



Research Process Formation in Veterinary, Animal, and Health-Sciences Education: An Activity-Theoretical Model Approach

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ABSTRACT

The education of veterinarians, animal scientists, and health professionals is often expected to culminate in evidence-based action, yet the research process itself is still frequently taught as a fragmented collection of techniques. This article proposes a more coherent model by treating the research cycle as a sequence of four interrelated but distinct activities: search and collect, analysis, synthesis, and challenge. Drawing on cultural-historical activity theory, argumentation theory, competency-based professional education, and recent work in veterinary and health sciences education, the article argues that each phase should be taught as an activity with its own object, mediations, community relations, and product. In this model, information enters the cycle as the broad universe of scholarly sources, discursive contributions, and statistics. Search and collect transforms information into documented sources. Analysis transforms sources into statements, understood as warranted judgments extracted from them. Synthesis transforms statements into arguments, which function as the building blocks of knowledge objects. Challenge transforms arguments and data into claims through deduction, induction, abduction, and direct confrontation with empirical material in order to support exploration, confirmation, explanation, inference, prediction, and narration. The article shows how this framework can organize longitudinal research education for undergraduate and graduate learners in veterinary, animal, and health sciences. It concludes that research formation becomes stronger when the curriculum is organized around these four activities, when genres and other persuasive media make reasoning inspectable, and when students repeatedly move between evidence, judgment, argument, and claim in authentic professional contexts.

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I. INTRODUCTION

Veterinary medicine, animal science, and the health professions require practitioners who can do more than recall accepted knowledge. They must be able to find relevant evidence, judge its quality, transform it into coherent understanding, and produce defensible claims in settings marked by uncertainty, ethical tension, and practical consequence. This expectation is now explicit in competency-based veterinary education and in One Health frameworks, both of which treat reasoning, communication, collaboration, and accountability as integral to professional action rather than as secondary accomplishments (Education et al., 2024; Frankson et al., 2016). Yet the research process is still commonly taught as a dispersed collection of library

sessions, methods courses, statistics modules, journal clubs, and thesis requirements. Students often encounter search, analysis, writing, and defense as separate pedagogical islands rather than as connected moments in a single developmental cycle.

That fragmentation is a curricular problem. If research is reduced to a set of isolated techniques, students may learn to comply with assignments without understanding what each phase of inquiry is trying to transform. They may collect articles without building a source corpus, summarize papers without producing analytic statements, review literature without constructing arguments, or accumulate data without learning how claims are justified and contested. The result is not simply weak scholarship. It is weak professional

formation, because clinical judgment, herd-health planning, public-health intervention, and translational science all depend on the capacity to move rigorously from information to claim.

This article argues that veterinarians, animal scientists, and health professionals should be educated for research by treating the research cycle as a system of four distinct but recursively related activities: search and collect, analysis, synthesis, and challenge. The proposal is inspired by the activity-theoretical tradition associated with Vygotsky, Leontiev, and Engeström, which understands learning as the collective, mediated transformation of meaningful activity systems rather than the accumulation of decontextualized competencies (Vygotsky, 1978; Leont’ev, 1978; Engeström, 1987; Engeström, 2001; Roth & Lee, 2007). It also draws on recent work that re-specifies the normative and communicative dimension of activity systems through persuasive media and mediated practical reason in veterinary and health sciences education (Rodríguez Frausto et al., 2026a; la et al., 2026b; Rodríguez Frausto et al., 2026c).

The central claim is straightforward. Each phase of the research cycle has its own object, mediations, social organization, and product. Search and collect transforms information into sources. Analysis transforms sources into statements. Synthesis transforms statements into arguments. Challenge transforms arguments and data into claims. These outputs are not interchangeable. A source is not yet a statement, because a documented text or dataset must still be judged. A statement is not yet an argument, because isolated judgments must still be related to each other. An argument is not yet a claim, because a knowledge construction must still be elaborated, tested, and confronted with data and criticism. Treating these products as distinct clarifies what students should be doing at each phase and how teaching, supervision, and assessment should be organized.

The article proceeds in seven steps. It first defines the research cycle in activity-theoretical terms. It then discusses each phase as a distinct educational activity. After that, it outlines how undergraduate and graduate formation should differ in level of responsibility and complexity. Finally, it proposes implications for curriculum design, assessment, and faculty work in veterinary, animal, and health sciences education.

II. LITERATURE REVIEW

A. The research cycle as a sequence of activities

Activity theory offers a useful language for the present problem because it insists that education must be organized around objects of activity rather than around disembodied topics. Activities are directed by motives and distinguished by their objects; they are realized through goal-directed actions and made possible through operations shaped by conditions (Leont’ev, 1978). In this perspective, learning

does not occur because students merely receive information. It occurs because they participate in historically formed practices, use mediating tools and signs, and gradually internalize and externalize increasingly complex forms of action (Vygotsky, 1978; Roth & Lee, 2007). Engeström’s development of activity systems adds a further insight that matters greatly for research education: the object of an activity is always socially distributed, mediated by artifacts, and transformed through contradictions that force participants to rethink what they are doing (Engeström, 1987; Engeström, 2001).

Applied to research education, this means that the research process should not be conceived as a single undifferentiated activity called “doing research.” It should be conceived as a chain of activities, each with its own object of transformation. Search and collect has as its object the conversion of a broad informational environment into a curated and documented corpus of relevant sources. Analysis has as its object the conversion of that corpus into statements, that is, warranted judgments regarding what the sources say, how they say it, and how much epistemic weight they deserve. Synthesis has as its object the conversion of statements into arguments, meaning structured relations among claims, reasons, contrasts, mechanisms, and positions that can support a knowledge object such as a review, conceptual framework, diagnostic explanation, or policy rationale. Challenge has as its object the elaboration of claims by placing arguments into disciplined confrontation with data, alternative explanations, collaborators, and inferential scrutiny. Claims are therefore not merely opinions at the end of a project. They are the products of a labor process in which deduction, induction, and abduction are used to support exploration, confirmation, explanation, inference, prediction, and narration.

This sequence is cyclical rather than linear. The products of one activity become mediations or inputs for the next, and challenge frequently forces a return to earlier activities. A weak claim may reveal that the argument is underdeveloped, that the statements are too crude, or that the source corpus is incomplete. Conversely, a careful search may only become possible after preliminary analysis clarifies which concepts matter. The cycle shows the interdependent phases connected by reversible relations, with outward-moving products and constant feedback.

A second advantage of the activity-theoretical perspective is that it foregrounds mediation. Research is never performed nakedly by a mind. It is mediated by databases, search strings, annotation systems, evidence tables, statistical software, codebooks, conceptual maps, dashboards, rubrics, discussion formats, posters, manuscripts, and oral defenses. Recent veterinary and health sciences work has argued that these media are not merely neutral containers. They carry norms, distribute attention, define what counts as relevant evidence, and persuade communities that certain lines of

reasoning are legitimate (Rodríguez Frausto et al., 2026b; Colina Garcia et al., 2026). In that sense, the genres of research are also persuasive media. A protocol persuades a committee that a design is coherent. An evidence table persuades a reader that the literature has been handled systematically. A methods section persuades peers that a claim deserves trust. A thesis defense persuades an academic community that the author can justify and revise a position under scrutiny. Research education becomes clearer when these media are taught explicitly rather than left inside the hidden curriculum.

A third advantage is that activity theory allows a strong distinction between undergraduate and graduate formation without forcing a rupture between them. The activities are the same, but the motives, division of labor, and level of independence change. Undergraduate education should introduce students to the cycle through highly scaffolded participation in authentic but delimited research activities. Graduate education should reorganize the same cycle around greater autonomy, original problem formulation, more complex data relations, and more demanding standards of justification. This continuity matters for veterinary and health sciences programs because professional students often need both research literacy for practice and research capability for advanced inquiry (Healey & Jenkins, 2009; Lee et al., 2021; Šlapeta & Ward, 2024; Cardwell et al., 2017).

B. Search and collect as an activity: from information to sources

The first activity of the research cycle is search and collect. Its object is not information in general, but the transformation of a diffuse informational environment into a documented set of sources that can legitimately enter a research project. Information, in the sense used here, includes scholarly papers, books, technical documents, databases, official reports, numerical records, and discursive contributions from supervisors, peers, producers, clinicians, patients, owners, and community members. Information is therefore wider than literature. It is the field of possible relevance. Search and collect becomes research activity only when students engage in deciding which informational items are sufficiently identifiable, traceable, and pertinent to be retained as sources.

This distinction is pedagogically important. Many students believe that search is a preparatory or clerical stage, but it is already intellectually demanding. It requires the clarification of a question, the identification of key concepts and synonyms, the selection of databases and repositories, the construction of search strategies, the application of inclusion and exclusion criteria, the management of duplicates, and the documentation of provenance. In veterinary and health sciences education, this work should be taught as the formation of a source corpus rather than as mere “finding articles.” Information literacy research in veterinary

education shows that students often struggle not only to retrieve scientific papers but also to evaluate them and read them strategically (Dinkelman & Viera, 2011; Eldermire et al., 2019). Librarians therefore should not be positioned as peripheral helpers. They should be recognized as co-educators in the first activity of the research cycle.

The educational object of search and collect can be framed differently at different levels of formation. Early undergraduates need repeated practice with bounded corpora, structured database exercises, controlled vocabularies, and guided comparison between stronger and weaker source types. In professional programs, this may involve companion-animal clinical questions, herd-health cases, or One Health controversies for which students assemble a documented evidence set. What matters is not simply recall of search mechanics. Students must see that their immediate product is a corpus whose quality will condition everything that follows. A review built on an untraceable or conceptually narrow source base will not be repaired by later sophistication.

At more advanced undergraduate and graduate levels, search and collect must become increasingly problem-driven and historically sensitive. Students should recognize a source corpus not as a pile of papers but an organized representation of a field. That representation changes depending on whether the research problem is diagnostic, epidemiological, educational, sociocultural, experimental, or policy-related. A question about antimicrobial stewardship in small-animal practice, for example, may require clinical trials, qualitative interviews, policy documents, prescribing guidelines, and owner communication studies, not simply biomedical experiments. A question about learning in veterinary education may require theoretical work, educational interventions, qualitative inquiry, and institutional documents. Search and collect therefore has a conceptual component: students learn what kind of object their question is.

The most effective pedagogies for this phase are those that bring search into authentic inquiry rather than isolating it in one-off library workshops. Undergraduate research and inquiry literature has long argued that students benefit when research is embedded across the curriculum and when they experience searching as part of disciplinary problem solving (Healey & Jenkins, 2009; Brew & Boud, 1995; Hunter et al., 2007; Brew, 2012). In veterinary education, curricular models that integrate evidence-based medicine, epidemiology, and authentic literature work have shown how research literacy can be linked to practical professional questions (Šlapeta & Ward, 2024; St-Hilaire et al., 2022). The point is not to turn all students into career researchers. It is to make search a normal form of disciplined professional action.

Assessment in this phase should therefore target the corpus rather than isolated recall. Students should be asked to

produce searchable questions, documented strategies, annotated bibliographies, evidence inventories, and short rationales for why specific items belong in the project. They should also learn to justify omissions, because every corpus excludes as well as includes. A search log, a PRISMA-like flow record where appropriate, or a source-justification memo can function as a persuasive medium that makes the reasoning behind the corpus inspectable. In activity-theoretical terms, these genres externalize the object of the phase. They make visible whether the student has really transformed information into sources.

C. Analysis as an activity: from sources to statements

Analysis begins when sources stop being treated as collected items and start being worked upon. The object of analysis is the transformation of documented sources into statements. A statement, as understood here, is a judgment extracted from a source under explicit criteria. It may concern a factual finding, a methodological feature, a conceptual distinction, a numerical tendency, an interpretive claim, an omission, or a contradiction. The key point is that statements are not simply copied sentences. They are analytic products. They emerge when the student reads, codes, classifies, compares, appraises, and reformulates what a source contributes.

This phase is frequently underdeveloped in higher education because students are often asked to summarize texts before they know how to produce warranted statements from them. In veterinary, animal, and health sciences this problem is intensified by methodological plurality. Students must be able to analyze experimental designs, observational studies, case reports, policy documents, curricular studies, interview data, and secondary syntheses. They must also learn that analysis is inseparable from appraisal. A statement from a randomized trial does not carry the same weight as a statement from an anecdotal report, and a thematic interpretation from a qualitative study must be judged according to standards appropriate to qualitative inquiry. Analysis is therefore the activity in which students begin to learn that evidence is not flat.

The professional relevance of this phase is clear. Clinical reasoning depends on the ability to convert multiple sources of evidence into explicit judgments regarding relevance, reliability, and applicability. Research on veterinary students' clinical reasoning shows that development in this area requires deliberate educational attention rather than simple immersion in cases (Vinten et al., 2016). The same is true of research training more broadly. If students cannot generate strong statements from sources, they cannot move responsibly into evidence-based decisions, reviews, protocols, or original studies.

The actions that constitute analysis vary by research tradition, but they share a common logic. Quantitative analysis of literature may involve extracting effect estimates, sample characteristics, study designs, measures, and limitations into structured tables. Qualitative analysis of

literature may involve coding authors' conceptual positions, recurring themes, metaphors, or assumptions. Analysis of field data may involve cleaning, coding, categorizing, visualizing, modelling, or memo writing. Across traditions, however, the crucial educational outcome is the same: students should learn to produce judgments that are both textually grounded and conceptually reformulated.

Good pedagogy in this phase depends heavily on mediating artifacts. Evidence tables, critical appraisal checklists, coding manuals, reading matrices, annotation conventions, statistical notebooks, and analytic memos all function as tools that stabilize judgment. They also function as persuasive media because they show others how the student's statements were produced. Recent work on mediated practical reason in veterinary education is useful here because it insists that professional reasoning must become teachable and assessable through inspectable warrants, rebuttals, and evidential standards (Rodríguez Frausto et al., 2026). The same insight applies to research analysis. If a learner writes that “the literature supports early intervention” or “farmer attitudes are central,” the question is not whether the sentence sounds plausible. The question is what source-derived statements justify it.

For undergraduate students, analysis should begin with coarse-grained but explicit judgment. They can be asked to determine what a paper studies, what it found, how it was designed, what limitations matter, and what practical implications can and cannot be drawn. As students advance, they should undertake more fine-grained operations such as comparing operational definitions across papers, identifying hidden assumptions, recognizing discrepancies between results and conclusions, and distinguishing empirical findings from authors' interpretations. Graduate learners should additionally be expected to design their own coding frameworks, generate analytic categories, justify inferential choices, and revise their statements in light of peer critique.

The distinction between source and statement can also reduce plagiarism and superficial paraphrase. Students plagiarize not only because of ethical weakness but often because they have not yet learned that the analytic task is not to transplant language but to produce judgment. When analysis is taught properly, note-taking shifts from copying to evidential abstraction. A student's notes begin to record what the source can be used to say, not merely what it literally says. That shift is foundational for genuine scholarly writing.

Assessment in analysis should therefore focus on the quality of judgment. Students can be evaluated through evidence tables, coded excerpts, appraisal memos, analytic notebooks, and oral explanations of how a statement was derived from a source. In mixed-methods or multidisciplinary settings, they should also be asked to explain why different source types require different analytic standards. Such tasks are especially important in One Health education, where

learners must integrate epidemiological, ecological, social, and institutional materials rather than treating all evidence as homogeneous (Frankson et al., 2016; Akkerman & Bakker, 2011).

D. Synthesis as an activity: from statements to arguments

Synthesis is often described too vaguely as “putting the literature together.” A more exact description is needed. The object of synthesis is the transformation of statements into arguments. Arguments are the building blocks of knowledge objects because they relate judgments to each other in ways that justify a position, an explanation, a framework, a recommendation, or a narrative. An argument is not a quarrel and not merely a conclusion. It is a structured relation between claims, reasons, evidence, contrasts, warrants, qualifications, and alternatives (Toulmin, 2003; Walton et al., 2008). In research education, synthesis is the phase in which students stop asking only what individual sources say and begin asking what can be responsibly argued across sources and statements.

This phase is especially important in veterinary and health sciences, where students often encounter bodies of literature that are methodologically mixed, contextually uneven, and practically consequential. A set of statements on analgesia, herd biosecurity, animal welfare, diagnostic test performance, or educational outcomes does not organize itself. Synthesis requires that the learner identify patterns, tensions, mechanisms, typologies, and gaps. It is therefore a creative but still disciplined activity. Creative, because it constructs relations not explicitly given in any single source. Disciplined, because those relations must remain answerable to the statements from which they are built.

Synthesis can take many forms. In a literature review it may yield a line of argument about how a concept has evolved or why findings diverge across settings. In a clinical case discussion, it may yield a differential-diagnostic argument that integrates signs, test results, and contextual knowledge. In animal production it may yield a systems argument linking welfare indicators, management practices, and productivity constraints. In public and One Health work it may yield a cross-sector argument about why an intervention is epidemiologically plausible, institutionally legitimate, and socially feasible. In each case, the product is not a list of statements but an organized knowledge object.

Theoretical support for treating synthesis in this way comes from both the teaching-research nexus literature and the argumentation literature. Research-based education has repeatedly shown that students need opportunities to learn through inquiry and to participate in the construction of knowledge rather than merely in its reception (Healey & Jenkins, 2009; Brew & Boud, 1995; Brew, 2012). Argumentation theory clarifies how such construction becomes accountable. Toulmin’s account of data, warrant, backing, rebuttal, and qualifier is particularly useful because it helps students see that the move from statements to

arguments requires explicit bridges (Toulmin, 2003). Argumentation schemes and critical questions further help students recognize common inferential forms and the conditions under which they are reasonable (Walton et al., 2008). Recent veterinary educational work that integrates logic, rhetoric, and persuasive media adds an important complement: arguments must not only be inferentially coherent, but also communicable and ethically oriented to the audiences who will use them (Rodríguez Frausto et al., 2026).

In practice, this means that synthesis should be taught through genres that make relational thinking visible. Concept maps, matrix displays, literature maps, theoretical memos, comparative essays, debate briefs, and structured discussion papers are all suitable mediations. Undergraduate students often benefit from activities in which they must organize a modest number of statements into a comparative or explanatory framework. Graduate students should go further and construct extended arguments that define a problem space, justify a conceptual choice, account for conflicting evidence, and show why a proposed line of inquiry is necessary.

Synthesis is also the phase in which students most clearly encounter contradiction. Activity-theoretical research has long emphasized that contradictions are not accidents to be eliminated but drivers of development (Engeström, 2001; Sannino et al., 2009). In research education, contradiction may appear as conflicting findings, incompatible value commitments, divergent participants’ interpretations, or mismatches between theoretical expectations and empirical tendencies. Good synthesis does not hide these tensions. It organizes them. Students should be taught to ask whether disagreement arises from population differences, measurement issues, methodological weaknesses, conceptual slippage, temporal change, or truly incompatible interpretations. Such work prepares them not only for scholarly writing but also for professional life, where decisions must often be made amid competing lines of argument.

Assessment in synthesis should therefore target structure, not accumulation. Students should be evaluated on whether they can build a coherent line of reasoning from analytic statements, distinguish central from peripheral claims, qualify conclusions appropriately, and respond to plausible counterarguments. Oral seminars, concept papers, and iterative drafts are especially valuable because they reveal whether the student can reorganize an argument under critique. In this phase, persuasive media such as rubrics, evidence matrices, and structured peer-review forms help stabilize the norms of argument quality. They show students that synthesis is neither literary flair nor summary, but disciplined construction of knowledge objects.

E. Challenge as an activity: from arguments and data to claims

The final activity of the cycle is challenge. The object of challenge is the elaboration of claims by confronting arguments with data, alternative explanations, inferential tests, and critical audiences. Claims are the products of acquired knowledge that has been worked upon through deduction, induction, abduction, and disciplined contestation. They support exploration, confirmation, explanation, inference, prediction, and narration. Challenge is therefore broader than defense at the end of a project. It includes all the moments in which a knowledge object is forced to prove its adequacy in relation to empirical material and reasoned opposition.

This phase deserves special emphasis because students are often taught to think of research claims as simple outputs of data analysis. That is too narrow. Data do not speak without argument, and arguments do not become claims until they are elaborated in relation to data and criticism. Deduction allows students to derive consequences from premises and to ask whether observations are consistent with what the argument implies. Induction allows them to move cautiously from patterned observations toward more general claims. Abduction allows them to generate the best available explanation for surprising or incomplete evidence. In real research practice, these inferential modes are intertwined rather than isolated (Toulmin, 2003; Walton et al., 2008). Challenge is the phase in which students learn to navigate that interweaving.

In veterinary, animal, and health sciences the forms of challenge are multiple. A quantitative project may test a model, estimate an association, or evaluate predictive performance. A qualitative project may challenge an initial interpretation by seeking disconfirming cases, comparing participant positions, or revising a thematic structure. A mixed-methods study may use one data strand to interrogate another. A literature review may challenge dominant assumptions by exposing weak warrants, hidden exclusions, or unstable generalizations. A clinical or One Health argument may be challenged by feasibility constraints, colleagues' values, or newly emerging evidence. In each case, the outcome is not certainty but a more explicit and defensible claim.

This phase is where recent work on persuasive media and communicative action becomes especially useful. Research claims are always presented through genres that both stabilize and test their legitimacy: protocols, posters, conference talks, manuscripts, dashboards, canvases, rounds, and defenses (Rodríguez Frausto et al., 2026b; de la Colina Garcia et al., 2026). These media do not simply report conclusions. They shape what kinds of critique can be raised and how claims must answer to objective, social, and subjective dimensions of the problem. In One Health settings, for example, a strong claim must often integrate

epidemiological evidence, institutional legitimacy, and stakeholder experience rather than relying on one domain alone (Frankson et al., 2016; la et al., 2026). Challenge is therefore inseparable from audience and accountability.

Pedagogically, the activity of challenge should begin much earlier than the thesis defense. Undergraduate learners can challenge provisional claims through journal clubs, evidence rounds, mini-posters, structured rebuttals, and classroom debates anchored in source and data work. They should learn to ask what evidence would weaken a claim, what alternative explanation deserves attention, what limitation changes interpretation, and what further data are needed. Graduate learners should undertake more demanding forms of challenge, including proposal defense, peer review of drafts, reproducibility checks, sensitivity analyses, triangulation, and direct response to expert critique. The crucial educational move is that students experience challenge as normal scholarly labor rather than as punishment.

The ethical dimension of this phase is also decisive. A claim that is technically sophisticated but rhetorically opaque or strategically manipulative is professionally dangerous, especially in animal welfare, public health, and clinical communication. The veterinary communication literature shows that persuasive skill is necessary but ethically fraught when asymmetries of expertise and vulnerability are present (Rodríguez Frausto et al., 2026c). Research education should therefore teach students to make claims with transparency about uncertainty, proportionality of inference, and openness to revision. This is as true for statistical claims as for narrative or explanatory ones. The educational goal is not aggressive certainty. It is accountable claim-making.

Assessment in challenge should focus on the learner's ability to elaborate and defend claims under scrutiny. Suitable tasks include defended posters, preprint-style manuscripts, oral examinations, response-to-reviewer letters, policy briefs, and data-confrontation memos that require students to explain how a claim survives or changes when faced with counterevidence. Such tasks are valuable because they bring together the whole cycle. A weak defense often reveals weakness in synthesis, analysis, or search. In that sense, challenge is both the last phase and the phase that most powerfully drives the cycle backward.

F. Longitudinal formation from undergraduate to graduate education

If the four activities define the research cycle, curriculum design should ensure that students traverse them repeatedly with increasing complexity. This does not mean waiting until late in the program for “real research.” It means designing a longitudinal strand in which the same activities recur with different objects, scales, and divisions of labor. Research-based higher education has shown that students benefit when inquiry is mainstreamed rather than reserved for a small elite (Healey & Jenkins, 2009; Hunter et al.,

2007). In veterinary and medical education, systematic reviews and curricular reports likewise show that research training is stronger when it combines formal instruction, mentorship, authentic projects, and progressive responsibility (Lee et al., 2021; Šlapeta & Ward, 2024; Rhind et al., 2026).

In undergraduate formation, the curriculum should emphasize structured participation. Students need repeated opportunities to assemble source corpora, produce analytic statements, build modest arguments, and defend constrained claims. At this stage, the object is not originality in the strong sense. It is the formation of habits of inquiry. Projects may be nested in courses, laboratory work, clinical problem sets, field observations, or team-based evidence reviews. The question should always be what activity the student is learning to perform. A first-year or second-year student may not yet formulate a completely original problem, but can still learn how to search systematically, judge sources, construct an evidence-based explanation, and revise a claim after criticism.

In graduate formation, the same cycle should be reorganized around autonomy, scope, and theoretical responsibility. Graduate students should formulate sharper researchable problems, construct more independent corpora, justify methodological choices at a higher level of abstraction, and produce claims that can contribute to a scholarly or professional conversation beyond the immediate classroom. They should also assume greater responsibility for managing the mediations of their work, including protocols, codebooks, analytic scripts, research notebooks, conceptual frameworks, manuscripts, and public presentations. In activity-theoretical terms, the division of labor changes. The supervisor increasingly becomes a critical collaborator rather than a director of each action.

The difference between undergraduate and graduate education is therefore not that undergraduates do simplify “projects” while graduates do “research.” Both are participating in the same cycle of activities. The difference lies in the complexity of the object, the degree of uncertainty tolerated, the density of mediation required, and the level of accountability expected. This distinction is especially important in professional programs where students may move between evidence-based practice, inquiry projects, and original research. A longitudinal model allows them to do so without conceptual discontinuity.

Examples from veterinary education support this approach. Curricular experiences that embed evidence-based medicine, epidemiology, and journal-club work can provide undergraduates with practical entry points into the cycle (St-Hilaire et al., 2022). Compulsory or embedded research projects can help students experience the full cycle, although studies also show that such projects require careful supervision and alignment of expectations (Cardwell et al., 2017; Rhind et al., 2026). Information literacy instruction

needs to be integrated and developmental rather than episodic (Dinkelman & Viera, 2011; Eldermire et al., 2019). Graduate seminars and capstone experiences, meanwhile, are ideal settings for deeper work on synthesis and challenge because they allow sustained problem formulation, peer critique, and public defense (Šlapeta & Ward, 2024).

A further implication is that interdisciplinary and One Health education should not be confined to the end of the program. Boundary crossing is difficult precisely because different communities organize sources, statements, arguments, and claims differently (Frankson et al., 2016; Akkerman & Bakker, 2011). Students need practice in moving across those boundaries from early on. A herd-health dashboard, a public-health outbreak briefing, a qualitative study of client experience, and an ecological risk model each involve the same four activities but configure them differently. When students compare these configurations, they learn that rigorous inquiry is plural without being arbitrary.

G. Assessment, supervision, and institutional design

A curriculum based on the four activities requires corresponding changes in assessment and evaluation. The dominant error in research education assessment is to grade only final products while leaving earlier activities invisible. When this happens, students can sometimes produce a tolerable review or presentation through last-minute assembly, but they do not necessarily learn how research is actually carried out. An activity-theoretical model suggests the opposite. Assessment and evaluation should make the products of each activity visible: source corpora, analytic statements, arguments, and claims.

This does not require a bureaucratic explosion. It requires carefully chosen genres that reveal work at each phase. Search logs, annotated bibliographies, and corpus rationales can externalize search and collect. Evidence tables, coding memos, and appraisal notebooks can externalize analysis. Concept papers, integrative essays, and literature maps can externalize synthesis. Defended posters, claim memos, manuscripts, and response-to-reviewer exercises can externalize challenge. Each genre functions as a persuasive medium because it allows teachers, peers, and external stakeholders to inspect how the student’s reasoning has been produced (Rodríguez Frausto et al., 2026b; Colina Garcia et al., 2026).

Supervision also needs to be reconceptualized. If the research process is made of distinct activities, supervisors should diagnose where a learner’s difficulty lies instead of issuing generic advice such as “read more,” “analyze better,” or “tighten your discussion.” A student with a weak claim may not need additional data but a stronger synthesis. Another may have a fine argument built on a poor source corpus. Another may have good analytic statements but no sense of genre for presenting claims to an audience. The four-activity model allows supervisory feedback to be more

precise, and that precision is likely to reduce frustration for both students and faculty.

Institutional design matters as well. Research education cannot be strengthened merely by exhorting students to be more inquisitive. Programs need time, spaces, partnerships, and infrastructures that support repeated participation in the cycle. Longitudinal assignments, library collaboration, field sites, laboratory access, research seminars, writing support, and public presentation opportunities are all part of the mediating environment. Faculty development is equally important. Teachers need to see their own courses as activity systems and to understand how the assignments they design either connect or fragment the research cycle (Engeström, 2001; Rodríguez Frausto et al., 2026). In veterinary and health professions education, where clinical and service demands are heavy, this often requires collective curriculum work rather than isolated faculty effort.

Competency-based frameworks can support this agenda if they are interpreted dynamically. Entrusted professional activities and other authentic assessments are most useful when they are not reduced to checklists but used to evaluate reasoning within real or realistically modeled activities (Education et al., 2024; ten Cate, 2005). In the present model, research education can align with competency-based education by treating each phase of the cycle as a domain of observable and improvable action. A learner can be judged on how well they construct a source corpus, how carefully they generate statements, how coherently they synthesize arguments, and how responsibly they elaborate and defend claims. Such assessment is more compatible with professional formation than examinations that isolate factual recall from inquiry.

III. CONCLUSION

To educate veterinarians, animal scientists, and health professionals for research, the curriculum must teach more than methods. It must teach the labor of inquiry as a sequence of distinguishable activities. Search and collect, analysis, synthesis, and challenge are not merely stages on a diagram. They are different forms of purposeful work with different objects and products. Search and collect turns information into sources. Analysis turns sources into statements. Synthesis turns statements into arguments. Challenge turns arguments and data into claims.

This distinction has practical value. It clarifies what students are trying to transform at each phase, what mediating tools they require, what forms of supervision are needed, and what should be assessed. It also clarifies why research competence matters in professional education. Veterinary and health professionals do not simply consume knowledge. They must search for it, judge it, organize it, confront it with data, and communicate claims that can guide action in uncertain and morally charged contexts. The research cycle

is therefore not peripheral to professional formation. It is one of its central engines.

The activity-theoretical perspective adds a further advantage by insisting that the cycle is collective, mediated, and developmental. Students do not become researchers or research-literate professionals by listening to descriptions of inquiry. They become so by participating in repeated and increasingly demanding forms of inquiry, using the genres and tools that make reasoning inspectable, and learning to revise their work under challenge. When curricula are built around these four activities, research education becomes more coherent, more assessable, and more transferable across clinical, production, laboratory, and One Health settings.

For undergraduate learners, this means structured participation in authentic inquiry from early in the program. For graduate learners, it means greater autonomy, denser theoretical responsibility, and stronger forms of public justification. For faculty and institutions, it means designing the curriculum so that evidence, judgment, argument, and claim remain visibly connected. Under those conditions, the research cycle becomes not just an academic requirement but a mode of formation capable of supporting exploration, confirmation, explanation, inference, prediction, and narration across the veterinary, animal, and health sciences.

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