**Abstract**

Clinical reasoning is a fundamental skill for veterinary clinicians and a competency required of graduates by the Royal College of Veterinary Surgeons. However, it is unknown how veterinary students develop reasoning skills and where strengths and shortcomings of curricula lie. This research aimed to use the University of Nottingham School of Veterinary Medicine and Science (SVMS) as a case study to investigate veterinary student clinical reasoning development. The analysis was framed in consideration of the taught, learnt and declared curricula. Sixteen staff and sixteen students from the SVMS participated separately in a total of four focus groups. In addition, five interviews were conducted with recent SVMS graduates. Audio transcriptions were used to conduct a thematic analysis. A content analysis was performed on all curriculum documentation. It was found that SVMS graduates perceive they have a good level of reasoning ability, but still experience a deficit in their reasoning capabilities when starting their first job. Overarching themes arising from the data suggest that a lack of responsibility for clinical decisions during the course and the embedded nature of the skill within the curriculum could be restricting development. Additionally, SVMS students would benefit from clinical reasoning training where factors influencing 'real life' decisions, for example finances, are explored in more depth. Integrating these factors into the curriculum could lead to improved decision making ability in SVMS graduates and better prepare students for the stressful 'transition to practice' period. These findings are likely to have implications for other veterinary curricula.

**Key words**

Clinical-reasoning, curriculum review, transition to practice

**Introduction**

Clinical reasoning can be defined as 'the cognitive processes physicians use to diagnose and manage patients'[1]. It involves the decision processes required for diagnosis and treatment planning, alongside influential contextual and situational factors[2]. As a focus of research in human medicine for the last forty years[3], dramatic developments have occurred in the understanding of both the cognitive underpinning of clinical reasoning in physicians and the practical demonstration of the skill as a health professional.

Clinical reasoning is also a fundamental skill for veterinary surgeons[4]. In contrast to human medicine, there have been very few studies dedicated to understanding the process of *veterinary* clinical reasoning[5,6] and as a result, veterinary educators have little certainty which medical research findings can be extrapolated to the their own field, and where differences between the disciplines affect decision making. This, in partnership with the embedded nature of the skill within curricula, make developing clinical decision making expertise a 'formidable challenge to veterinary educators and their students.'[7(P.200)]

Studies into medical and veterinary undergraduate clinical reasoning development frequently examine the effect of a specific intervention on the reasoning skills of students, not the current reasoning development within an established curriculum. Although these interventions can have positive effects[8–12], graduating with competence in clinical reasoning

undoubtedly lies in more than just one teaching activity. Evaluation of the contribution and effectiveness of all aspects of the curriculum to clinical reasoning development is needed to understand shortcomings and indicate the need and appropriate use of these interventions.

Understanding veterinary student reasoning development has recently increased in urgency, as the Royal College of Veterinary Surgeons (RCVS) now include clinical reasoning ability as a day one competency of graduates[4]. The work of Tomlin et al.[13,14] provides the biggest insight into veterinary undergraduate clinical reasoning, demonstrating that students' methods and opinions about clinical decision making can differ substantially from what their clinical teachers predict. This suggests educators' assumptions about reasoning development in curricula are unreliable. However, this study only provides a snapshot of the process during a final year examination, which is difficult to extrapolate to the whole course. Further information is needed to understand how veterinary students learn to make clinical decisions, what level of competence they achieve and how this process can be optimised.

The aim of this study was to use the University of Nottingham School of Veterinary Medicine and Science (SVMS) as case study to examine veterinary student clinical reasoning skill development. It was hoped that information gained from a detailed investigation of one veterinary curriculum in the United Kingdom would provide some insight into clinical reasoning development that could be generalised to other veterinary schools[15] and contribute to general understanding of the process.

The five year Veterinary Medicine and Science course at the SVMS is a vertically integrated spiral curriculum arranged into body system modules (e.g. cardiorespiratory system). Harden describes a spiral curriculum as '…one in which there is an iterative revisiting of topics, subjects or themes throughout the course'[16 p.141]. Importantly, each topic must be built upon with each encounter, increasing the skill of the student with time. The SVMS also uses a distributed model; whereby the clinical practice modules that make up the final year of the course are taught offsite by university staff at associate veterinary practices. In addition to this practical experience, the RCVS requires all veterinary students to complete 26 weeks of clinical extra-mural studies (CEMS), consisting of workplace-based learning in private veterinary practices during holiday periods.

At the SVMS, clinical reasoning is considered to be an 'embedded' topic – meaning it is integrated throughout all modules of the course,[17] within various teaching sessions (e.g. case-based learning [CBL]). There is also a dedicated lecture and a practical session explaining the concept and process of clinical reasoning to students in the third year of the program. Students are examined on their clinical reasoning ability in the fourth and final years of the course using case-based questions. This study aimed to clarify where and how decision-making expertise was developed.

## Methods

Hardens conceptualization of a curriculum[18] was utilized as a framework for analysis. This model presents three overlapping, but separate, components within a curriculum: (1) information declared to be taught (2) what actually is taught and (3) what the student actually learns. As clinical reasoning is a topic integrated within many aspects of the SVMS curriculum, thus difficult to isolate and access, structuring the study in this way gave a systematic way to analyze the curriculum - ensuring all perspectives and experiences were

considered. Harden includes the hidden curriculum in his framework, embedded within the 'learnt' perspective.

A mixed method approach was used. The concurrent mixed design[19] had two stages: 1) quantitative analysis of the declared curriculum through document content analysis and 2) qualitative analysis of the taught and learnt curricula through staff and student/graduate perceptions respectively. Inferences from these two data sets were integrated post-analysis. All components of the study were approved by the SVMS Ethics Committee

*Content analysis of the declared curriculum*

The declared curriculum was analysed by conducting a document content analysis – a process that codes and quantitatively analyses qualitative data[20]. Method guidelines by Cohen et al[21] were modified by selectively coding only information that related to clinical reasoning. The inclusion and exclusion criteria for the coding are shown in Table 1.

INSERT TABLE 1 HERE

Documents were selected using a purposive sampling technique, whereby all documents describing the content of the SVMS curriculum were included. These were sourced from the Teaching, Learning and Assessment department. As the SVMS has been operational for just nine years, only eleven documents were found; most created for the purpose of accreditation. These included detailed learning objective records, student handbooks, self-evaluation reports and programme specifications. No documents were excluded.

In two of the documents curriculum learning objectives were recorded next to the session type they were delivered in (i.e. Lecture, practical, self-directed learning (SDL), seminar or CBL). In these documents the session type associated with each coded learning objective was noted and the percentage of codes (and therefore learning objectives relating to clinical reasoning) that appeared in each session type were calculated.

*Thematic analysis of the taught and learnt curricula*

The taught and learnt curricula were investigated qualitatively, utilising the perceptions of SVMS staff, students and recent graduates. Separate focus groups were held with SVMS staff (total of 16 participants) and students (total of 16 participants). Interviews were held with five SVMS recent graduates.

Focus groups

Using a non-randomised purposive sampling technique, all staff involved in the teaching or planning of key curriculum areas were invited to participate in a focus group. Two focus groups were run with volunteer staff members, one with eight participants and the other with ten.

A convenience sample of SVMS students were recruited via email. First year students were not included as they had very limited experience of SVMS teaching (data collection took place within the first two weeks of a new student intake). Two focus groups containing eight students were run, with two students from each year group (years 2-5).

Both staff and student focus groups used a semi-structured questioning approach and lasted approximately 90 minutes. The participants of all groups were provided with a definition of clinical reasoning. Questions focussed on participant perceptions of clinical reasoning as a process and how they felt it develops during the SVMS curriculum.

Interviews

A convenience sample of SVMS graduates less than two years post qualification were interviewed individually to determine their view of the learnt curriculum and their experiences of clinical reasoning in their first job. Interviews were semi-structured and conducted both in person and by telephone, lasting between 45-60 minutes. Participants from small animal, equine and farm animal practices were included. Questions focussed on competence in clinical reasoning upon graduation and perceptions of how the SVMS curriculum assisted or hindered development.

Analysis

Interviews and focus groups were audio recorded and transcribed. Transcriptions from all focus groups and interviews were combined into one dataset for ongoing analysis. Data collection ceased when both 1) a minimum of two transcripts were collected for each cohort (staff/student/graduate) and 2) data saturation occurred. Thematic analysis was performed using guidelines developed by Braun & Clarke[22]. Complete inductive code generation was performed, managed through NVIVO (QSR, version 10). Codes were then interpreted and grouped together to form subthemes and themes. These themes were iteratively revised and edited. A 10% selection of the data was coded by a second researcher and agreement reached in order to ensure a consistent approach. Once coding was complete, all themes were defined and explained.

## Results

*Content analysis of the declared curriculum*

By considering the location and frequency of the clinical reasoning codes found within the documentation the following key findings were identified:

1. There is limited declared clinical reasoning exposure before fourth year. All modules in years one to three have very little coding in both qualitative descriptions and learning objective lists. The modules in fourth year are highly coded, suggesting that clinical reasoning is a more frequently taught concept from fourth year onwards, or is only made explicit to students from this point onwards.
2. There is very limited occurrence of codes in reference to Extra-Mural Studies (EMS) throughout all of the documentation. This is despite coding two student manuals dedicated to EMS. This suggests that either EMS is not expected to be a source of clinical reasoning exposure, or that staff did not feel the need to make clinical reasoning involvement with EMS explicit in materials produced about it.

The learning objective documentation allowed mapping of the delivery of clinical reasoning according to the learning objectives. Learning objectives from the final year of study, spent completing workplace-based learning, were classified as a practical session. This analysis (Table 2) shows 39.2% and 32.4% of clinical reasoning learning objectives are scheduled to

be delivered within lectures and practical sessions respectively. CBL and seminar sessions have the lowest percentage of clinical reasoning learning objective occurrence.

INSERT TABLE 2 HERE

*Thematic analysis of the taught and learnt curricula*

The thematic analysis produced 6 overarching themes. Each theme is described in the following section. Quotes from the focus group/interview transcriptions are used to demonstrate each theme and are identified as graduate, staff or student.

Theme one: Graduates are functional, but not skilled

This theme developed from the contrasting views of clinical reasoning skill attainment. Some participants found SVMS instruction to be successful, particularly in diagnosis.

> *'I think they prepared us really well. For making a diagnosis, I think it was really good.' Graduate*

This was counteracted by specific deficits observed in students and a varying ability level within each year group.

> *'The fourth years… just come up with a whole list of tests and they can't prioritise them, so I don't think they learn to develop clinical reasoning' Staff*

> *'(Clinical reasoning ability) is very variable on the individual.' Staff*

Additionally, graduates seem to lack confidence in their clinical reasoning ability, and as a result go through a steep curve of reasoning improvement in their first job.

> *'When I first started, there was no way I would have gone to a farm and elected not to give an animal any treatment… I just didn't have the confidence.' Graduate*

> *'Something like a wound, that was a big learning curve coming out of vet school. 'Do I stitch this or not? Do I give it antibiotics or not?', all those sort of choices… I just didn't feel that well prepared in making that choice.' Graduate*

Theme two: Components of reasoning development

During the analysis, perceptions of the factors contributing to the development of clinical reasoning skills in students were identified. Firstly, students need some kind of formal teaching in critical thinking methods and problem solving.

> *'You must teach the (clinical reasoning) process.' Staff*

> *'…If you haven't got the theory in place you can't really then apply it.' Student*

Secondly, they must experience clinical reasoning by spending time in practice. This could mean watching experienced clinicians make decisions – but the biggest gains come from experiencing the reasoning process themselves.

> *'I think when you're actually on rotations… you do realise then, actually I am starting to do (clinical reasoning) subconsciously.' Student*

In addition to these events, which can be scheduled into a curriculum, clinical reasoning skills require ongoing development through knowledge acquisition and general, non-clinical decision making experience.

'*There is a baseline of knowledge that you need in order to do clinical reasoning.' Staff*

*'(Reasoning ability) evolves as you're going through life.' Staff*

The data indicated that participants viewed these four components – experience in practice, critical thinking, knowledge and life skills – as required to produce an expert in clinical reasoning.

Theme three: Responsibility for decisions

It emerged that students need a sense of responsibility for their decisions before they really learn from the outcome. This has two dimensions: independence and consequences. Firstly students need the opportunity to make decisions alone, without a clinician acting as a safety net diverting consequences. This is discussed in the following dialogue within a staff focus group:

*Staff 1:* *'But does that not drive the quality of the reasoning if they realise that they might kill the cow or kill the horse?*

*Staff 2:* *'No, I don't think students ever do feel that pressure because they're still in a very cossetted environment… There's always that safety net there.'*

Secondly, students need to feel there will be real consequences as a result of their clinical reasoning. Without this, students do not invest in their decisions or feel a strong desire to make the correct decision.

*'It's the outcome, isn't it, of the decision? Is that going to fall on your shoulders or somebody else's shoulders? And that triggers you perhaps to think about it maybe slightly differently.' Staff*

*'I didn't make a decision that I could claim until you know I was on the line and I had to do something. So once it became my responsibility, then I think I started making decisions, and prior to that I think it was something else.' Staff*

Consequences could include personal embarrassment at performing badly, irritating on-call clinicians, animal welfare issues and threats of legal action.

*'Clients and rotations - you don't want to be rubbish with a client, you don't want to get a bad rotation report.' Student*

*'You want to be able to justify (your clinical decisions) and not get sued.' Student*

*'You're responsible for somebody, you're responsible for a real live animal. It's not on something on a piece of paper, it's somebody's pet. It's like my dog… if I said the*

*wrong thing then a) my parents would be annoyed with me, b) I'd look like an idiot when my parents went to the vets back at home.' Student*

Theme four: Holistic decision making

This theme developed from the impression that certain components of clinical reasoning are not covered in the SVMS curriculum. In particular, students are rarely confronted with several problems of 'real-life' decision making – including finances, drug course length, clients and ineffective treatment regimes.

*'I think we don't have any idea about finances. Well I didn't anyway and I think that we should know what drugs are expensive, what drugs are cheap.' Graduate*

*'No one ever really teaches you how long to give an antibiotic necessarily … 'Do I do a week? Do I do ten days? Do I do fourteen days?' … it was just basically making it up with course length…' Graduate*

Students would like to practice clinical reasoning *in situ*, so all components of the decision making process are included. Standardised patient (SP) simulation, already a feature of the SVMS communication skills curriculum, was suggested as a way to expose students to a more holistic clinical reasoning experience.

*'The hardest thing is… putting everything else on the side, like the computer system, printing labels, sorting out the nurses. So I think if you kind of had that in a (simulated) practice situation… that might be quite useful.' Student*

Theme five: Inhibitive curriculum

There are features of the SVMS curriculum that appear to unintentionally impede the development of clinical reasoning skills. The most significant is that clinical reasoning exposure is not made overt to students. They appeared unaware of the terminology, process or role of clinical reasoning until it is examined in fourth year. There is a general assumption by staff that students should be developing the skill, but this is not clearly articulated to the students themselves.

*'I think we subliminally subject them to clinical-reasoning.' Staff*

*'Looking back now you are exposed to (clinical reasoning) from the start but you don't know it.' Student*

Both CBL and clinical extra-mural studies (CEMS) do not seem to be achieving their potential for clinical reasoning development. CBL sessions appear to have become more 'question-answer' focussed than student-directed problem solving. Students are also able to predict answers, based on the content of the week's lectures.

*'The (CBL) sessions are actually on the whole they're quite directed… which doesn't exactly always lend itself to clinical-reasoning' Staff*

*'If (CBL) is supposed to be clinical reasoning, it's not.' Student*

CEMS was suggested as a key opportunity for clinical reasoning development, however students can lack the confidence or motivation to discuss decisions made by veterinary surgeons, and thus learn little about the reasoning process.

> *'The only way the students are going to get (clinical reasoning) is by seeing it in action; seeing it in EMS, but therefore the EMS needs to be effective.' Staff*

> *'(Your clinical decision) is a conclusion you put in your notes most of the time, so unless the Vet actually takes the time to go through that, they don't see it going on. They don't realise what's happening.' Staff*

Other structural features of the curriculum – for example a lack of clinical tutorials, or effective reasoning examination – were also described as preventing student development. Overall, some areas of the curriculum could be functioning more effectively to promote clinical reasoning skills in students.

Theme six: Challenges to teaching

It emerged that there are inbuilt challenges to providing a comprehensive education in clinical reasoning. Throughout the investigation, students were opposed to any intervention that may cause 'more work', regardless of the potential for reasoning skill improvement.

> *'I know (practicing clinical reasoning) would be a lot of work for us and I think I'd hate it.' Student*

There was an underlying assumption by staff and students that direct teaching on clinical reasoning topics would not be absorbed. Students themselves felt apprehensive about having to understand the topic and wanted to limit their exposure to it.

> *'If we brought in clinical-reasoning in Year 1… are they actually going to get anything from it?' Staff*

> *'I think (clinical reasoning theory) just makes it too complicated and that scares me.' Student*

Finally, many participants, particularly students, did not think knowledge of clinical reasoning theory was necessary because it would not affect practice.

*'I don't know if knowledge of different (clinical reasoning) methods is particularly relevant' Student*

**Discussion**

This study has highlighted the successes and the shortcomings of a veterinary curriculum when trying to foster clinical reasoning development in students. A mixed methods approach was used to 'draw from the strengths and minimize the weaknesses' [23(p.14)] of the qualitative and quantitative paradigms. This allowed methods to be chosen according to suitability, unrestricted by positivist or constructionist epistemologies[19]. The study findings indicate that the SVMS is producing graduates that can function as veterinary surgeons and are confident in certain aspects of decision making, but are by no means 'skilled'. As a result

of this they may need to significantly develop their reasoning ability once in practice. Although new graduates are not expected to be expert clinical decision makers, their current shortfall is such that it may be increasing their stress burden. While the specific level of deficit depends on the individual, all graduates reported some clinical reasoning challenges they felt unprepared for. This appears to contradict opinions of surveyed graduates from other veterinary schools[24,25], who report a good grounding in clinical decision making skills during their courses. However, survey data are limiting, and further qualitative investigation in one study[24] revealed a lack of confidence in new graduates similar to that reported here, despite high survey scores. As the RCVS have recently included clinical reasoning as a day one competency[4], more research to clarify the competence of new graduates is needed. This study demonstrates the benefits of performing a structured mixed method analysis to assist with this.

It can be argued that the reasoning shortfall experienced by SVMS graduates can only be filled once working alone in practice, and it is impossible to produce a graduate that is fully competent in this skill. However, the theme *holistic decision making* suggests methods, such as simulation, to try and fill this gap in experience and create a more 'practice-ready' graduate. Simulation has been shown to improve clinical reasoning in other disciplines[26–29], but there are countless ways to implement it, meaning trials of specific interventions are needed in this area before curriculum changes can be made. In veterinary medicine, one study has demonstrated the potential of contextualised simulation to improve decision-making skills[30]. Although this research relies on student 'self-assessment' data, therefore lacking objective measurement, it provides good reason to investigate simulation further as a method of clinical reasoning development.

It is also apparent that the 'real-life' aspects of decision making (e.g. clients, finances) need to be incorporated into teaching[30,31], as it seems veterinary reasoning has more dimensions than simply clinical knowledge[7]. This corresponds to research in medicine which has demonstrated that decision-accuracy was affected by context and interference[2], suggesting that these factors need to be integrated into teaching. It is interesting to note that direct effort by SVMS to teach students clinical reasoning -- including lectures, practicals and evidence-based medicine sessions – were not described by students as influencing their skill development. This may indicate that students do not associate the 'classroom' version of decision making with the 'consultation room' version.

Creating responsibility for decisions is a theme that emerged very strongly in this study, but is incredibly difficult to recreate. Due to animal welfare concerns students will never be able to have the 'last say' on a case. This is detrimental to development, as graduates cite lack of experience working with responsibility as a key factor that makes the transition to practice difficult[25]. Whilst innovations such as virtual patients are a potential way to give students decision making power[8,32,33], they still have limitations. Students indicated that substituting medical responsibility for another high stakes outcome -- particularly embarrassment at poor performance in front of a client or clinician -- may be an effective way to replicate pressure and improve performance. Further research into the comparison of 'true' responsibility and other motivators to perform well is needed, but this study corroborates research by Baillie et al.[30] suggesting that using real or standardised clients during decision-making sessions to create this 'performance-pressure' may be beneficial.

The components identified as contributing to clinical reasoning development – critical thinking instruction, experience in practice, knowledge and life skills - are similar to findings from studies examining individual interventions[12,34–37]. The fact that knowledge is perceived by staff, students and graduates to be a key dimension of the clinical reasoning may explain why the largest proportion of SVMS coded learning objectives are delivered in lectures. It is likely, however, that these perceptions are based on a lack of insight into the clinical reasoning development process; meaning the use of lectures to 'deliver' the skill may be misguided. As understanding of clinical reasoning grows, misconceptions about how best to teach the skill – particularly within staff designing curricula – must be addressed. It is clear that clinical reasoning tutelage needs to be based on evidence, not tradition.

The lack of awareness by students of the concept of clinical reasoning, and the attitude that students should 'assume' they should be learning it, is evident within the SVMS curriculum. It is likely that this is detrimental to students, as it makes it difficult for them to track or reflect on their reasoning skill development. Curriculum transparency is a wider issue of clinical curricula. Acceptance that much student learning occurs within informal interactions, rather than just in declared teaching sessions[38], has led to a call for greater accessibility of medical curricula generally[18]. To make curricula more transparent, Harden[18] advocates the use of curriculum mapping. This allows students to identify exactly where in the curriculum they are given opportunities to develop knowledge and skills, and is being adopted by many medical schools[39]. Currently the SVMS uses curriculum mapping purely as a management tool for accreditation purposes. Expanding this to include the mapping of embedded topics, and formatting it for use by student and staff may, as described by Harden, 'make explicit the implicit…' (P.124)

*Limitations*

The SVMS has been used as a case study[40] in this research. Although investigating only a single institution, there is a degree of generalisability[15] to other veterinary curricula where clinical reasoning is an embedded skill. Comparing this work to similar case studies from other veterinary schools, if they were performed, would enhance our understanding of the subject and provide greater evidence for extrapolation of findings.

This study has not directly considered the effect of assessment on clinical reasoning development[41]. It was clear from student focus groups that students want to improve their reasoning skills in order to become a competent veterinary surgeon, not because they see it as necessary to pass exams. Consequently, this avenue was not explored further, but could be expanded on in future work. Additionally, this study did not take into the consideration the opinions of employers when evaluating the clinical reasoning ability of graduates, due to the focus being on the curriculum. Information of this kind could be used to triangulate graduate interview findings.

When asking staff to critique their own curriculum, particularly in a focus group environment, it is possible that they may be either overly critical or defensive. Similarly, students may feel an affinity to the school that affects their perspectives. These factors, along with the fact that participants are 'self-reporting' on their clinical reasoning ability, should be considered when interpreting the results of this study.

## Conclusion

This study provides a novel insight into the development of clinical reasoning in a modern veterinary curriculum. It highlights the key role of responsibility in the process, and discusses the need to ensure a holistic approach to the concept of decision making within veterinary schools, and clinical curricula generally. Finally, it identifies a shortfall in graduate reasoning competence that may be contributing to high stress levels during the 'transition to practice' period.

## References


1. Cutrer W, Sullivan W, Fleming A. Educational strategies for improving clinical reasoning. Curr Probl Pediatr Adolesc Health Care. 2013;43(9):248–57.

2. Durning SJ, Artino AR, Boulet JR, Dorrance K, van der Vleuten C, Schuwirth L. The impact of selected contextual factors on experts' clinical reasoning performance (does context impact clinical reasoning performance in experts?). Adv Heal Sci Educ. 2012;17(1):65–79.

3. Norman G. Research in clinical reasoning: past history and current trends. Med Educ. 2005;39(4):418–27.

4. Eraut M. RCVS Day One Competences. 2014 p. 1–12.

5. Vandeweerd J, Vandeweerd S, Gustin C, Keesemaecker G, Cambier C, Clegg P, et al. Understanding Veterinary Practitioners' Decision-Making Process: Implications for Veterinary Medical Education. J Vet Med Educ. 2012;39(2):142–51.

6. Everitt S. Clinical decision making in veterinary practice. University of Nottingham; 2011.

7. May S. Clinical reasoning and case-based decision making: the fundamental challenge to veterinary educators. J Vet Med Educ. 2013 Jan;40(3):200–9.

8. Chapman D, Mondfrans A. Assessing Effectiveness of a Problem- Based Learning Curriculum in Teaching Clinical Reasoning Skills. J Clin Reason Proced competency. 2013;1(1):17–28.

9. Banning M. The think aloud approach as an educational tool to develop and assess clinical reasoning in undergraduate students. Nurse Educ Today. 2008;28(1):8–14.

10. Chamberland M, St-Onge C, Setrakian J, Lanthier L, Bergeron L, Bourget A, et al. The influence of medical students' self-explanations on diagnostic performance. Med Educ. 2011;45(7):688–95.

11. Gerdeman J, Lux K, Jacko J. Using concept mapping to build clinical judgment skills. Nurse Educ Pract. 2013;13(1):11–7.

12. Seif G, Coker-Bolt P, Kraft S, Gonsalves W, Simpson K, Johnson E. The development of clinical reasoning and interprofessional behaviors: service-learning at a student-run free clinic. J Interprof Care. 2014;28(6):559–64.

13. Tomlin J, Pead M, May S. Veterinary Students' Attitudes toward the Assessment of Clinical Reasoning Using Extended Matching Questions. J Vet Med Educ. 2008;35(4):612–21.

14. Tomlin J, Pead M, May S. Attitudes of veterinary faculty to the assessment of clinical reasoning using extended matching questions. J Vet Med Educ. 2008;35(4):622–30.

15. Silverman D. Doing Qualitative Research: A Practical Handbook. SAGE Publications; 2013

16. Harden RM. What is a spiral curriculum? Med Teach. 1999;21(2):141–3.

17. Dent J, Harden RM. A Practical Guide for Medical Teachers. Elsevier Health Sciences; 2013.

18. Harden R. Curriculum mapping: a tool for transparent and authentic teaching and learning. Med Teach. 2001;23(2):123–37.

19. Onwuegbuzie A, Johnson R. The Validity Issue in Mixed Research. Res Sch. 2006;13(1):48–63.

20. Braun V, Clarke V. Successful Qualitative Research: A Practical Guide for Beginners. SAGE; 2013. 400 p.

21. Cohen L, Manion L, Morrison L. Research Methods in Education. Oxon: Routledge; 2011. Chapter 23 p.

22. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3:77–101.

23. Johnson R, Onwuegbuzie A. Mixed Methods Research : A Research Paradigm Whose Time Has Come. 2014;33(7):14–26.

24. Gilling M, Parkinson T. The transition from veterinary student to practitioner: A “make or break” period. J Vet Med Educ. 2009;36(2):209–15.

25. Jaarsma D, Dolmans D, Scherpbier A, Van Beukelen P. Preparation for practice by veterinary school: a comparison of the perceptions of alumni from a traditional and an innovative veterinary curriculum. J Vet Med Educ. 2008;35(3):431–8.

26. Powell-Laney S, Keen C, Hall K. The Use of Human Patient Simulators to Enhance Clinical Decision-making of Nursing Students. Educ Heal. 2012;25(1):11–5.

27. Kneebone R, Baillie S. Contextualized simulation and procedural skills: a view from medical education. J Vet Med Educ. 2008;35(4):595–8.

28. Steadman R, Coates W, Huang Y, Matevosian R, Larmon B, McCullough L, et al. Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills. Crit Care Med. 2006;34(1):151–7.

29. Kelly M, Hager P, Gallagher R. What matters most? Students’ rankings of simulation components that contribute to clinical judgment. J Nurs Educ. 2014;53(2):97–101.

30. Baillie S, Pierce S, May S a. Fostering integrated learning and clinical professionalism using contextualized simulation in a small-group role-play. J Vet Med Educ. 2010;37(3):248–53.

31. Patel R, Sandars J, Carr S. Clinical diagnostic decision-making in real life contexts: A trans-theoretical approach for teaching: AMEE Guide No. 95. Med Teach. 2014;37(3):211–77.

32. Dhein CR. Online small animal case simulations, a.k.a. the Virtual Veterinary Clinic. J Vet Med Educ. 2005;32(1):93–102.

33. Cook D, Triola M. Virtual patients: a critical literature review and proposed next steps. Med Educ. 2009;43(4):303–11.

34. Baguley J. The role of final year extramural placements in the undergraduate veterinary curriculum. Aust Vet J. 2006;84(5):182–6.

35. Facione N, Facione P, Sanchez C. Critical thinking disposition as a measure of competent clinical judgment: the development of the California Critical Thinking Disposition Inventory. J Nurs Educ. 1994;33(8):345–50.

36. Lasater K, Nielsen A. Reflective journaling for clinical judgment development and evaluation. J Nurs Educ. 2009;48(1):40–4.

37. Chamberland M, Mamede S, St-Onge C, Rivard M, Setrakian J, Lévesque A, et al. Students' self-explanations while solving unfamiliar cases: the role of biomedical knowledge. Med Educ. 2013;47(11):1109–16.

38. Hafferty FW. Beyond curriculum reform: confronting medicine's hidden curriculum. Acad Med. 1998;73(4):403–7.

39. Willett TG. Current status of curriculum mapping in Canada and the UK. Med Educ. 2008;42(8):786–93.

40. Denzin NK, Lincoln YS. The SAGE Handbook of Qualitative Research. SAGE Publications; 2011

41. Fuentealba C. The role of assessment in the student learning process. J Vet Med Educ. 2011;38(2):157–62.

## Tables

Table 1: content analysis inclusion and exclusion criteria

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| the term 'clinical reasoning' or 'clinical decision making' or 'clinical judgement' | References only to assessment methods |
| A reference to the development of or importance of<br>○ Diagnosis<br>○ Differential diagnoses<br>○ Diagnostic testing or planning<br>○ Clinical and historical data interpretation<br>○ Treatment options or planning<br>○ Prognosis<br>○ Critical thinking | References to Problem-Based Learning without a clinical context |

Table 1: The inclusion and exclusion criteria used to perform the document analysis coding

Table 2: Learning objectives analysis

| | Lecture | Practical | Self-directed learning | CBL | Seminar |
|---|---|---|---|---|---|
| **Total number of coded learning objectives** | 258.0 | 213.0 | 114.0 | 54.0 | 19.0 |
| **Percentage of coded learning objectives** | 39.2 | 32.4 | 17.3 | 8.2 | 2.9 |
| **Percentage of total learning objectives** | 2.5 | 2.0 | 1.1 | 0.5 | 0.2 |

Table 2: The number of learning objectives coded as relating to clinical reasoning within each session type; this value as a percentage of both the total number of course learning objectives and the total number of learning objectives coded for clinical reasoning.