (22.2)	3.83

Note. $n = 18$.

3.3 Conceptual understanding

Students reported generally favorable perceptions of conceptual understanding. The highest-rated item was that the cases made concepts easier to remember (mean = 4.28), followed by

the ability to relate theoretical knowledge to clinical cases (mean = 3.89) and perceived understanding of parasite pathogenesis (mean = 3.89). Understanding parasite life cycles received a mean score of 3.83. Differentiating similar parasites received the lowest rating within this domain, although the mean remained favorable at 3.67. The mean across the five conceptual-understanding items was 3.91/5(Table 3).

Table 3. Students' self-reported conceptual understanding during case-based teaching

Conceptual understanding item	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)	Mean
Case-based teaching improved my understanding of parasite life cycles	0 (0.0)	0 (0.0)	8 (44.4)	5 (27.8)	5 (27.8)	3.83
I better understand parasite pathogenesis	0 (0.0)	0 (0.0)	7 (38.9)	6 (33.3)	5 (27.8)	3.89
I can relate theory to clinical cases	0 (0.0)	1 (5.6)	4 (22.2)	9 (50.0)	4 (22.2)	3.89
I can differentiate similar parasites better	0 (0.0)	2 (11.1)	4 (22.2)	10 (55.6)	2 (11.1)	3.67
The cases made concepts easier to remember	0 (0.0)	0 (0.0)	3 (16.7)	7 (38.9)	8 (44.4)	4.28

Note. $n = 18$.

3.4 Clinical reasoning

Students reported favorable perceptions of clinical reasoning following case-based teaching. The highest-rated clinical-reasoning item was that case-based teaching improved problem-solving skills (mean = 4.28), followed by the ability to suggest parasite-control measures (mean = 4.11). Confidence in diagnosing ectoparasites, interpreting clinical signs, and selecting appropriate diagnostic tests each received a mean score of 3.83.

The mean across the five clinical-reasoning items was 3.98/5(Table 4).

Table 4. Students' self-reported clinical reasoning during case-based teaching

Clinical-reasoning item	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)	Mean
I feel more confident diagnosing ectoparasites	0 (0.0)	1 (5.6)	5 (27.8)	8 (44.4)	4 (22.2)	3.83
I can interpret clinical signs better	0 (0.0)	1 (5.6)	3 (16.7)	12 (66.7)	2 (11.1)	3.83
I can select appropriate diagnostic tests	0 (0.0)	1 (5.6)	4 (22.2)	10 (55.6)	3 (16.7)	3.83
I can suggest parasite-control measures	0 (0.0)	0 (0.0)	3 (16.7)	10 (55.6)	5 (27.8)	4.11
Case-based teaching improved my problem-solving skills	0 (0.0)	0 (0.0)	5 (27.8)	3 (16.7)	10 (55.6)	4.28

Note. $n = 18$.

3.5 Students' perceptions and satisfaction

Students expressed particularly favorable perceptions of the intervention. All participants agreed or strongly agreed that case-based teaching was better than traditional lectures (mean = 4.72/5). Students also reported favorable perceptions of motivation to learn (mean = 4.50), enjoyment of learning (mean = 4.44), preference for more case-based teaching sessions (mean = 4.28), and willingness to recommend the approach to other students (mean = 4.39) (Table 5).

Table 5. Students' perceptions and satisfaction with case-based teaching

Perception/satisfaction item	Strongly disagree n (%)	Disagree n (%)	Neutral n (%)	Agree n (%)	Strongly agree n (%)	Mean
Case-based teaching is better than traditional lectures	0 (0.0)	0 (0.0)	0 (0.0)	5 (27.8)	13 (72.2)	4.72
I prefer more case-based teaching sessions	0 (0.0)	0 (0.0)	2 (11.1)	9 (50.0)	7 (38.9)	4.28
Case-based teaching improved my motivation to learn	0 (0.0)	0 (0.0)	2 (11.1)	5 (27.8)	11 (61.1)	4.50
Case-based teaching made learning enjoyable	0 (0.0)	0 (0.0)	2 (11.1)	6 (33.3)	10 (55.6)	4.44
I would recommend case-based teaching to other students	0 (0.0)	0 (0.0)	3 (16.7)	5 (27.8)	10 (55.6)	4.39

Note. $n = 18$.

4. Discussion

This classroom action research study examined the implementation of contextually relevant case-based teaching in undergraduate veterinary parasitology education. The principal finding was a substantial increase in knowledge-test performance following the intervention. The mean score increased from 12.83 to 29.33, representing a 16.50-point increase and a 128.57% relative increase from the pre-test mean. The paired comparison was statistically significant, with a very large pre–post effect size (Cohen's $d = 2.20$).

The observed change is consistent with broader evidence supporting active learning in STEM education. Active learning provides students with opportunities to retrieve, discuss, apply, and reorganize knowledge rather than relying predominantly on passive reception of information (Freeman *et al*., 2014; Prince, 2004). Case-based learning can extend this principle by placing disciplinary knowledge within meaningful problems that require interpretation, application, and decision-making (Thistlethwaite *et al.*, 2012).

The conceptual framework proposed in this study helps explain how the intervention may have supported learning. The cases provided an authentic stimulus, while collaborative analysis required students to identify relevant information and articulate interpretations. Theoretical integration then required students to connect biological concepts with clinical and epidemiological information. Diagnostic and control planning further required application of knowledge, and group presentations created opportunities for explanation, argumentation, and peer questioning. Finally, instructor synthesis and feedback provided opportunities to correct misconceptions and consolidate learning.

This sequence is consistent with active-learning and constructivist perspectives in which knowledge is strengthened through application, interaction, explanation, and integration with

prior understanding (Brooks & Brooks, 1999; Prince, 2004). Importantly, however, the present design cannot determine which individual component of the intervention was responsible for the observed change. The improvement should therefore be interpreted as an outcome associated with the overall instructional intervention rather than evidence that any single pedagogical component was independently effective.

The engagement findings support the feasibility and acceptability of the approach. The overall engagement rating was 4.04/5, with particularly favorable responses for active participation and discussion with classmates. These findings are compatible with educational perspectives emphasizing participation, social interaction, and meaningful engagement in learning (Fredricks *et al*., 2004). However, the study did not collect a comparable quantitative engagement measure during conventional lectures. Consequently, these findings indicate favorable perceived engagement during case-based teaching rather than a statistically established increase in engagement relative to lecture-based teaching.

Students also reported favorable perceptions of conceptual understanding, with an overall mean of 3.91/5. The highest-rated conceptual item indicated that cases made concepts easier to remember. Students also reported that they could better relate theoretical knowledge to clinical cases and understand parasite pathogenesis. These findings suggest that contextualized cases may help students organize abstract parasitological concepts around clinically meaningful problems. The finding is consistent with the broader rationale for case-based approaches, which seek to integrate disciplinary knowledge with applied situations rather than treating factual and practical knowledge as separate domains (Barrows, 1986; Thistlethwaite *et al*., 2012).

Perceived clinical reasoning was similarly favorable, with an overall mean of 3.98/5. Problem-solving skills received the highest rating, while students also reported favorable perceptions of interpreting clinical signs, selecting diagnostic tests, and proposing parasite-control measures. These outcomes are relevant to veterinary education because clinical reasoning involves integrating knowledge with case information and selecting appropriate diagnostic and management decisions (May, 2013; Norman, 2005). Nevertheless, these results should be interpreted cautiously because clinical reasoning was measured through student self-report rather than an objective assessment of reasoning performance.

Students' perceptions of and satisfaction with case-based teaching were particularly favorable. All participants agreed or strongly agreed that the approach was better than traditional lectures, while motivation, enjoyment, preference for additional case-based sessions, and willingness to recommend the approach also received high ratings. These findings demonstrate strong acceptance of the instructional strategy within this cohort. They should not, however, be interpreted as evidence that case-based teaching is universally superior to lectures. Rather, they indicate that students in this particular educational context perceived the intervention favorably.

The local contextualization of the cases is another important feature of the intervention. Veterinary students training in pastoral areas encounter livestock-production systems, disease patterns, and management constraints that may differ from those represented in generic teaching materials. Incorporating locally relevant clinical and epidemiological scenarios may therefore increase the meaningfulness of learning and strengthen connections between classroom concepts and professional practice. This approach is consistent with the broader need

436 to adapt veterinary education to contemporary professional contexts (Jabbar & Gasser, 2018;
437 Strube *et al*., 2018).
438
439 The findings are also relevant to the Ethiopian educational context. Research on problem-based
440 learning in Ethiopian health-sciences education has identified both educational benefits and
441 implementation challenges, including staff preparation, curriculum design, governance,
442 resource limitations, and institutional readiness (Mohammed *et al*., 2024). The present
443 intervention illustrates a comparatively modest instructional adaptation that can be
444 incorporated into an existing course without requiring complete curricular restructuring. This
445 may be particularly relevant in resource-constrained institutions where extensive simulation
446 technologies or additional clinical facilities are not always available.
447
448 From a STEM education perspective, the contribution of the study lies in demonstrating how
449 a discipline-specific instructional innovation can operationalize broader STEM learning
450 priorities. Veterinary parasitology is fundamentally grounded in biological science, but its
451 educational demands extend beyond factual scientific knowledge to include interpretation of
452 evidence, diagnostic reasoning, problem-solving, and application of scientific concepts to real-
453 world animal-health problems. The intervention therefore provides an example of how
454 authentic disciplinary problems can be used to connect foundational STEM knowledge with
455 applied reasoning.
456
457 The study also illustrates the value of disciplinary contextualization within STEM education.
458 Rather than treating STEM pedagogy as independent of disciplinary content, the intervention
459 integrated educational principles with the specific knowledge structures and professional
460 practices of veterinary parasitology. This aligns with the journal's emphasis on empirically

461 grounded research that integrates subject-content expertise with educational practice and
462 addresses meaningful challenges in STEM teaching and learning.
463
464 Importantly, the intervention should be viewed as complementary to rather than necessarily
465 replacing conventional instruction. Foundational lectures can efficiently introduce complex
466 concepts, terminology, and biological mechanisms, whereas case-based activities can create
467 opportunities for application, discussion, reasoning, and synthesis. A blended pedagogical
468 model may therefore provide a practical approach for veterinary STEM programmes seeking
469 to strengthen active learning while retaining the efficiency of structured content delivery.
470

471 5. Limitations

472
473 Several limitations should be considered when interpreting the findings. First, the study
474 involved only 18 students from a single veterinary school. The small, single-institution cohort
475 limits statistical precision and the generalizability of the findings to other veterinary
476 programmes. Second, the one-group pre-test/post-test design did not include a control or
477 comparison group. Therefore, the observed increase in knowledge-test scores cannot be
478 attributed exclusively to case-based teaching. Maturation, concurrent learning activities,
479 repeated exposure to course content, instructor effects, and other contextual factors may have
480 contributed to the observed change. Third, although different questions were used at pre-test
481 and post-test to reduce familiarity, recall, and testing effects, both assessments targeted the
482 same broad learning domains. Residual testing effects therefore cannot be completely
483 excluded. Fourth, engagement, conceptual understanding, clinical reasoning, motivation,
484 enjoyment, and satisfaction were assessed through self-report. These measures may be
485 influenced by social-desirability, response, or expectancy biases and should not be interpreted

as objective measures of behavior or competence. Fifth, the study did not include objective measures of clinical reasoning, practical competence, or longer-term retention. Consequently, the favorable clinical-reasoning findings cannot establish that students developed measurable improvements in clinical performance. Sixth, the study did not quantitatively compare student engagement during case-based teaching with engagement during conventional lectures. The high engagement ratings therefore represent students' perceptions of the intervention rather than evidence of an experimentally demonstrated increase in engagement.

Finally, the study was conducted as a classroom action research project embedded within routine teaching. This strengthened the ecological relevance of the intervention but also means that the findings reflect a specific institutional, curricular, and instructor context.

Future research should therefore include larger samples across multiple veterinary schools and, where feasible, comparison groups or randomized designs. Objective assessments of clinical reasoning, structured practical examinations, validated measures of engagement, and longer-term retention assessments would strengthen the evidence base. Future studies could also investigate which components of the six-step case-based process contribute most strongly to learning and whether the approach produces durable improvements in transfer to clinical practice.

6. Conclusion

In this classroom action research study of 18 third-year Doctor of Veterinary Medicine students, implementing contextually relevant case-based teaching was associated with substantial gains in veterinary parasitology knowledge-test performance and with favorable student-reported engagement, conceptual understanding, clinical reasoning, motivation, and

satisfaction. The study demonstrates how a discipline-specific veterinary intervention can address broader STEM education priorities by linking biological knowledge to authentic problem-solving, collaborative learning, evidence interpretation, and applied decision-making. Case-based teaching may therefore be a feasible and contextually relevant strategy to complement conventional instruction in veterinary parasitology, particularly in resource-constrained educational settings. However, the findings should be interpreted as preliminary because of the small single-cohort sample, the absence of a comparison group, possible testing and contextual effects, and reliance on self-reported measures for several outcomes. Larger controlled and multi-institutional studies incorporating objective measures of clinical reasoning, practical competence, and longer-term learning outcomes are warranted.

Declarations

Ethics approval and consent to participate

This study involved a questionnaire survey of students enrolled in Veterinary Parasitology at Borana University. The study protocol was reviewed by the Borana University Institutional Research Ethics Review Committee (BRU–IRERC), which determined that formal ethics approval was not required because the research was a non-invasive survey involving human participants. An exemption was granted under reference number BRU/1236/7/1. Before data collection, the purpose of the study, the voluntary nature of participation, the right to withdraw, and measures to maintain confidentiality were explained to all participants, and informed consent was obtained. No personally identifiable information was collected or reported. The study was conducted in accordance with applicable institutional and ethical requirements for research involving human participants and, where applicable, the principles of the Declaration of Helsinki.

Consent for publication

Not applicable. No individually identifiable personal information or images are reported in this manuscript.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request, subject to applicable institutional and ethical requirements.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Latera Solomon: Conceptualization, methodology, intervention implementation, data collection, statistical analysis, and manuscript drafting. **Makida Elias:** Intervention implementation, literature review, and critical review. **Lamesa Ayana**: Laboratory session facilitation and data collection assistance. **Olefirom Yadessa**: Laboratory session facilitation and data handling. **Amanu Marema:** Data management, verification of statistical analyses, and manuscript editing. All authors read and approved the final manuscript.

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List of abbreviations

CBT — Case-based teaching

HDP — Higher Diploma Program

SD — Standard deviation

STEM—Science, Technology, Engineering, and Mathematics

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