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JONASSEN'S PROBLEM TAXONOMY AND ITS RELEVANCE FOR VETERINARY, ANIMAL, AND HEALTH SCIENCES EDUCATION AND RESEARCH

An activity-theoretical framework for designing problem-solving interventions

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ABSTRACT:

Problem solving is central to professional education in veterinary medicine, animal science, and the health sciences, yet educational interventions often treat problems as if they were pedagogically interchangeable. David H. Jonassen's problem taxonomy, more precisely his problem typology, remains one of the most useful frameworks for differentiating problem forms and aligning instruction to their distinctive demands. This article explains Jonassen's taxonomy and argues that its strongest educational application emerges when it is coupled with cultural-historical activity theory. Jonassen clarifies that problems vary by structuredness, complexity, and domain specificity, and that different classes of problems call for different instructional supports. Activity theory clarifies how such problems should be situated within meaningful collective activity, mediated by tools, roles, and developmental trajectories. Activity theory is an adequate pedagogical foundation for educational models which, together with wider literature on clinical reasoning, systems thinking, simulation, and One Health, veterinary, animal, and health sciences are ideal domains for applying Jonassen's taxonomy. These fields require learners to move from well-structured procedural tasks to diagnosis-solution problems, decision making under uncertainty, troubleshooting, strategic performance, systems analysis, design, and ethical dilemmas. The article concludes that Jonassen's taxonomy should not be used as a static classification scheme but as a design grammar for constructing activity-theoretical interventions that align learning tasks, mediating tools, and developmental expectations with the real problem ecologies of professional practice and research.

Keywords: *Problem typology, Jonassen taxonomy, activity theory, professional education, clinical reasoning, systems thinking, veterinary education*

INTRODUCTION

Problem solving is among the most frequently invoked aims in contemporary professional education, yet it is often treated as a single generic skill. That assumption is especially problematic in veterinary, animal, and health sciences. A learner may need to calculate a drug dose, interpret a laboratory pattern, troubleshoot a failed instrument, decide between competing treatment paths, design a herd-level intervention, model a One Health system, or work through a welfare dilemma in which no option is morally clean. These are not the same kind of problem. They differ in structure, uncertainty, social distribution, time horizon, and evaluative criteria. If educational interventions collapse them into one undifferentiated category, instruction will either oversimplify real practice or misalign supports with actual cognitive and social demands.

David H. Jonassen's work remains foundational precisely because it rejects such flattening. In his 2000 article on a design theory of problem solving, he argued that problems differ by structuredness, complexity, and domain specificity, and that each type engages distinct cognitive, affective, and conative processes and therefore requires differentiated instructional support [1]. In later work, he refined this position and acknowledged that the

2000 scheme was a typology rather than a final taxonomy, but he retained the core claim that educational design must begin by asking what kind of problem is being taught [2].

The usefulness of Jonassen's taxonomy is magnified when placed in an activity-theoretical frame. We have published elsewhere that activity theory is a valid and useful pedagogical foundation to design educational interventions based on six principles: activity and consciousness, object orientation, the hierarchy of activity, actions, and operations, mediation, internalization and externalization, and development [3]. These principles offer what Jonassen's taxonomy alone does not provide: a theory of how problems function within socially organized practice and how educational interventions should connect problem types with collective objects, tools, and developmental trajectories.

This article therefore pursues two aims. The first is to explain Jonassen's problem taxonomy in a way that is pedagogically precise. The second is to justify its application to veterinary, animal, and health sciences education and research through activity theory. The argument advanced here is that Jonassen's taxonomy is highly suitable for these fields because their problem ecologies are intrinsically diverse, but that it should be operationalized through activity-theoretical interventions rather than as a decontextualized instructional menu.

JONASSEN'S PROBLEM TAXONOMY

Jonassen's key contribution was to challenge the assumption that all problems are pedagogically equivalent. His 2000 article proposed that problems vary at least along three major dimensions: structuredness, complexity, and domain specificity or abstractness [1]. Well-structured problems are constrained, have relatively convergent solution paths, and typically rely on a limited set of manipulable variables. Ill-structured problems, by contrast, have uncertain boundaries, multiple legitimate interpretations, several possible solution paths, and evaluative criteria that cannot be reduced to simple correctness [1, 4].

In later work, Jonassen summarized his 2000 typology as including logical problems or puzzles, algorithms, story problems, rule-using problems, decision making, troubleshooting, diagnosis-solution problems, strategic performance, systems analysis, design problems, and dilemmas [2]. These categories are best understood not as rigid compartments but as an ordered family of problem forms, moving from relatively well-structured to increasingly ill-structured and context-dependent configurations.

The instructional significance of the taxonomy lies in its refusal of a one-size-fits-all pedagogy. If a problem is algorithmic, then worked examples, procedural modeling, and deliberate practice may be appropriate. If a problem is diagnostic, then learners need support in cue integration, hypothesis generation, comparison, and revision. If a problem is a dilemma, then instruction must address competing values, not only technical adequacy. Jonassen later emphasized this point specifically for decision making, arguing that it is one of the most common forms of problem solving and a component of more complex ill-structured problem types such as policy and design problems [5].

A concise synthesis of the taxonomy and its relevance to veterinary, animal, and health sciences is presented in Table 1.

What Jonassen offers, then, is not merely a classificatory scheme but a pedagogical warning: when educators fail to distinguish problem types, they often apply supports suited to one kind of problem to another kind for which those supports are inadequate.

WHY JONASSEN'S TAXONOMY NEEDS ACTIVITY THEORY

Jonassen's taxonomy clarifies the nature of the problem. Activity theory clarifies the nature of the educational intervention. Without this second layer, the taxonomy may remain cognitively useful but pedagogically under-socialized. Problems in veterinary and health sciences are rarely faced by isolated minds. They arise in collective, tool-mediated, institutionally organized settings. They are shaped by rules, by divisions of labor, by material infrastructures, and by communities of concern. Educational interventions must therefore do more than match strategy to problem type. They must situate learners inside the activity systems within which those problems acquire meaning and consequence.

The above cited article on activity theory as a pedagogical foundation provides the necessary bridge. It argues that educational models can be grounded in six principles: activity and consciousness, object orientation, the hierarchy of activity, actions and operations, mediation, internalization and externalization, and development [3]. These principles make it possible to reinterpret problem-solving interventions not as isolated exercises but as developmental reorganizations of participation in socially meaningful work.

ACTIVITY AND CONSCIOUSNESS

The first principle implies that problem solving should not be reduced to a mental skill detached from practice. Learners develop problem-solving capacities by participating in activities that matter and that reshape motives, attention, and identity. This matters in veterinary and health education because the same problem form can carry very different significance depending on the activity system. A dosage calculation in a classroom worksheet is not the same activity as a dosage calculation in an unstable emergency context. Activity theory therefore prevents educators from mistaking formal equivalence for practical equivalence.

OBJECT ORIENTATION

Jonassen's taxonomy classifies problem types, but activity theory asks what object of activity the problem belongs to. This is crucial. A diagnostic problem is not only an epistemic puzzle. In practice it is part of a wider object such as restoring animal health, managing uncertainty for a client, protecting a herd, or preventing public harm. Educational design must begin from meaningful objects rather than from decontextualized task fragments [3]. This means that problem-solving instruction should be organized around authentic objects of veterinary and health work, not merely around abstract exercises that happen to resemble them.

HIERARCHY OF ACTIVITY, ACTIONS, AND OPERATIONS

Jonassen's taxonomy largely differentiates problem types at the level of action. Activity theory adds the higher and lower levels. At the higher level, an activity is animated by a motive. At the lower level, operations depend on conditions and can become routinized [6]. This has direct instructional implications. Algorithmic and rule-using problems often belong to the operational level and can be automated through practice. Diagnosis, decision making, systems analysis, and dilemmas usually remain action-level or even activity-level concerns, because they require conscious goal setting, contextual interpretation, and motive-sensitive judgement. Educational interventions should therefore not teach every problem type as if it required the same degree of reflection or proceduralization.

MEDIATION

We place strong emphasis on mediation, including tools, discourse, persuasive tools, and division of labor [3]. Jonassen's taxonomy is strengthened when mediation is made explicit. Story problems are mediated by case narratives. Diagnostic problems are mediated by charts, test results, heuristics, and clinical conversation. Systems-analysis problems are mediated by models, maps, and simulations. Design problems are mediated by prototypes, feedback loops, and stakeholder workshops. Dilemmas are mediated by ethical frameworks, legal constraints, and persuasive discourse. Activity theory therefore turns the taxonomy into a design framework for tools and environments, not only for content.

INTERNALIZATION AND EXTERNALIZATION

Problem-solving competence develops through movement between shared, externally scaffolded activity and increasingly self-regulated performance. This principle is highly relevant to veterinary and health sciences because learners must often externalize their reasoning in case notes, oral presentations, simulations, rounds, or design products before they can reliably internalize it. The clinical-reasoning literature repeatedly shows that making reasoning visible is essential for feedback and development across health professions [7-8]. Activity theory gives a developmental explanation for this. Externalization is not merely assessment. It is part of how internal regulation is formed.

DEVELOPMENT

Finally, activity theory insists that integra formation is developmental and historically situated. Contradictions are not noise to be removed but resources for growth [9-10]. Jonassen's taxonomy can benefit from this principle because professional problems in veterinary and health fields rarely appear as isolated, neatly bounded events. They emerge in sequences, aggregates, and systems. A learner may begin with a rule-using problem, move into troubleshooting, confront a diagnosis-solution problem, and finish with a dilemma. Educational interventions should therefore be designed developmentally, allowing learners to move across problem types while understanding how they are connected.

WHY THE TAXONOMY FITS VETERINARY, ANIMAL, AND HEALTH SCIENCES

Veterinary, animal, and health sciences are especially suitable for Jonassen's taxonomy because they embody nearly the full range of problem types he described. This makes them excellent fields not only for applying the taxonomy but for testing its pedagogical value.

CLINICAL REASONING AS DIAGNOSIS-SOLUTION, DECISION MAKING, AND TROUBLESHOOTING

Clinical reasoning is a paradigmatic example of diagnosis-solution problem solving. In medical education, clinical reasoning is widely treated as a complex problem-solving process requiring both domain knowledge and structural knowledge such as critical-thinking and reasoning skills [11]. In veterinary education, the same point is now explicit. Carr and colleagues describe clinical reasoning as an essential competence for veterinary graduates and emphasize that it includes cognitive, metacognitive, social, and situational activities [12]. May earlier framed clinical reasoning and case-based decision making as the fundamental challenge for veterinary educators, underscoring that veterinary learners must be taught not only to know but to reason under authentic conditions [13].

These observations map directly onto Jonassen's taxonomy. Differential diagnosis exemplifies diagnosis-solution problems. Treatment selection exemplifies decision making. Equipment failure, poor response to therapy, or breakdowns in diagnostic workflow exemplify troubleshooting. The clinical ecology itself frequently forces movement among these problem forms. This is why generic "problem-solving skills" instruction is insufficient. Learners must be taught the particular reasoning structures required by different clinical situations.

Veterinary work also adds a further layer: uncertainty. Petrovski and Kirkwood emphasize that uncertainty can impair decision making and care quality, yet veterinary education often leaves learners to acquire coping strategies informally [14]. This makes Jonassen's focus on ill-structured problems especially relevant. Clinical uncertainty is not a curricular inconvenience. It is part of the problem space.

STRATEGIC PERFORMANCE IN SIMULATION AND TEAM-BASED PRACTICE

Strategic performance problems are central in emergency care, anesthesia, surgery, outbreak response, and other dynamic settings where learners must coordinate actions in real time. Veterinary education has increasingly turned to simulation-based training for precisely these reasons. A recent systematic review of veterinary simulation studies found that learning goals, activities, and outcomes were often poorly aligned, but also concluded that simulation-based education should provide a structured and constructively aligned process to support the development of practical ability and clinical reasoning [15]. Jonassen's taxonomy helps clarify what kind of problems simulations should target, while activity theory clarifies how simulations should be embedded in broader developmental trajectories.

Strategic performance problems cannot be taught adequately through explanation alone. They require rehearsed but reflective action, role coordination, and debriefing. Activity theory strengthens this instructional logic by showing that what is being learned is not only a sequence of responses but participation in a collective activity system under pressure.

SYSTEMS ANALYSIS IN ONE HEALTH, PATIENT SAFETY, AND ANIMAL SCIENCE

Some of the most important problems in veterinary and health fields are not reducible to individual cases. They are systems-analysis problems. One Health initiatives, antimicrobial resistance, food-system resilience, patient safety, and livestock sustainability all involve multiple interacting variables, delayed effects, competing interests, and feedback loops. Khanna, Roberts, and Lane argue that health-professions curricula should be designed with systems-thinking perspectives because curricula and practice settings are complex systems and because educators need conceptual tools that address interdependencies and context rather than fragmentary subsystems [16]. In veterinary education, Cathcart and colleagues make a related case for embedding human factors and systems thinking into patient safety education, showing that the issue concerns not only what is taught but how curricular delivery itself is designed [17]. In animal science research, Stephens argues that systems thinking is increasingly necessary because pressing animal-science problems are complex and dynamic, yet the field has not systematically equipped researchers with the tools for such analysis [18].

Jonassen's systems-analysis category therefore has immediate applicability. It provides a conceptual place for problem-solving tasks that concern interdependence rather than isolated causality. Activity theory then helps educators design these interventions as collective modeling activities linked to real communities and institutions.

DESIGN PROBLEMS AND PARTICIPATORY CHANGE

Veterinary and health sciences increasingly require design capacities. Learners must design interventions, protocols, communication tools, workflows, curricula, and technologies. In health professions education, design thinking has already been explored as a problem-solving framework for curriculum and service innovation, though the literature remains uneven and often focused on partial or early stages of the design cycle [19]. This design turn makes Jonassen's design-problem category more salient than ever.

In animal and One Health contexts, design problems are rarely purely technical. They are socio-ecological. Duboz and colleagues argue that participatory modeling is an appropriate systems-thinking method for integrated approaches to health because it is iterative, adaptive, and explicitly social [20]. Rüegg and colleagues likewise propose a systems-based framework for evaluating One Health initiatives because such initiatives aim to influence complex systems and therefore require systemic rather than linear reasoning [21]. These literatures show that design problems in veterinary and health sciences are best addressed through collective modeling, stakeholder negotiation, and iterative refinement. Activity theory is particularly apt here because it makes the social organization of design visible.

DILEMMAS AS INDISPENSABLE EDUCATIONAL OBJECTS

Dilemmas are among the most important yet least reducible problem types in veterinary and health practice. Euthanasia decisions, culling under disease control, antimicrobial stewardship under livelihood pressure, and balancing ideal care with financial constraint all involve competing goods rather than straightforward optimization. Jonassen's inclusion of dilemmas is pedagogically important because it prevents educators from treating all complex problems as if they were solvable by more information alone.

In these cases, activity theory again adds something crucial. Dilemmas do not arise in a vacuum. They are historically and institutionally produced. The relevant intervention is therefore not only moral reflection but also analysis of the activity system that gives the dilemma its particular shape. In some cases, what appears as an individual moral conflict is partly the expression of broader contradictions in professional, economic, or ecological systems.

DESIGNING ACTIVITY-THEORETICAL EDUCATIONAL INTERVENTIONS FOR JONASSEN'S PROBLEM TYPES

If Jonassen's taxonomy tells educators that problem types differ, activity theory shows how to build interventions around those differences.

The first design principle is sequencing without reductionism. Learners should encounter well-structured problems early because procedural fluency matters, but they should not be trapped there. Clinical and research

competence require deliberate movement into diagnosis, decision making, troubleshooting, systems analysis, design, and dilemmas. Jonassen's 1997 distinction between well-structured and ill-structured problem-solving outcomes is useful here because it shows that different forms of instructional design are needed for different problem ecologies [4].

The second principle is object authenticity. The attached activity-theory article argues that pedagogical design should begin from socially meaningful objects and should organize curriculum around forms of practice rather than topics alone [3]. Applied to problem solving, this means that learners should not solve abstract problems disconnected from the objects of veterinary or health work. They should work on patient care, herd health, surveillance, safety, welfare, and community health as evolving object fields, within which different Jonassen problem types appear.

The third principle is mediation design. Educational interventions should make tools, representations, roles, and discourse explicit. Algorithms require worked examples and transparent procedures. Diagnosis requires case representation tools, hypothesis matrices, and structured discussion. Systems analysis requires models, maps, and simulation. Dilemmas require deliberative forums and justification frameworks. The power of activity theory lies in treating these mediators as central components of instruction rather than as background resources.

The fourth principle is developmental externalization. Learners should repeatedly make their reasoning visible through case analyses, oral defenses, decision records, troubleshooting logs, models, and design prototypes. This makes it possible to assess not only whether a learner reached an answer, but what kind of problem they believed they were solving and how they organized the activity.

The fifth principle is contradiction-sensitive curriculum design. Veterinary and health problem spaces are full of contradictions: welfare versus cost, urgency versus uncertainty, standardization versus adaptation, safety versus access. An activity-theoretical intervention does not treat these as unfortunate noise. It uses them to structure inquiry and reflection. This is particularly important for systems-analysis and dilemma problems, where oversimplification is itself a source of educational failure.

IMPLICATIONS FOR RESEARCH IN VETERINARY AND HEALTH SCIENCES EDUCATION

The combination of Jonassen and activity theory also has methodological implications for education research. First, it suggests that studies of problem-solving interventions should specify which problem type is being addressed. Too often, interventions are evaluated under a generic heading such as "clinical reasoning" or "problem solving" without distinguishing whether the task concerns diagnosis, decision making, troubleshooting, strategic performance, or systems analysis.

Second, it suggests that outcome measures should match the problem type. Brentnall and colleagues show that assessment of clinical reasoning across health professions is methodologically complex and requires alignment between construct and assessment format [8]. Jonassen's taxonomy can sharpen this alignment. Not every problem type should be assessed in the same way.

Third, it suggests that intervention studies should analyze the activity system, not only the learner. The attached article's activity-theoretical framework explicitly connects curriculum, teaching, assessment, and institutional organization [3]. For research on problem-solving interventions, this means that tools, rules, supervision, community context, and division of labor should be treated as explanatory variables, not merely background conditions.

CONCLUSION

Jonassen's problem taxonomy remains one of the most important frameworks for thinking seriously about problem solving in education. Its enduring value lies in a simple but powerful insight: different problems demand different forms of support. Veterinary, animal, and health sciences offer especially rich terrain for its application because they encompass nearly the full range of Jonassen's problem types, from algorithms and rule use to diagnosis, decision making, troubleshooting, systems analysis, design, and dilemmas.

Yet the taxonomy becomes pedagogically strongest when it is joined to activity theory. Jonassen differentiates the kinds of problems learners face. Activity theory explains how those problems are embedded in meaningful collective activity, how they should be mediated, and how problem-solving competence develops through participation in real object systems. For veterinary and health sciences education and research, this combination offers more than a classification scheme. It offers a design grammar for building interventions that are cognitively differentiated, socially grounded, and developmentally coherent.

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