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Democratic Division of Labor for Data-Intensive Veterinary and Animal Husbandry Education and Research: A Marxian–Activity Theory Framework Applied to Educational Settings and Research Groups

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ABSTRACT: Veterinary and animal husbandry programs are being pulled simultaneously toward (a) accelerated technological change (precision livestock farming, clinical informatics, AI-enabled diagnostics), (b) competency-based training models, and (c) the ethical and political demand to serve communities—especially marginalized or underserved populations—without reproducing extractive relationships. This essay proposes a governance-ready framework that harmonizes (1) Marxian concepts of production relations and the social/technical division of labor with (2) cultural-historical activity theory (CHAT) and expansive learning, then applies the resulting framework to (3) veterinary and animal husbandry educational settings and (4) research groups. The core claim is practical: data work (collection, stewardship, analysis, interpretation, and dissemination) should be organized as a *community-accountable collective worker* with a democratically governed division of labor that is competence-sensitive (clear roles, mentorship ladders, and safety constraints) while actively resisting the drift toward managerial control and "black-box" technical authority. Concrete deliverables include role architectures, a RACI matrix, assessment implications for competency-based education, and a staged implementation roadmap using Change Laboratory–style formative interventions.
KEYWORDS: Democratic governance, division of labor, cultural-historical activity theory (CHAT), competency-based veterinary education, precision livestock farming (PLF), data stewardship

INTRODUCTION

Veterinary and animal husbandry programs now operate in an environment where data are produced continuously across clinics, farms, laboratories, and classrooms. Precision livestock farming (PLF) systems, sensor networks, electronic medical records, genomics, and AI-enabled decision support redistribute cognitive work across people, tools, and institutions, increasing the coordination required to turn measurements into decisions. As these systems scale, questions of data access, ownership, downstream use, and accountability become inseparable from questions of educational and scientific quality, because who controls the data infrastructure also shapes who can interpret, critique, and act on the evidence (Doidge et al., 2023; Krampe et al., 2024; Wiseman et al., 2019).

In parallel, veterinary education is increasingly organized around competency-based veterinary education (CBVE), with explicit outcomes, assessment toolkits, and competency domains intended to support safe, accountable practice (Association of American Veterinary Medical Colleges (AAVMC), 2018, 2025; Matthew et al., 2020; Foreman & Mashima, 2024). Community-oriented training—including service-learning rotations, student-run community clinics, and One Health engagement—adds an ethical and political layer: programs must engage communities as partners, not merely as service recipients or research sites, because good intentions do not guarantee positive outcomes (King et al., 2021; Otero et al., 2023; Perret et al., 2023; Powell et al., 2022; Watson et al., 2024; Agency for Toxic Substances and Disease Registry (ATSDR) et al., 2024).

Taken together, these shifts make the division of labor more than a managerial concern: it becomes a curricular object and a governance object. Technical specialization is unavoidable in data-intensive work, but it can harden into social divisions in which modeling expertise becomes black-box authority, administrative coordination becomes control over deadlines and recognition, and community partners are treated as data sources rather than co-determiners of the work's object and outcomes. Marxian analyses of production relations and labor processes clarify why fragmentation and deskilling tend to reproduce dependency and unequal control (Marx, 1990; Braverman, 1974). Cultural-historical activity theory (CHAT) adds a design method: by treating work and learning as

tool-mediated collective activity, it makes contradictions visible and supports expansive redesign of rules, roles, and artifacts (Engeström, 1987, 2001; Engeström & Sannino, 2010).

This essay develops a governance-ready synthesis of these traditions and applies it to veterinary and animal husbandry educational settings and research groups. Its practical deliverables include democratic, competence-sensitive role architectures; a RACI matrix that clarifies decision rights without freezing authority; assessment implications for CBVE (including transparent contribution statements) (Brand et al., 2015); and a staged implementation roadmap using Change Laboratory–style formative interventions (Engeström & Pyörälä, 2021; Morris et al., 2021). It also aligns these governance artifacts with expectations for data stewardship and sharing, including FAIR-oriented documentation and reproducible workflows (Wilkinson et al., 2016; The Turing Way Community, 2019; Wilson et al., 2017) and formal data management and sharing requirements (National Institutes of Health, 2025a, 2025b).

The argument proceeds as follows. Section 1 frames why division of labor is now an educational and political design problem under conditions of accelerated datafication. Section 2 builds the conceptual synthesis of Marxian production relations with CHAT. Section 3 articulates a normative orientation of community accountability and democratic governance. Sections 4 and 5 apply the framework to curriculum and clinical training and to research groups, respectively. Section 6 presents an implementation roadmap, and the conclusion summarizes the implications for community-oriented, data-intensive veterinary and animal husbandry practice.

1. Why "Division of Labor" is Now an Educational and Political Design Problem

Veterinary and animal husbandry education has always been entangled with production systems: food animal medicine, public health, companion-animal care, farm economics, and the regulation of disease. What has changed is the density of *data* and the intensity of *coordination* required to turn data into action. Precision livestock farming (PLF) systems, sensor networks, electronic medical records, genomics, and AI-based decision support redistribute cognitive labor across people, tools, and institutions—and, critically, across power relations over data access, ownership, and interpretation (Doidge et al., 2023; Krampe et al., 2024; Wiseman et al., 2019).

At the same time, veterinary programs increasingly emphasize competency-based veterinary education (CBVE), including assessment toolkits and competency domains that can be adapted to local needs (Association of American Veterinary Medical Colleges (AAVMC), 2018, 2025; Foreman & Mashima, 2024; Matthew et al., 2020). In community-oriented training—such as service-learning rotations and student-run community clinics—ethical engagement practices have become indispensable because "good intentions do not guarantee positive outcomes" (King et al., 2021; Otero et al., 2023; Perret et al., 2023; Powell et al., 2022; Watson et al., 2024). These shifts make the "division of labor" more than a management question: it becomes a *curricular object* and a *governance object*.

2. Conceptual Synthesis: Production Relations + Division of Labor, Updated Through Activity Theory

2.1 Marxian starting points: production relations and the social/technical division of labor

In Marxian terms, *production relations* specify who controls the conditions of production, how labor is coordinated, and how surplus is appropriated (or, in educational contexts, how value and recognition are allocated) (Braverman, 1974; Marx, 1990). The division of labor is never merely technical: it is a social relation that can (a) enable collective capacity or (b) enforce dependency through fragmentation, deskilling, and managerial command (Braverman, 1974).

In data-intensive veterinary and animal science work, the same risk appears in contemporary form:

- **Technical specialization becomes authority** ("only the statistician understands the model").
- **Administrative coordination becomes control** (deadlines, approvals, authorship, and access rights).
- **Community partners become data sources rather than co-governors** (extractive research and outreach).

If the object of education is "competent professionals," but the production relations of training reproduce asymmetries—between faculty and students, between university and community, and between technologists and domain practitioners—then competency becomes a narrow credential rather than collective capability.

2.2 Activity theory update: activity systems, mediation, contradictions, and expansive learning

Cultural-historical activity theory reframes work and learning as collective, tool-mediated activity oriented to an *object* (a problem-space) and stabilized by persuasive tools, community, and division of labor (Engeström, 1987, 2001; Engeström & Sannino, 2010). Crucially, CHAT treats contradictions (e.g., between persuasion and object, or tools and division of labor) as drivers of transformation rather than as individual deficits. In clinical and professional education settings, expansive learning and Change Laboratory interventions have been used to redesign work/learning arrangements collaboratively (Engeström & Pyörälä, 2021; Morris et al., 2021).

This is the key upgrade to Marxian analysis for educational design: we do not only diagnose domination or fragmentation; we also specify *how a collective can redesign its activity* by making contradictions visible and co-constructing new artifacts (charters, workflows, assessment regimes, data governance rules) that reorganize labor.

2.3 A governance-ready synthesis

We can now define a practical synthesis:

- Production relations in a university–clinic–farm–community network correspond, in CHAT terms, to the configuration of **persuasion tools**, **community membership**, and the **division of labor**, especially around control of tools and data infrastructure.
- A democratic, community-oriented setting requires not the abolition of hierarchy (which is sometimes necessary for safety and accountability), but **the containment and rotation of hierarchy** under collectively chosen rules, with transparent delegation and recall.
- Technical divisions of labor are necessary; the design task is to ensure they do not harden into *social* divisions that block learning, voice, and shared governance.

In short: **organize the "collective worker" as an activity system that is competence-sensitive and democratically governed, with community co-determination of the object and outcomes.**

3. Normative Orientation: Community Accountability and Democratic Governance

A community-oriented, democratically governed work setting implies at least three commitments.

1. **Community engagement as co-production, not service delivery.** Veterinary community engagement guidelines explicitly emphasize ethical, evidence-informed engagement and the responsibilities of programs working with marginalized or underserved communities (Watson et al., 2024). Human health engagement guidance similarly foregrounds partnership, local fit, and long-term relationship building (Agency for Toxic Substances and Disease Registry (ATSDR) et al., 2024).
2. **Economic democracy and cooperative practice as design constraints.** Organizational democracy literature clarifies that participation is not an optional "nice-to-have"; it changes political efficacy, responsibility, and the distribution of expertise (Dahl, 1985; Pateman, 1970). Cooperative principles (voluntary membership, democratic member control, education/training, cooperation among cooperatives, and concern for community) provide implementable governance norms (International Co-operative Alliance, 1995).
3. **Data as a governed common pool resource when communities and producers are implicated.** PLF and farm data governance issues include farmer reluctance to share, concerns about downstream use, and the social/ethical implications of technology deployment (Doidge et al., 2023; Krampe et al., 2024; Wiseman et al., 2019). This makes "data governance" inseparable from "community governance."

4. Application to Veterinary and Animal Husbandry Education

4.1 Design goal: a "data praxis spine" inside CBVE/competency-based curricula

CBVE frameworks provide a language for outcomes; the present framework specifies how to organize collective work so those outcomes are achieved without reproducing extractive relations (Association of American Veterinary Medical Colleges (AAVMC), 2018, 2025). Practically, programs can implement a **data praxis spine** across the curriculum:

- **Year 1–2:** data literacy as *community-relevant* practice (ethics, data quality, documentation, bias, and local meaning).
- **Year 2–3:** team-based inquiry (reproducible analysis, stewardship, and interpretation in context).
- **Year 3–final:** service-learning / clinical / production rotations with authentic data governance and public-facing deliverables.

Veterinary informatics has been argued for years as a core professional need; the difference now is that informatics is inseparable from governance and community outcomes (Brito et al., 2025; Johnson, 2011).

4.2 Three "signature activity systems" for programs

Below are three recurring activity systems that can anchor courses, rotations, and research practica.

A. Community veterinary engagement clinic (companion animals + public health interface)

Evidence from One Health and community-based clinic models shows effects on trust, learning, and student development (King et al., 2021; Powell et al., 2022; Sweeney et al., 2018). Design this as an activity system:

- **Object:** improve access to care and community-defined outcomes (animal welfare + public wellbeing).
- **Tools:** clinic EHR templates, intake protocols, case dashboards, referral maps, consent instruments.
- **Rules:** VCE principles; informed consent; community feedback loops; fair service protocols.
- **Division of labor:** interprofessional teams; explicit data stewardship role; community liaison.

Student-run and community-based clinics also show the need for cultural humility and structured support (e.g., Indigenous community contexts; disability and low-income contexts) (Otero et al., 2023; Perret et al., 2023).

B. Precision livestock farming and herd/production analytics (animal husbandry core)

PLF innovations increasingly require multi-actor data sharing and governance; farmers may be reluctant when benefits, control, or risk distribution are unclear (Krampe et al., 2024; Wiseman et al., 2019). Design this as an activity system:

- **Object:** improve animal health and production outcomes *with producer-defined constraints* (labor, cost, welfare, privacy).

- **Tools:** sensor streams, herd records, statistical models, dashboards, on-farm experimentation protocols.
- **Rules:** data use agreements; ethical review; producer co-authorship or co-ownership of outputs where appropriate.
- **Division of labor:** producer "product owner" role; student analytics cell; technician field ops; faculty stewardship.

C. Population health and participatory epidemiology (livestock + One Health systems)

Participatory epidemiology and community-based surveillance approaches offer a proven pathway for engaging local knowledge and improving relevance (Alders et al., 2020). In educational settings:

- **Object:** jointly identify and mitigate animal health risks using both local knowledge and formal methods.
- **Tools:** participatory mapping, outbreak line-lists, sampling plans, reproducible reports.
- **Rules:** shared problem definition; transparent uncertainty; shared interpretation; community benefit agreements.
- **Division of labor:** rotating facilitation; data steward; field logistics; analysis; community validation.

4.3 A democratic, competence-sensitive team architecture for student projects

A workable pattern is a **three-layer architecture** with *bounded hierarchy*:

1. **Project Assembly (governance layer)**

Membership: students, instructors, technicians, and community partners (when applicable).

Mandate: set the object, approve rules, allocate roles, review ethical issues, and validate deliverables.

2. **Technical Data Cell (technical competence layer)**

Roles: Data Steward, Analyst(s), Research Software/Workflow Lead, QA/Validation Lead.

Mandate: manage data lifecycle, reproducibility, versioning, and quality controls.

3. **Operations and Partnerships Cell (administrative and relational layer)**

Roles: Community Liaison, Logistics Coordinator, Documentation/Reporting Lead, Compliance/Ethics Liaison.

Mandate: scheduling, procurement, consent/permissions, communications, and stakeholder accountability.

Why this structure works: it separates *decision rights* (assembly) from *execution roles* (cells) while making competence visible and teachable. Hierarchy is present (because safety and accountability demand it), but it is *procedurally subordinate* to democratic governance.

4.4 Role definitions (student-facing, faculty-facing, and community-facing)

Role taxonomy (adaptable for courses, rotations, and capstones)

Role	Primary function	Typical competence level	Democratic constraint
Steward/Facilitator (often faculty)	holds process integrity; ensures safety/ethics; supports learning	advanced	decisions reviewable by Assembly; role rotates where feasible
Data Steward	data dictionary, metadata, access controls, provenance, storage	intermediate→advanced	access rules approved by Assembly; community constraints binding
Analyst/Modeler	analysis plan, inference, uncertainty communication	intermediate→advanced	methods explainability requirement; peer review required
Field Ops/Clinical Data Lead	data capture, sample chain-of-custody, clinical completeness	intermediate	quality checks transparent; feedback from community
Community Liaison	relationship stewardship; translation of needs; consent/feedback loops	intermediate	community can appoint/replace liaison
Project Administrator	timelines, budgets, reporting cadence, meeting minutes	intermediate	admin authority limited to process; no unilateral technical decisions
Student Apprentices	rotating roles; reflective logs; contribution statements	novice→intermediate	protected learning time; right to question and escalate

4.5 RACI matrix for a typical veterinary/animal science data project

Legend: **R** Responsible, **A** Accountable, **C** Consulted, **I** Informed.

Task	Assembly	Steward/Facilitator	Data Steward	Analyst	Field Ops	Community Liaison	Project Admin
Define problem/object	A	R	C	C	C	R	I
Data governance rules & access	A	R	R	C	C	C	I
Data collection protocol	C	A	C	C	R	C	I
Data cleaning + documentation	I	A	R	R	C	I	I
Analysis plan preregistration / QA	I	A	R	R	C	I	I

Task	Assembly	Steward/Facilitator	Data Steward	Analyst	Field Ops	Community Liaison	Project Admin
Interpretation + community validation	A	C	C	R	C	R	I
Report / dashboard release	A	C	R	R	C	C	R
Authorship / contributorship statements	A	R	C	C	C	C	R

Use contributorship taxonomies (e.g., CRediT) to reduce disputes and make labor visible in assessment and publication (Brand et al., 2015).

4.6 Assessment implications for CBVE

CBVE assessment should recognize *collective capability*, not only individual performance. Pair CBVE tools with:

- **Entrustment decisions** on role execution (e.g., "Data Steward for a small dataset under supervision").
- **Contribution statements** (CRediT-style) + reflective justification.
- **Reproducibility checks** as a competency artifact (organized repositories, documented workflows) (The Turing Way Community, 2019; Wilkinson et al., 2016; Wilson et al., 2017).
- **Community feedback** as part of competence evidence in VCE settings (Agency for Toxic Substances and Disease Registry (ATSDR) et al., 2024; Watson et al., 2024).

5. Application to Veterinary and Animal Husbandry Research Groups

5.1 Research group as a democratically governed "collective worker"

In Marxian terms, the research group is a collective worker producing knowledge, interventions, and professional formation. In CHAT terms, it is an activity system whose object often drifts (publish vs. impact vs. funding). The design task is to stabilize a community-oriented object and make production relations explicit via governance artifacts.

A practical starting point is a **Lab/Group Charter** (one page) specifying:

- the object (scientific + community outcomes),
- membership rights and responsibilities,
- decision rules (assembly, committees, recall/rotation),
- conflict resolution,
- data governance (access, sharing, embargoes),
- authorship/contribution policy.

5.2 Data governance and stewardship: minimal standards for credibility and justice

Research integrity and funder policy increasingly require explicit data management and sharing plans, including oversight responsibilities and restrictions where necessary (National Institutes of Health, 2025a, 2025b). Life-science RDM resources emphasize practical role guidance for data stewards and researchers (Alper et al., 2025). A veterinary/animal science group should treat these as the baseline—not the ceiling.

Minimal "good practice" package:

- **FAIR-oriented metadata and stewardship** (to the extent compatible with privacy, producer rights, and community agreements) (Wilkinson et al., 2016).
- **Reproducible workflows** (version control, structured projects, documented decisions) (The Turing Way Community, 2019; Wilson et al., 2017).
- **Ethical and social governance for farm and community data** (data use agreements; limits on secondary use; benefit sharing) (Doidge et al., 2023; Krampe et al., 2024; Wiseman et al., 2019).

5.3 Democratic division of labor in the lab: bounded hierarchy with rotating authority

A feasible model is a **bicameral structure**:

1. **Lab Assembly (all members + invited community partners for relevant projects)**

Authority: object-setting, policy approval (data, authorship, onboarding), major resource allocations.

2. **Stewardship Council (small, rotating)**

Roles: Safety/ethics steward, Data steward lead, Methods lead, Partnerships lead, Admin lead.

Authority: implement Assembly decisions; urgent decisions with post-hoc review.

This avoids "flatness as fiction" while resisting permanent managerial stratification.

5.4 Publishing, recognition, and equity

Because authorship is a major site where production relations materialize (credit allocation), groups should institutionalize:

- **CRediT-based contribution records** for all outputs (Brand et al., 2015).
- **Transparent authorship criteria** aligned to discipline norms *and* community contributions (e.g., producer co-authorship when appropriate).
- **Budget and labor transparency** (who is paid to do what; what is student labor; what is community labor).

The CBVE-aligned educational gain is direct: students learn scientific practice as accountable collaboration rather than competitive individualism.

6. Implementation Roadmap Using Activity-Theory Formative Interventions

To avoid "policy theater," implementation should follow an expansive learning logic: surface contradictions, design new mediating artifacts, test, and institutionalize.

Phase 1: Activity system mapping (2–4 weeks)

- Map current objects, tools, rules, community, and division of labor for (a) a course team project and (b) a lab project.
- Identify contradictions (e.g., "open science" vs. producer data concerns; "student autonomy" vs. safety).

Phase 2: Change Laboratory–style redesign (4–8 weeks)

Use facilitated sessions to co-design: - a project charter template, - a data stewardship workflow, - a contribution/assessment protocol, - a community feedback loop. CHAT-informed Change Laboratory approaches in health education provide usable methodological precedent (Engeström & Pyörälä, 2021; Morris et al., 2021).

Phase 3: Pilot in one signature activity system (one term)

Pick one: community clinic, PLF analytics project, or participatory epidemiology module. Measure: - reproducibility/quality indicators, - student competency evidence (entrustment + contributions), - community satisfaction and perceived benefit, - conflict frequency and resolution time.

Phase 4: Scale and institutionalize (2–3 cycles)

- Add the data praxis spine across years.
- Institutionalize governance artifacts (charter, DMP templates, contribution policy).
- Train rotating stewards (students and staff) as part of leadership development.

7. CONCLUSION

A community-oriented and democratically governed veterinary/animal husbandry program or research group does not emerge from goodwill or rhetoric. It requires *production relations by design*: explicit decision rights, bounded and rotating hierarchy, competence-sensitive technical roles, and community co-determination of the object. Marxian analysis clarifies why divisions of labor tend to harden into domination; activity theory clarifies how collectives can redesign their work through contradictions and new mediating artifacts. Applied to CBVE curricula and to research groups, the result is a practical architecture for data-intensive collaboration that treats students, staff, and community partners as participants in a collective worker—capable of producing credible science, ethical practice, and locally meaningful outcomes.

Appendix: Minimal templates (headings you can operationalize immediately)

A**. One-page Project Charter (suggested headings)**

- Object and intended community benefit
- Stakeholders and membership boundaries
- Decision rules (Assembly quorum, voting, escalation)
- Division of labor (roles + rotation schedule)
- Data governance (ownership, access, sharing, retention)
- Quality and reproducibility checks
- Communication cadence and meeting minutes
- Conflict resolution pathway
- Contribution and authorship policy

B. Two-page Data Management Plan (course/lab level)

Align with NIH-style recommended elements where applicable: data type; tools/software/code; standards; preservation/access timelines; access and reuse considerations; oversight (National Institutes of Health, 2025b).

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