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# Beyond Pedagogical Binaries: A Four-Dimensional Framework for Lesson Analysis

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**Abstract:** Binary classifications of teaching as transmission or constructivism obscure how participation, authority, knowledge practices, and conceptual work can vary within one lesson. This article introduces the social, procedural, epistemic, and conceptual (SPEC) framework for episode-level lesson analysis. SPEC was developed through a structured purposive theory synthesis rather than an exhaustive systematic review. A documented corpus of foundational traditions, observation systems, and targeted verification sources was compared using explicit inclusion, boundary, and disposition rules. Candidate constructs were assigned by observable target; three indicators per dimension were retained as a parsimonious authorial proposal; and qualitative descriptors were generated from theoretically warranted adjacent distinctions checked against cross-dimensional counterexamples. The dimensions are analytically distinguishable but potentially related. Their descriptor codes form non-additive, non-normative profiles rather than composite scores or judgments of teaching quality. An instructional episode is the primary unit; a hypothetical transcript illustrates indicator coding, opportunity/evidence flags, and rejection of nearby alternatives. SPEC is an initial conceptual proposal requiring operationalization, reliability examination, and validity testing. Ordering, thresholds, and cross-domain use require study before evaluative application.

**Keywords:** *Classroom discourse, epistemic agency, lesson analysis, multidimensional pedagogy, SPEC framework.*

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## Introduction

For more than half a century, educational scholarship has contrasted teacher-centered transmission with student-centered constructivism (Bransford et al., 2000; Dewey, 1938). Transmission accounts emphasize stable knowledge, directive instruction, and accurate reproduction, whereas constructivist accounts emphasize the construction of meaning through inquiry, dialogue, and reflection (Vygotsky, 1978). Classroom practice rarely fits either pole. A lesson may move from exposition to guided investigation and then to student discussion while also changing who controls the activity, what counts as evidence, and how ideas are connected. A useful analytic framework must therefore distinguish these simultaneous features rather than treat pedagogy as a single continuum.

Existing frameworks illuminate parts of this complexity but serve different purposes. Inquiry frameworks describe control over questions and methods; discourse schemes represent turn-taking patterns and teacher feedback; dialogic and cooperative-learning traditions foreground participation; and taxonomies characterize engagement or conceptual organization. CLASS, the Framework for Teaching, and ICAP also describe classroom climate, teaching practice, or engagement. The narrower gap is that these approaches do not separately profile social organization, procedural authority, epistemic practice, and conceptual structure within a bounded instructional episode. Table 1 summarizes this comparison.

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*Table 1. Comparative Architecture and Construct Coverage of Selected Frameworks*

*Panel A1. Purpose, users, and primary unit*

| Framework | Purpose / intended users | Primary unit/evidence |
|---|---|---|
| Inquiry levels (Banchi & Bell, 2008; Blanchard et al., 2010) | Classify learner authority in inquiry: researchers and teachers | Inquiry task or activity |
| IRF/IRE discourse schemes (Mehan, 1979; Sinclair & Coulthard, 1975) | Analyze classroom exchange structure; discourse researchers | Transcript exchange sequence |
| Cognitive taxonomy (Anderson & Krathwohl, 2001) | Classify objectives and cognitive processes; educators and curriculum analysts | Objective, task, or curriculum artifact |
| Knowledge-structure / concept frameworks (Biggs & Collis, 1982; Erickson, 2007) | Characterize response complexity or conceptual organization; researchers and teachers | Learner response or curriculum content |
| Dialogic teaching (Alexander, 2018; Mercer & Howe, 2012) | Develop and analyze classroom talk; teachers and researchers | Discourse and interaction |
| Cooperative learning (Johnson & Johnson, 2009; Slavin, 1995) | Design and study productive group learning; teachers and researchers | Group task and interaction |
| ICAP (Chi & Wylie, 2014) | Classify engagement mode; researchers and teachers | Learner behavior during a particular learning activity |
| CLASS (Pianta et al., 2008) | Observe interaction quality; trained observers and researchers | Standardized observation cycle |
| Framework for Teaching (Danielson, 2013) | Describe or evaluate teaching and support professional growth; teachers, observers, and leaders | Lesson, artifacts, and practice components |
| PLATO (Grossman et al., 2013) | Observe ELA instructional quality; researchers and trained observers | Independent 15-minute observation segment |
| MQI (Hill et al., 2008) | Analyze the mathematical quality of instruction; researchers and trained observers | Five-minute lesson segment plus lesson summary |
| RTOP (Sawada et al., 2002) | Rate reform-oriented mathematics/science teaching; trained observers | Observed class session |
| EQUIP (Reinholz & Shah, 2018) | Quantify participation equity; researchers, teachers, and coaches | Student contribution or participation sequence |
| SPEC | Analyze instructional configurations; researchers initially | Bounded instructional episode |

*Panel A2. Within-lesson sensitivity and output*

| Framework | Within-lesson sensitivity | Output / aggregation |
|---|---|---|
| Inquiry levels (Banchi & Bell, 2008; Blanchard et al., 2010) | Can differ across activities | Categorical inquiry level |
| IRF/IRE discourse schemes (Mehan, 1979; Sinclair & Coulthard, 1975) | Explicitly exchange-by-exchange | Exchange-pattern labels |
| Cognitive taxonomy (Anderson & Krathwohl, 2001) | Not designed for episode change | Taxonomy category or matrix |
| Knowledge-structure / concept frameworks (Biggs & Collis, 1982; Erickson, 2007) | Can compare tasks or products, not episode profiles | Level or conceptual structure |
| Dialogic teaching (Alexander, 2018; Mercer & Howe, 2012) | Recognizes changing talk forms | Principles, repertoire, or qualitative characterization |
| Cooperative learning (Johnson & Johnson, 2009; Slavin, 1995) | Variation observable but not its primary architecture | Design conditions and outcomes |
| ICAP (Chi & Wylie, 2014) | Applicable within activities; no formal lesson-segmentation protocol | Passive, active, constructive, or interactive category |
| CLASS (Pianta et al., 2008) | Repeated cycles sample variation | Dimension and domain ratings; aggregation supported |
| Framework for Teaching (Danielson, 2013) | Primarily component- and lesson-level evidence | Component and domain performance ratings |
| PLATO (Grossman et al., 2013) | Explicit segment-by-segment ratings | Element ratings; teacher-level aggregation supported |
| MQI (Hill et al., 2008) | Explicit segment-by-segment coding | Mathematics-specific codes and lesson ratings |
| RTOP (Sawada et al., 2002) | Items summarize the lesson rather than pedagogical episodes | Twenty-five item ratings summed to a total |
| EQUIP (Reinholz & Shah, 2018) | Explicit contribution-level coding | Disaggregated participation analytics |
| SPEC | Explicit sequence of episode profiles | Indicator codes or ranges; no composite |

*Panel B. Representation of SPEC constructs*

| Framework | Social | Procedural | Epistemic | Conceptual |
|---|---|---|---|---|
| Inquiry levels | △ | ✓ | ○ | ○ |
| IRF/IRE discourse schemes | ✓ | △ | ○ | ○ |
| Cognitive taxonomy | ○ | ○ | ○ | ● |
| Knowledge-structure / concept frameworks | ○ | ○ | ○ | ✓ |
| Dialogic teaching | ✓ | ● | ● | ● |
| Cooperative learning | ✓ | ● | ○ | ○ |
| ICAP | △ | ○ | ○ | ● |
| CLASS | ● | △ | ○ | ● |
| Framework for Teaching | ● | ● | ● | ● |
| PLATO | ✓ | ○ | ● | ✓ |
| MQI | △ | ○ | ✓ | ✓ |
| RTOP | ✓ | ✓ | ✓ | ✓ |
| EQUIP | ✓ | ○ | ● | ○ |
| SPEC | ✓ | ✓ | ✓ | ✓ |

*Note.* ○ = absent (no dedicated item, category, or dimension); △ = adjacent (inferable from another code but not separately operationalized); ● = qualitative (named or defined but not independently coded); ✓ = coded (a dedicated observable item, category, or dimension). Within-lesson sensitivity means formal recording of segment change. Purpose and user entries summarize published uses. The purposive set spans inquiry, discourse, conceptual organization, cooperation, engagement, observation, reform, and participation equity; it is neither exhaustive nor evidence of SPEC's uniqueness. ICAP is △ for Social because Interactive engagement shows peer exchange without separately coding social organization. RTOP is ✓ across all four because relevant items are present, although they enter a reform-oriented total and are not assumed equivalent to SPEC constructs.

Established systems provide broad quality ratings, subject-specific measures, reform-oriented totals, or fine-grained participation analytics; several address more SPEC constructs than the earlier comparison suggested. Within this purposive set, however, none separately operationalizes all four as a non-additive profile of a functionally bounded episode. SPEC proposes that profile and keeps four questions visible at once: who participates, who controls the activity, how claims are warranted, and what form of understanding is constructed. This is a proposed analytic affordance that still requires empirical testing.

Drawing on productive disciplinary engagement—problematizing content, granting students authority, holding them accountable to peers and disciplinary norms, and providing resources (Engle & Conant, 2002)—this article proposes SPEC. Its primary purpose is episode-level research; lesson interpretation is secondary, and teacher reflection should be considered only after validation. SPEC is not a scoring or evaluation instrument.

The article defines the constructs, boundaries, indicators, unequal descriptor structures, and profiles needed to move beyond binary labels. Two questions guide the analysis:

1. What constructs and bodies of literature warrant distinguishing social, procedural, epistemic, and conceptual dimensions in classroom analysis?
2. How can each dimension be specified through observable indicators and ordered qualitative descriptors while preserving construct boundaries and non-additive profile interpretation?

## Theoretical Framework

### *Rationale for a Multidimensional Framework*

Constructivist and sociocultural traditions agree that learning involves more than the reproduction of correct answers, but they do not assign the same analytic role to interaction, activity structure, standards of evidence, or conceptual organization. Research on classroom discourse shows that authoritative and dialogic forms can shift within a lesson (Scott et al., 2006), while inquiry research distinguishes the openness of questions and methods from the quality of the resulting reasoning (Banchi & Bell, 2008; Blanchard et al., 2010). These differences make a single teacher-centered/student-centered continuum analytically insufficient.

Structured observation systems address adjacent but different purposes. ICAP classifies engagement as passive, active, constructive, or interactive (Chi & Wylie, 2014); CLASS organizes observation around emotional support, classroom organization, and instructional support (Pianta et al., 2008); and the Framework for Teaching includes planning, classroom environment, instruction, and professional responsibilities (Danielson, 2013). These systems can register important aspects of participation and instructional quality, but they do not separately code the four SPEC questions or represent their possible divergence within a bounded episode.

Episode-sensitive analysis follows from changing classroom activity. Broad lesson ratings can obscure movement among explanation, guided comparison, collaborative inquiry, and synthesis. Dialogic quality cannot be inferred from one teacher move, and procedural openness does not establish evidence quality or conceptual integration (Alexander, 2020; Mercer & Howe, 2012; Ruiz-Primo, 2011). SPEC therefore represents within-lesson variation as a sequence of profiles rather than one averaged judgment.

The dimensions draw on complementary traditions. Dialogic research explains participation and uptake (Gillies, 2016; Mercer & Dawes, 2014); inquiry models explain control over questions, methods, and resources (Banchi & Bell, 2008; Blanchard et al., 2010); epistemic and argumentation research explains claims, evidence, and uncertainty (Chinn et al., 2011; Kelly & Licona, 2018); and conceptual-change research explains abstraction, connectedness, and representational organization (Leach & Scott, 2003; Linn et al., 2004). The dimensions are analytically distinguishable, not empirically independent; their relationships remain open questions.

Accordingly, SPEC describes configurations rather than defining universally good teaching. A teacher-directed episode may contain demanding conceptual and epistemic work, while an open or highly interactive episode may not. The framework asks which pedagogical functions are present and how they combine; appropriateness depends on purpose, learners, content, and context.

### *Framework Development Procedure*

SPEC was developed through a structured purposive theoretical synthesis, not an exhaustive systematic review. The task was to delimit an initial framework for describing participation, activity control, knowledge claims, and conceptual understanding within one episode. Following guidance for conceptual and integrative theory development, the procedure made source roles, selection logic, comparison criteria, and inferential steps explicit without claiming statistical coverage of the literature (Jaakkola, 2020; Jabareen, 2009; Torraco, 2005).

The source base comprised derivational, comparator, and methodological literature identified through targeted searches of ERIC and publisher databases and supplemented by citation chaining. Additional searches were conducted when construct-boundary questions emerged. Records were checked against publisher, DOI, ERIC, or official instrument sources.

Five query families paired focal constructs with related terms:

- Social interaction: discourse, dialogue, and cooperation paired with participation and uptake;
- Procedural authority: inquiry and learner authority paired with questions, methods, and resources;
- Epistemic activity: epistemic practice and argumentation paired with claims, evidence, warrants, uncertainty, and revision;
- Conceptual organization: conceptual change, knowledge integration, and representation paired with abstraction, coherence, and translation; and
- Observation frameworks: classroom and lesson observation paired with framework, protocol, and instrument.

Search syntax was adapted to each interface. The procedure checked literature coverage and possible gaps but did not produce prevalence estimates, PRISMA counts, or claims of exhaustiveness.

Sources were retained for a primary definition, observable construct, published instrument architecture, or adjacent-transition warrant. Outcome-only, trait or self-report, target-free engagement, duplicate, and avoidable secondary sources were excluded. Discipline-specific work was retained only when its construct could be abstracted; transfer remains untested. Sources were added only if they changed an indicator, boundary, transition, or comparator code. Checking stopped when targeted searches and citation chaining yielded no candidate requiring a fifth core question; omissions remain possible.

The synthesis used six passes: define the questions, inventory candidates, assign targets, merge or exclude constructs, test cross-dimensional counterexamples, and draft adjacent contrasts. The four dimensions and three indicators are parsimonious authorial propositions, not statistical discoveries. Tables 2–4 record derivation, disposition, and transition warrants.

Candidates were assigned by observable target: participation and uptake to Social; question, method, and resource control to Procedural; claim grounds and revisability to Epistemic; and abstraction, connections, and representation to Conceptual. Each provisional three-indicator set preserves distinct evidentiary targets. Cross-dimensional counterexamples checked leakage; omitted traditions and disciplinary weighting remain selection risks.

*Table 2. Derivation and Boundaries of the Proposed SPEC Indicators*

*Panel A. Theoretical Sources and Indicator Warrants*

| Dimension/indicator | Principal theoretical sources | What the sources warrant |
|---|---|---|
| Social / student–student interaction | Vygotsky, 1978; Mercer & Littleton, 2007; Howe et al., 2019 | Reciprocal uptake can organize joint meaning-making. |
| Social / student–teacher interaction | Alexander, 2018; Mercer & Dawes, 2014; Pontefract & Hardman, 2005 | Learner contributions vary in whether they shape subsequent talk. |
| Social / participation structure | Johnson & Johnson, 2009; Slavin, 1995; Wells, 1999 | Participation can be monologic, teacher-mediated, interdependent, or reciprocally collaborative. |
| Procedural / question ownership | Banchi & Bell, 2008; Blanchard et al., 2010 | Inquiry authority varies with who frames or refines the question. |
| Procedural / method control | Banchi & Bell, 2008; Blanchard et al., 2010; Crawford, 2014 | Consequential control over procedure can remain prescribed or transfer to learners. |
| Procedural / tools and resources | Engle & Conant, 2002; Crawford, 2014 | Authority includes selecting, adapting, or locating resources. |
| Epistemic / claim status and agency | Chinn et al., 2011; Kelly, 2008; Kelly & Licona, 2018; Scardamalia & Bereiter, 2005 | Claims can be received, justified, evaluated, or revised through epistemic practices. |
| Epistemic / evidence use | Chinn & Malhotra, 2002; Osborne, 2010; Osborne et al., 2004 | Evidence differs in whether it is supplied, applied, evaluated, or used to revise claims. |
| Epistemic / uncertainty | King & Kitchener, 2004; Manz & Suárez, 2018; Sandoval, 2005 | Uncertainty can be suppressed, managed, examined, or made productive. |
| Conceptual / generality and abstraction | Bruner, 1996; Erickson, 2007; Vosniadou, 2013 | Understanding can move from local instances to general principles and theories. |
| Conceptual / connectedness and coherence | Biggs & Collis, 1982; Leach & Scott, 2003; Linn et al., 2004 | Ideas differ in relational organization and explanatory coherence. |
| Conceptual / representational integration | Ainsworth, 2006; diSessa, 2004; Kozma & Russell, 2005; Wu & Puntambekar, 2012 | Translation and transformation across representations can reorganize understanding. |

*Panel B. Operational boundary or non-example*

| Dimension/indicator | Boundary or non-example |
|---|---|
| Social / student–student interaction | Co-presence, divided tasks, or agreement without uptake. |
| Social / student–teacher interaction | Teacher control of the task is Procedural, not Social. |
| Social / participation structure | Group seating alone does not establish interdependence or collaboration. |
| Procedural / question ownership | Choosing an answer to a fixed question is not question ownership. |
| Procedural / method control | Cosmetic execution choices do not change the inquiry pathway. |
| Procedural / tools and resources | Selecting evidence only from assigned material is a bounded rather than an independent choice. |
| Epistemic / claim status and agency | Novel output without evidence-responsive revision is not the highest epistemic descriptor. |
| Epistemic / evidence use | Mentioning an example without a ground-to-claim relation is not evidential justification. |
| Epistemic / uncertainty | Confusion alone is not critical examination of uncertainty. |
| Conceptual / generality and abstraction | Abstract terminology without demonstrated generalization. |
| Conceptual / connectedness and coherence | Several facts without coordinated relations. |
| Conceptual / representational integration | Parallel representations without explicit translation or transformation. |

*Note*. The source chain warrants qualitative distinctions, not completeness, equal intervals, universal stages, or calibrated thresholds.

*Table 3. Disposition of Major Candidate Construct Families*

| Candidate family | Disposition | Reason/boundary |
|---|---|---|
| Uptake/voice distribution | Social | Interactional organization; not evidence quality. |
| Task coordination/roles | Merge: Social | Retain for interdependence; task-design authority is Procedural. |
| Learner initiation | Merge: Social evidence | Folded into interaction evidence, not retained as a separate indicator or qualifier; it need not imply Procedural authority (Garton, 2012; Waring, 2011). |
| Question/method/resource authority | Procedural | Consequential control of activity framing/enactment. |
| Assessment/reflection | Split | Procedural if learners control process; Epistemic if claims/standards are evaluated. |
| Claims/evidence/uncertainty/ revision | Epistemic | Grounds and revisability of knowing; not difficulty. |
| Cognitive-demand or Bloom-style labels | Exclude/reassign | Reassign to epistemic grounds or conceptual organization; never use difficulty alone. |
| Abstraction/connections/ representation | Conceptual | Organization of ideas; not participation or authority. |
| Affect/management/accuracy/ outcomes | Exclude from core | Important but outside the four questions. |
| Equity/power | Contextual lens | SPEC evidence may inform, but cannot establish, equity/power. |

*Note*. Exclusion marks scope.

*Design Commitments, Construct Boundaries, and Scale Architecture*

Analytic distinctiveness. SPEC treats the dimensions as distinguishable but potentially related. Social evidence concerns participation and uptake; Procedural evidence concerns control over questions, methods, and resources; Epistemic evidence concerns claims, evidence standards, and uncertainty; and Conceptual evidence concerns abstraction, connectedness, and representational integration. Dialogue is not automatically epistemically rigorous, procedural autonomy does not imply conceptual depth, and a complex representation does not itself demonstrate understanding (Ford & Forman, 2006).

Observability with theoretical anchoring. Indicators are interpreted from enacted evidence and corroborating materials, not inferred from labels such as inquiry, dialogue, or student-centeredness. Coders record opportunity and evidence status before coding each indicator. If indicators diverge, the profile retains their codes or ranges rather than forcing convergence. Evidence precedence, duration, opportunity, and adjudication rules follow.

Ordinal descriptors and non-comparability. Descriptor counts reflect proposed qualitative distinctions, not numerical symmetry. Social participation uses four ordered descriptors from minimal exchange to collaborative reciprocal uptake. Learner initiative may contribute to interaction evidence but is not separately coded because it neither defines an ordered Social stage nor establishes Procedural authority (Garton, 2012; Waring, 2011). Procedural authority follows a prescribed–bounded–guided co-design–learner-directed progression. Epistemic activity uses five descriptors because evidence-responsive revision is qualitatively distinct from evaluation. Conceptual organization uses four descriptors from local instances to cross-context theoretical systems. Levels are ordinal only within their own indicators and dimensions: S4 is not equivalent to P4, E4, or C4, and intervals are not assumed equal (Stevens, 1946).

Non-additive and non-normative profiles. SPEC does not average levels, calculate an overall score, or assume that a higher descriptor is always preferable. A configuration is interpreted in relation to the purpose and phase of instruction. Teacher explanation may be appropriate when introducing unfamiliar content, while greater student authority may be useful during later inquiry. The analytic question is how the four functions are organized, not whether a total score or graphic makes one lesson appear better than another.

Scope and testability. The framework primarily addresses episodes with observable instructional interaction, although bounded individual work can be coded when task, authority, epistemic, and conceptual features are identifiable. Transfer across subjects, cultures, ages, and languages requires testing. This article offers preliminary coding guidance and testable boundary propositions, not a validated measurement instrument.

The sources in Table 4 warrant qualitative distinctions between adjacent descriptors, not equal intervals, universal stages, or calibrated thresholds. Each transition is a testable construct proposition whose ordering, reliability, monotonicity, and invariance across subjects and cultures require examination.

*Table 4. Theoretical Warrants and Boundary Rules for Adjacent Descriptor Transitions*

| **Transition** | **Boundary rule** | **Principal warrant** |
|---|---|---|
| S1 → S2 | Recurrent teacher-mediated response; isolated/choral/one-word reply remains S1. | Mehan, 1979; Pontefract & Hardman, 2005 |
| S2 → S3 | Peers functionally depend on contributions toward a shared task; parallel/teacher-routed work remains S2. | Johnson & Johnson, 2009; Slavin, 1995 |
| S3 → S4 | Two linked uptake cycles or one three-turn contingent sequence; reporting, division, or agreement remains S3. | Alexander, 2018; Gillies, 2016; Howe et al., 2019; Mercer & Littleton, 2007 |
| P1 → P2 | A permitted option can change the question, evidence, procedure, resource base, or substantive product; cosmetic choice remains P1. Provisional SPEC distinction. | Banchi & Bell, 2008; Engle & Conant, 2002 |
| P2 → P3 | Learners formulate/materially adapt an element with guidance; preset selection remains P2. | Banchi & Bell, 2008; Blanchard et al., 2010 |
| P3 → P4 | Learners originate and retain authority without case-by-case approval; teacher frame/approval remains P3. | Banchi & Bell, 2008; Engle & Conant, 2002 |
| E1 → E2 | Visible ground-to-claim connection, even if supplied; reproduction/authority alone remains E1. | Chinn et al., 2011; King & Kitchener, 2004; Sandoval, 2005 |
| E2 → E3 | Learners use evidence or a criterion to justify a claim; repeating supplied support remains E2. | Berland & Reiser, 2009; Osborne et al., 2004 |
| E3 → E4 | Learners evaluate adequacy, alternatives, warrants, limitations, or uncertainty; preset-rule application remains E3. | Chinn et al., 2011; King & Kitchener, 2004; Osborne, 2010 |
| E4 → E5 | Evidence/uncertainty causes traceable material revision; novelty, comparison, or copied correction remains E4/lower. | Manz & Suárez, 2018; Scardamalia & Bereiter, 2005 |
| C1 → C2 | Stable concept plus one explicit relation; labels/examples without relation remain C1. | Erickson, 2007; Linn et al., 2004 |
| C2 → C3 | Generalizable principle coordinates at least two relations; local links remain C2. | Biggs & Collis, 1982; Linn et al., 2004 |
| C3 → C4 | Multiple principles form a coherent system across different contexts or with explicit scope; one-domain model remains C3. | Biggs & Collis, 1982; Vosniadou, 2013 |

*Note.* Learner initiation is Social interaction evidence and does not establish Procedural authority; Procedural indicators remain separate; representational integration is coded only when elicited and cannot determine conceptual generality or connectedness.

## The SPEC Model

*Unit of Analysis and Profile Interpretation*

The primary unit is a bounded instructional episode: a period organized around a relatively stable task or instructional function, with no fixed duration. Episode construction and SPEC coding occur in separate passes. In Pass 1, independent unitizers mark only observable structural events: an announced or enacted change in task or instructional goal; a change in participant configuration; a change in activity, material, or required product; or an explicit transition cue followed by a durable new interaction format. Inferred SPEC levels are not boundary criteria. Boundary marks within the same completed transcript turn—or, provisionally, within 10 seconds of one another—are treated as a single boundary. Unitizers adjudicate disagreements from the raw record using only these structural rules and freeze the episode set before Pass 2 (Hennessy et al., 2020; Krippendorff, 1995).

In Pass 2, coders record low-inference evidence for each indicator before assigning a descriptor. Video/audio records and associated transcripts provide the primary record of enacted interaction; task materials establish intended affordances; student artifacts show products; and observation notes supplement, but do not silently override, the direct record. When sources conflict, the enacted behavior is coded and the discrepancy is retained. Missing or inaudible evidence is marked IE rather than inferred from the planned task. Coders do not move boundaries to make a profile more homogeneous. A sustained internal shift is coded as a range or flagged for codebook revision, and unitizing agreement is reported separately from category agreement. If alternative defensible segmentations change the interpretation, both are reported in a sensitivity analysis.

Minimum evidence depends on the target indicator. Social interaction codes require a video/audio record, a transcript, or sufficiently detailed time-linked observation notes that preserve speakers, sequence, and contingent uptake; a lesson plan or student product cannot substitute for unavailable interaction. Procedural codes require evidence of the relevant allocation or decision point from enacted talk, directions, task materials, or a corroborated observation record. Epistemic and Conceptual codes require inspectable claims, grounds, relations, or representations in talk, writing, or artifacts linked to the episode. If this minimum is not met, the indicator is IE.

Each record contains both a descriptor and an elicitation/evidence status. OE (opportunity elicited) means that the episode provided a reasonable opportunity for the target feature; NE (not elicited) means that the design did not elicit such an opportunity; IE (insufficient evidence) means that the record is inadequate to determine opportunity or enactment; and NA (not applicable) is used only when an indicator genuinely does not apply. NE is not evidence of learner incapacity and is never treated as IE. When absence is part of the pedagogical organization, retain the descriptor and append NE—for example, P1/NE when the teacher fixes the only method. When a genuine opportunity occurs and adequate evidence shows non-occurrence, code the warranted lower descriptor with OE. One-representation work with no relevant translation demand is NA for representational integration, not C1.

Four operational definitions guide boundary decisions. Relevant opportunity means an uptake sequence (Social), decision point (Procedural), knowledge claim or uncertainty (Epistemic), or conceptual relation/representation demand (Conceptual). For dynamic interactional, epistemic, and conceptual features, sustained means recurrence across at least two relevant opportunities or one uninterrupted sequence of at least three contingent turns or actions; a single move does not elevate the code. If only one possible opportunity exists, code the lower descriptor or adjacent range unless a decisive structural condition settles the indicator. Procedural authority is the exception: one explicit allocation can establish the state because it governs subsequent decisions. These thresholds are provisional codebook rules for calibration in pilot coding.

A consequential choice is an enacted option that could change the inquiry question, evidence, procedure, resource base, or substantive product; color, order, partner, wording, or display format is cosmetic when the epistemic path is unchanged. Learner initiative may involve self-selection or a contribution beyond the expected response (Waring, 2011). Such initiative supports an S4 code only within sustained reciprocal uptake and negotiated meaning; even across learners, it does not establish P4 authority over the question, method, or resources, which may remain teacher-controlled (Garton, 2012). Material revision requires a traceable before-and-after change linked to evidence or uncertainty in a claim, its scope, an explanatory relation, a model, or a standard of judgment; rewording, an unintegrated example, an unsupported answer switch, or a copied correction is not material revision.

A whole lesson is interpreted as a sequence or distribution of episode profiles, not as one average. The framework's primary use is research-oriented analysis, with structured lesson interpretation as a secondary use. Teacher reflection may become a future application after validation, but the present framework should not be used for teacher ratings, accountability, or composite judgments of instructional quality.

Tables 5–8 give an observable anchor, affirmative instance, and adjacent exclusion for every indicator-level descriptor; the instances are evidence examples, not models of better teaching. Code the three indicators independently. Use the lower descriptor when the next feature is isolated, the upper descriptor only when its rule is sustained, and an adjacent range when two patterns are sustained or a boundary remains unresolved despite adequate evidence. Use IE only for inadequate evidence, not for a borderline substantive pattern. Report a dimension-level shorthand only when all three indicators converge; otherwise retain the indicator codes.

*Social Dimension*

The social dimension concerns how participation is organized and how ideas are taken up in interaction. Sociocultural accounts emphasize that higher psychological functions develop through joint activity before they become individual competencies (Vygotsky, 1978; Wells, 1999). Classroom-discourse research further shows that recitative and dialogic exchanges afford different opportunities for learners to contribute, encounter alternatives, and refine ideas (Alexander, 2018; Gillies, 2016; Howe et al., 2019; Mercer & Howe, 2012). The construct therefore concerns the social organization of thinking, not simply the amount of talk.

The three indicators capture student-to-student interaction, student-to-teacher interaction, and participation structure. They distinguish, respectively, how peers respond to one another, how learner contributions shape teacher–student exchanges, and whether activity is organized individually, through teacher mediation, through cooperative interdependence, or through collaborative negotiation (Johnson & Johnson, 2009; Mercer & Littleton, 2007; Pontefract & Hardman, 2005).

The four descriptors distinguish minimal participation, teacher-assisted participation, cooperative interdependence, and collaborative meaning-making. The transition from cooperation to collaboration requires sustained mutual uptake and negotiated joint meaning rather than task division alone. Learner-initiated moves that launch, reframe, coordinate, challenge, or redirect a line of talk and receive uptake may support an S4 judgment when they occur within sustained reciprocal meaning-making. They remain Social evidence: even initiative by several learners can coexist with teacher control of the question, method, or resources and therefore does not establish P4 (Garton, 2012; Waring, 2011).

Social evidence is kept separate from the other dimensions. A highly interactive episode may remain epistemically uncritical or conceptually local, while a teacher-led episode may nevertheless contain sophisticated explanation. The social code asks how participation functions, not whether the lesson is good overall.

*Table 5. Indicator-Level Coding Rules for the Social Dimension*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Student–student S1 | No substantive peer exchange. | Learners work individually or address only the teacher. | Acknowledgement, echo, or aside remains S1. |
| Student–student S2 | Brief peer response is teacher-prompted/routed. | A prompted peer comment returns immediately to the teacher. | Teacher-routed comments without peer dependence remain S2. |
| Student–student S3 | Peers depend on contributions to coordinate work; meaning is not negotiated. | Members divide sources and combine findings. | Parallel work is below S3; information exchange alone is below S4. |
| Student–student S4 | Two linked cycles extend, clarify, challenge, or negotiate ideas. | Peers question and jointly revise an interpretation. | One response/agreement remains S3 or lower. |
| Student–teacher S1 | No learner response enters the exchange. | Teacher explains while learners listen/copy. | Choral repetition or one-word reply remains S1. |
| Student–teacher S2 | Recurrent teacher initiation and evaluation. | Teacher questions; learners answer; teacher confirms/corrects. | Many answers that do not shape facilitation remain S2. |
| Student–teacher S3 | Learner input changes teacher probing, scaffolding, or sequence. | A difficulty prompts the teacher to reorganize the next step. | Acknowledgement/adaptation without reciprocal negotiation remains S3. |
| Student–teacher S4 | Reciprocal questioning/extension spans linked sequences. | Learners challenge a claim, the teacher requests warrants, and both revise their positions. | One open question followed by evaluation remains S2/S3. |
| Participation S1 | Individual or teacher-monologic organization. | Silent individual work follows teacher directions. | A brief quiet interval does not determine S1. |
| Participation S2 | Turns are centrally allocated/routed. | Several learners contribute only through the teacher. | Many voices without interdependence remain S2. |
| Participation S3 | Stable roles organize interdependent work. | Reader, recorder, and checker coordinate outputs. | A shared product without negotiated meaning remains S3. |

*Table 5. Continued*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Participation S4 | Sustained collective meaning-making uses reciprocal uptake; learner-initiated moves may contribute when they are taken up within the sustained exchange. | Different learners launch, reframe, challenge, and coordinate a jointly revised account, and each move receives uptake. | Initiative alone, or multiple speakers without linked uptake, remains below S4; learner initiation does not establish P4. |

*Interpretive boundary*: S4 identifies sustained collaborative reciprocal uptake and may include learner-initiated moves that shape the line of talk. A teacher-controlled episode can therefore be S4 and P1: conversational participation does not establish learner authority over the question, method, or resources, and the Social code does not determine whether claims are well warranted.

*Procedural Dimension*

The procedural dimension concerns who controls the structure and flow of the activity through which knowledge is pursued. Inquiry traditions distinguish teacher-prescribed pathways from increasing learner authority over questions, methods, and resources, while also emphasizing that productive autonomy can require substantial scaffolding (Banchi & Bell, 2008; Blanchard et al., 2010; Hmelo-Silver et al., 2007; Kirschner et al., 2006). Procedural openness is therefore not an all-or-nothing property and is not equivalent to epistemic sophistication.

The first indicator is ownership of the question: whether the inquiry focus is teacher-authored, jointly refined, or student-generated. The second is control of method: whether the method is prescribed, adaptable, or designed by learners. The third is use of tools and resources: whether materials, texts, and instruments are assigned and fixed in function or whether students can choose, adapt, or independently locate what they need (Banchi & Bell, 2008; Blanchard et al., 2010; Crawford, 2014). These indicators may diverge, so a coder should retain indicator-level differences rather than assume one global degree of openness.

The four descriptors adapt inquiry-level distinctions to foreground authority rather than expected-answer openness. Prescribed activity fixes the question, method, and use of resources; bounded activity retains the teacher's frame while allowing limited but observable choices; guided co-design transfers consequential authority over refinement, method, or resources; and learner-directed activity gives students substantial control over all three. Movement across descriptors represents redistribution of procedural authority, not a universal ranking of quality.

*Table 6. Indicator-Level Coding Rules for the Procedural Dimension*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Question P1 | Teacher/task fixes the question. | All groups answer the supplied question. | Wording/example choices remain P1. |
| Question P2 | Learners make a consequential choice among preset foci. | A group selects one supplied species relationship. | Preset selection is P2; question refinement is P3. |
| Question P3 | Learners formulate/refine within a teacher frame. | Students narrow a broad issue after feedback. | Teacher framing/approval prevents P4. |
| Question P4 | Learners originate and retain question authority. | They formulate and independently rescope an inquiry. | Method/resource autonomy alone does not establish question P4. |
| Method P1 | Method and sequence are fixed. | Learners follow specified steps and rules. | Expert execution remains P1. |
| Method P2 | Learners enact consequential preset variation. | They choose a sampling interval that changes evidence. | Cosmetic choice remains P1; complete preset methods remain P2. |
| Method P3 | Learners materially adapt/design with guidance. | Students revise a sampling plan after feedback. | Minor adjustment remains P2; approval prevents P4. |
| Method P4 | Learners independently design and revise method. | They detect and replace a flawed procedure. | Teacher nonintervention or learner confusion does not establish P4. |
| Resources P1 | Resources and functions are fixed. | Teacher specifies text, passage, and organizer. | Color/layout/order choices remain P1. |

*Table 6. Continued*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Resources P2 | Learners choose consequentially among supplied resources. | They select evidence cards shaping their claim. | Supplied selection is P2; adaptation/strategy is P3. |
| Resources P3 | Learners adapt/combine approved resources with guidance. | They combine source and dataset after feedback. | A fixed menu remains P2; approval prevents P4. |
| Resources P4 | Learners locate/create/evaluate resources independently. | They reject a source and create a replacement tool. | Sophisticated teacher-selected resources do not establish P4. |

*Interpretive boundary*: Apply P1–P4 separately to question, method, and tools/resources. P2 is an explicit SPEC proposal whose distinctness from P1 and P3 is unvalidated; it requires enacted consequential choice, never cosmetic freedom. The three Procedural codes are retained when they diverge.

*Epistemic Dimension*

The epistemic dimension concerns how knowledge claims are positioned: as fixed or revisable, warranted by authority or evidence, and certain or open to challenge. Epistemic-cognition and argumentation research emphasizes the public standards by which claims, evidence, alternatives, and uncertainty are examined (Chinn et al., 2011; Chinn & Malhotra, 2002; Ford, 2008; Ford & Forman, 2006; Kelly & Licona, 2018; Osborne, 2010; Osborne et al., 2004). The construct is therefore distinct from cognitive difficulty or conceptual abstraction; it addresses the status and grounds of knowing.

Three indicators represent epistemic activity. The claim-status and epistemic-agency indicator records whether claims are received from authority, explained from supplied support, justified within prescribed criteria, evaluated against alternatives, or materially revised. The evidence-use indicator records whether support is absent, supplied, applied through prescribed criteria, weighed against alternatives, or used to revise claims and models. The role-of-uncertainty indicator records whether ambiguity is suppressed, acknowledged, managed, critically examined, or used to drive further inquiry (Berland & Reiser, 2009; Manz & Suárez, 2018; Sandoval, 2005).

The five descriptors are Authority-Received, Provided Support, Evidence-Supported, Evaluative, and Evidence-Responsive Revision. At the first level, claims are accepted as settled. At the second, explanations or evidence are supplied but not independently assessed. At the third, students apply prescribed evidence or criteria. At the fourth, they compare claims, warrants, alternatives, and uncertainty. At the fifth, evidence or uncertainty produces a traceable material revision of a claim, model, or standard of evidence. These transitions concern learners' epistemic relations to claims, not a hierarchy of cognitive difficulty: supplied explanation differs from justification through public criteria; evaluative work compares grounds and alternatives; and evidence-responsive revision changes claims or standards in response to uncertainty. The distinction between evaluative judgment and evidence-responsive revision is informed by reflective-judgment and knowledge-building traditions (King & Kitchener, 2004; Scardamalia & Bereiter, 2005).

Inquiry formats, group work, and open discussion are not themselves epistemic evidence. The code depends on whether the grounds for claims are made available for examination and revision. An episode can therefore be socially collaborative but epistemically authority-received, or procedurally structured but epistemically evaluative.

*Table 7. Indicator-Level Coding Rules for the Epistemic Dimension*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Claim E1 | Claim accepted/reproduced; no ground examined. | Learners copy an authoritative explanation. | Assertion/authority alone remains E1. |
| Claim E2 | The claim is linked to a supplied ground or warrant. | A supplied rule explains the claim. | Restating support without new judgment remains E2. |
| Claim E3 | Learners use evidence or a criterion to justify the claim. | A passage is selected and linked to an interpretation. | One preset criterion does not establish E4. |
| Claim E4 | Learners evaluate claims, alternatives, warrants, or uncertainty. | Rival explanations are weighed and qualified. | Unsupported comparison or disagreement remains E3 or lower. |
| Claim E5 | Evidence or uncertainty causes a traceable material revision. | Counterevidence narrows a claim and changes its warrant. | Novelty/correction without grounded before–after change remains E4/lower. |
| Evidence E1 | Evidence is absent, opaque, or authoritative. | A conclusion is supplied without inspectable support. | A source/example without claim connection remains E1. |

*Table 7. Continued*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Evidence E2 | Evidence and relevance are supplied. | Teacher identifies the decisive datum and meaning. | Repeating the link remains E2. |
| Evidence E3 | Learners select/apply evidence through a criterion. | Measurements and threshold justify classification. | Fixed-rule use on one set remains E3. |
| Evidence E4 | Learners weigh adequacy, credibility, limits, or conflict. | Two sources' reliability is compared. | Listing both sides without evaluation remains E3. |
| Evidence E5 | Evidence evaluation changes a claim, model, or standard. | New measurements alter a causal relation. | Example addition/answer switch without reason remains below E5. |
| Uncertainty E1 | Uncertainty is suppressed/closed by authority. | Teacher ends alternatives with one answer. | Hesitation alone is not epistemic uncertainty. |
| Uncertainty E2 | Uncertainty and its management are supplied. | The teacher identifies a limitation and supplies qualifying wording. | Repeating the caveat remains E2. |
| Uncertainty E3 | Learners apply a prescribed uncertainty rule. | A confidence rule determines data adequacy. | Rule use without evaluation remains E3. |
| Uncertainty E4 | Learners compare sources, consequences, or possible resolutions. | Learners examine bias and sample size as possible sources of uncertainty. | Naming uncertainty or applying a preset remedy remains at E3 or lower. |
| Uncertainty E5 | Uncertainty drives material revision or new standard. | Learners narrow a claim and specify needed evidence. | Further inquiry without traceable revision remains below E5. |

*Interpretive boundary*: E5 is evidence-responsive revision, not creativity or novelty. If an episode permits evaluation but not revision, the revision opportunity is NE and the evidence may still warrant E4. Claim, evidence, and uncertainty codes remain separate when they diverge.

*Conceptual Dimension*

The conceptual dimension concerns the form of understanding constructed in an episode. Curriculum and conceptual-change research distinguishes isolated facts and topic labels from generalizable concepts, principles, and theoretical systems (Bruner, 1996; Erickson, 2007; Leach & Scott, 2003; Linn et al., 2004; Vosniadou, 2013). The dimension records whether ideas remain local or become increasingly abstract, connected, and transferable.

The three indicators are conceptual generality and abstraction; structural connectedness and coherence; and representational integration. The last indicator concerns meaningful translation or transformation across language, diagrams, models, graphs, or symbolic forms—not the mere presence of several representations (Ainsworth, 2006; diSessa, 2004; Kozma & Russell, 2005; Wu & Puntambekar, 2012). The indicators may diverge: terminology can be abstract while relations remain weak, or ideas can be coherent within one representation without translation across modes.

The four descriptors distinguish Local/Concrete, Topic-Bound, Principled Networks, and Theoretical Systems. The transition to principled networks requires generalizable principles and coordinated relations, while theoretical systems require cross-cutting explanatory structures. Representational integration is coded separately and is not a prerequisite for a C4 code on generality or connectedness. These descriptors characterize the organization of knowledge, not generic cognitive demand or an automatic judgment that more abstraction is appropriate in every episode.

*Table 8. Indicator-Level Coding Rules for the Conceptual Dimension*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Generality C1 | Specific facts, labels, events, or examples. | Learners identify details in one case. | A general account illustrated by one concrete example is not thereby reduced to C1. |
| Generality C2 | Stable topic concepts; no generalizable principle. | Local cases are classified by named concepts. | Concepts without organizing generalization remain C2. |
| Generality C3 | A principle/model explains or predicts beyond instances within a domain. | A feedback model explains two cases and predicts a third. | Abstract vocabulary/one-case explanation remains C2. |

*Table 8. Continued*

| Indicator and code | Observable anchor | Affirmative instance | Adjacent exclusion or boundary |
|---|---|---|---|
| Generality C4 | Multiple principles form a system across contexts or with explicit scope. | Conservation, transfer, and dissipation explain mechanical and thermal cases. | A one-domain model remains C3; representations alone do not establish C4. |
| Connectedness C1 | Ideas lack an explicit relation. | Causes are named without links to outcomes. | Proximity/sequence/conjunction is not a conceptual relation. |
| Connectedness C2 | One explicit topic-level relation. | One factor is linked directionally to another. | Separate pairwise links without coordination remain C2. |
| Connectedness C3 | A principle coordinates at least two relations. | A mechanism links conditions, process, and outcome. | Associative chain without an organizing principle remains C2. |
| Connectedness C4 | Multiple principles/relations cohere across contexts. | Two mechanisms are reconciled and applied across contexts. | Terminology/one-domain model remains C3. |
| Representation C1 | When elicited, representations remain isolated/copied; use NA if translation is irrelevant. | Graph and equation are read separately. | One relevant representation is NA, not C1. |
| Representation C2 | A local cross-representation correspondence. | A graph segment is matched to a narrated event. | Label matching without relation remains below C3. |
| Representation C3 | Translation between representations supports a generalizable principle. | Learners relate graph slope to the rate in an equation to make a prediction. | Parallel display or one-way labeling remains C2. |
| Representation C4 | Bidirectional transformation preserves system relations across contexts. | Diagram, equation, and verbal model test the same system. | Fluency without a cross-context system remains C3; other indicators are separate. |

*Interpretive boundary*: Generality and connectedness can reach C4 without multiple representations. Representational integration is coded only when a relevant translation or transformation opportunity exists; otherwise it is NA. Its code never elevates the other Conceptual indicators.

*Illustrative Application of SPEC*

The following is an illustrative hypothetical episode, not empirical validation. In a lower-secondary science lesson, the teacher supplies the question, two oxygen datasets from a sealed terrarium and a pond microcosm, and a fixed compare–explain–qualify organizer. The episode begins when the teacher releases the class for group work and ends at the explicit whole-class reconvening cue. The transcript was constructed to make the evidence-to-code chain and rejection of nearby alternatives inspectable.

This case demonstrates an analytically important configuration: high conceptual depth can coexist with low procedural authority. The teacher fixes the question, method, and resources, yet learners coordinate several principles across two contexts, evaluate evidence, and revise a causal explanation. Low Procedural codes therefore describe the allocation of authority; they do not imply poor teaching or weak thinking.

*Table 9. Hypothetical Classroom Transcript*

| Turn | Speaker | Utterance or action |
|---|---|---|
| 1 | Teacher | The question and procedure stay the same: use both supplied oxygen tables, complete the compare–explain–qualify organizer in order, and explain why oxygen changes overnight in both systems. |
| 2 | Lina | Both tables decline after darkness. My first claim is that the plants stop producing oxygen. |
| 3 | Arun | That explains no new oxygen, but not the decline. Respiration must be consuming oxygen; the fall continues all night. |
| 4 | Mei | The organizer asks us to compare intervals. The terrarium falls steadily, but the pond's decline slows near morning. |
| 5 | Lina | Then stopping photosynthesis is only part of it. Oxygen availability or organism activity may change the rate. |
| 6 | Arun | The common principle is net change: oxygen decreases when respiration consumes more than photosynthesis produces. Darkness makes production nearly zero in both systems. |
| 7 | Mei | And the system conditions explain the different rates. The balance principle transfers, but the size of each process differs between the terrarium and the pond. |
| 8 | Recording note | Audio is unavailable during the episode's only teacher–group exchange; the teacher's and learners' words cannot be recovered. |

*Table 9. Continued*

| Turn | Speaker | Utterance or action |
|---|---|---|
| 9 | Lina | Our original claim was too simple. I revise it: darkness stops photosynthetic oxygen production while respiration continues, and system conditions affect the rate. |
| 10 | Arun | That coordinates the balance principle with both processes across the two ecosystems, but the data cannot show which condition causes the pond rate to slow. |
| 11 | Mei | Record that limitation. We would need carbon-dioxide or organism-activity data to distinguish the mechanism. |
| 12 | Teacher | Please stop group work and return to the whole-class discussion. |

*Table 10. Indicator-Level Coding of the Hypothetical Episode*

| Dimension / indicator | Code / status | Observed evidence | Nearby alternative rejected |
|---|---|---|---|
| Social / student–student | S4/OE | Turns 2–7 and 9–11 contain repeated uptake, challenge, extension, and joint revision across linked cycles. | Not S3: peers negotiate and materially reshape the account rather than only coordinate work. |
| Social / student–teacher | IE | The only teacher–group exchange is missing from the audio record (turn 8). | Do not infer S2–S4 from later revision; opportunity may have existed, but evidence is inadequate. |
| Social / participation | S4/OE | Lina launches the claim, Arun reframes the cause, and Mei redirects comparison; each initiative receives uptake. | Not S3: several learners initiate or redirect the exchange, and their moves receive sustained reciprocal uptake; this remains Social evidence and does not imply P4 authority over the question, method, or resources. |
| Procedural / question | P1/NE | Turn 1 fixes the question; no opportunity to select, refine, or originate it. | Not P2: explaining across cases does not change the supplied question. NE is not learner incapacity. |
| Procedural / method | P1/NE | Turn 1 fixes both the comparison procedure and its sequence. | Learners' competent execution and reasoning do not create method authority. |
| Procedural / tools/resources | P1/NE | Both datasets and the organizer are supplied and required. | Using two sophisticated resources is not authority over their selection or function. |
| Epistemic / claim and agency | E5/OE | The initial claim in turn 2 is challenged and materially revised in turns 5 and 9, with mechanism and scope qualified. | Not E4: a traceable, evidence-responsive before-and-after change occurs. |
| Epistemic / evidence | E5/OE | Learners use temporal patterns and cross-system differences to reject a simpler claim and revise the explanation. | Not E4: evaluated evidence directly changes the claim. |
| Epistemic / uncertainty | E5/OE | Turns 5, 10, and 11 identify unresolved mechanism uncertainty, narrow the claim, and specify needed evidence. | Not E4: uncertainty drives material revision and a new evidential requirement. |
| Conceptual / generality | C4/OE | Learners coordinate net balance, photosynthesis, and respiration and apply the system across terrestrial and aquatic contexts. | Not C3: multiple principles form a coherent system explicitly transferred across substantively different contexts. |
| Conceptual / connectedness | C4/OE | The account links darkness, production, consumption, system conditions, rates, and evidential limits without contradiction. | Not C3: the coordinated system explains different cases and states its scope and limits. |
| Conceptual / representation | NA | Both sources are tables; no second representational form or translation demand is relevant. | Do not code C1: one representational form with no translation task is non-applicable, not failed integration. |

*Note*. OE = Opportunity Elicited. NE = Not Elicited. IE = Insufficient Evidence. NA = Not Applicable. Learner initiation is Social evidence within S4; it is not a separate qualifier and does not imply Procedural authority.

The non-additive indicator profile is Social (S4/OE; IE; S4/OE), Procedural (P1/NE; P1/NE; P1/NE), Epistemic (E5/OE; E5/OE; E5/OE), and Conceptual (C4/OE; C4/OE; NA). Collaborative reciprocal uptake, learner-initiated moves, evidence-responsive revision, and cross-context integration occur within a prescribed task; directive structure can support demanding thinking. IE preserves missing evidence, NE records unelicited choice without implying incapacity, and NA prevents irrelevant representation demands from becoming low codes.

## Conclusion

SPEC contributes a non-additive descriptive language for profiling coexisting pedagogical functions. It distinguishes participation, authority, knowledge practice, and conceptual organization without ranking lessons from poor to good or privileging one configuration universally.

This selective proposal requires empirical examination of its source base, boundaries, episode rules, descriptors, ordinality, and dimensional distinctiveness; no reliability or validity evidence supports evaluative use. The initial questions may have shaped the structure. Open inquiry, extensive dialogue, and abstraction are not automatically desirable; value depends on learners, content, purpose, phase, and context.

Next, trained coders should independently apply SPEC to diverse episodes, document disagreements and borderline cases, and refine the codebook before broader reliability, validity, and cross-context studies.

### *Implications for Educational Methodology*

For researchers, SPEC provides a provisional vocabulary for comparing episode profiles and developing hypotheses about how participation, authority, epistemic practice, and conceptual organization align or diverge. Such comparisons must address dimensions and purposes rather than rank lessons by a total score.

For teacher educators, SPEC may eventually support video analysis, case discussion, and reflection on trade-offs. Until validated, such use should remain reflective and descriptive rather than evaluative or prescriptive.

For classroom observers, SPEC structures dimension-specific evidence and uncertainty. Observers should retain indicator descriptions, not composite ratings, accountability judgments, or global evaluations.

Methodologically, SPEC frames broad constructs as testable questions about boundaries, indicators, dimensional relations, and profile variation. Its contribution is conceptual clarity and an operationalization agenda, not demonstrated codability, transferability, or validity.

### *Limitations and Future Validation*

The synthesis is non-exhaustive and weighted toward inquiry, discourse, and science education. The dimensions and indicators are parsimonious, not exhaustive; affect, equity and power, management, content accuracy, and outcomes are not directly assessed. Transfer across cultures, languages, disciplines, and age groups remains untested. Segmentation, mixed evidence, and boundaries require judgment. No evidence yet supports interrater reliability, construct validity, ordinal interpretation, or dimensional distinctiveness. Open inquiry, extensive dialogue, and abstraction are not invariably appropriate; value depends on learners, content, purpose, phase, and context.

Validation should begin with expert review of content validity, diverse pilot coding, classroom-episode comparisons, and codebook refinement. Independent coding should then examine adjudication, interrater reliability, transition discrimination, monotonicity, dimensional distinctiveness, and construct-validity evidence. Later studies should compare SPEC with CLASS, the Framework for Teaching, ICAP, PLATO, MQI, RTOP, and EQUIP and test it across subjects and cultural settings, ages, languages, and lesson phases. Outcomes and professional-development uses should be examined only later. Intended uses require an accumulating validity argument, not face plausibility alone (Cronbach & Meehl, 1955; Kane, 2013).

### Generative AI Statement

The author has not used generative AI or AI-supported technologies.

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