KWLH–E FOR TEACHING STATISTICS AND PROBABILITY IN PRIMARY MATHEMATICS: A FIVE-CRITERIA FRAMEWORK

Ho Anh Tuyet[3], Le Thi Hau[3], Nguyen Ngoc Quynh Nhu[3], Duong Huynh Anh Thu[3],
Vo Thi Ai Suong[3], Do Thi Thu Hang[2], Le Thanh Binh[1]
[1] Faculty of Primary and Early Childhood Education, QNU
[2] Faculty of Early Childhood and Primary Education, VNU University of Education (UEd), VNU, Hanoi
[3]Undergraduate student, Faculty of Primary and Early Childhood Education, QNU

Abstract: *The 2018 General Education Curriculum for primary mathematics in Vietnam frames statistics and probability as data-and-chance inquiry, where conclusions must be grounded in tables, charts, counts, and ratios. Using document analysis of the curriculum and the official "Kết nối tri thức với cuộc sống" Mathematics textbooks (Grades 4–5), this paper develops a five-criteria framework for evaluating instructional techniques in this strand and compares KWLH with five common approaches (Think–Pair–Share, Placemat, mind mapping, problem-based and problem-posing approaches, and the 5E model). The analysis suggests that KWLH is particularly strong in tracing conceptual change and supporting formative assessment through visible learning artifacts. The proposed framework highlights evidence alignment and traceability of learning as strand-defining requirements and clarifies boundary conditions for scalable use, including question quality, explicit evidence expectations, and workload-sensitive assessment criteria. Building on this, we propose KWLH–E, an evidence-focused adaptation that requires explicit claim–evidence links, and offer minimal rubrics for assessing investigable questions (W) and evidence alignment (L–E). Practical implications for feasible implementation in primary classrooms are discussed.*

Keywords: *KWLH–E; formative assessment; statistics and probability; primary mathematics; evidence.*

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I. INTRODUCTION

The statistics and probability strand in Vietnamese primary mathematics, as specified in the 2018 General Education Curriculum, introduces students to basic ideas of data representation and chance through activities such as collecting and recording data, reading and describing tables and charts (e.g., picture graphs, bar charts, and pie charts), and experimenting with simple random devices to count outcomes and express empirical chance via frequencies and ratios (Ministry of Education and Training [MOET], 2018). In the official 'Kết nối tri thức với cuộc sống' mathematics textbook series, these ideas are implemented through classroom tasks on bar charts and simple randomness in Grade 4 and on pie charts, data investigations, and empirical probability in Grade 5 (Khoái et al., 2023; Khoái et al., 2024).

Despite their accessibility, data-and-chance topics pose two instructional challenges that are less prominent in number and geometry strands. First, students often produce unsupported interpretations when interpreting data, unless instructional routines explicitly require numerical or representational evidence (American Statistical Association [ASA], 2020; Ben-Zvi, 2004). Second, in random experiments students may expect short-run regularity and underestimate variability; without structured reflection, they can misinterpret legitimate fluctuations across trials as errors or unfairness (Cambridge Mathematics, 2019). These challenges call for a technique that simultaneously (i) supports inquiry cycles in data and chance and (ii) generates traceable artifacts for formative assessment (Black & Wiliam, 1998).

While Vietnamese studies have discussed KWLH as a competency-oriented teaching technique in primary mathematics (Tran, 2024), there remains a need for a strand-specific rationale that positions evidence alignment as a core design requirement for statistics and probability. Addressing this gap, this paper addresses three questions: (1) What didactic demands does the 2018 curriculum impose for data-and-chance learning in primary grades? (2) In what respects does KWLH provide comparative advantages over five common active-learning techniques? (3) Can an evidence-focused variant (KWLH–E) and a minimal rubric enhance feasibility and rigor of formative assessment in primary classrooms?

II. RESEARCH CONTENT

2.1. Curricular expectations for data-and-chance learning in Vietnamese primary mathematics

MOET (2018) specifies a developmental trajectory in which students progress from simple data recording and picture graphs to tables, bar charts, and pie charts, and from qualitative chance language to empirical descriptions based on repeated trials, counting, and frequency ratios. This trajectory foregrounds an inquiry logic: posing questions, generating or organizing data, representing data, and drawing evidence-based conclusions. International guidance in statistics education similarly emphasizes reasoning with data, attention to variability, and explicit links between claims and evidence (ASA, 2020; Ben-Zvi, 2004).

2.2. KWL/KWLH as a metacognitive scaffold and formative assessment artifact

The K-W-L model (Ogle, 1986) was designed to activate prior knowledge (K), establish learning goals/questions (W), and consolidate new learning (L). The extension to KWLH adds a reflective and forward-looking component (H: how to learn more), which can be interpreted as a lightweight metacognitive scaffold that turns learning progress into a visible record. Such records are highly compatible with formative assessment principles, where feedback loops depend on evidence of students' current thinking (Black & Wiliam, 1998; National Council of Teachers of Mathematics [NCTM], n.d.). In Vietnamese primary mathematics, KWLH has been framed as supporting competency development through active engagement and self-reflection (Tran, 2024).

2.3. From KWLH to evidence alignment: rationale for KWLH–E

A limitation of generic KWLH implementation is that students' L statements may remain descriptive or intuitive unless instructional expectations require explicit evidence. In science education, KLEW/KLEWS-type organizers integrate an Evidence component to connect claims to data and support inquiry-based explanation (National Science Teaching Association [NSTA], 2006). Translating this principle to statistics and probability is theoretically warranted because the strand's epistemic norm is precisely that conclusions must be grounded in data representations, counts, and ratios (ASA, 2020). This paper therefore proposes KWLH–E as a strand-specific adaptation that strengthens the claim–evidence link while retaining the feasibility of a single-lesson organizer. Evidence-augmented KWL variants (e.g., KLEW/KLEWS) have been documented in science education; our contribution is to articulate an evidence-centered adaptation that retains the H (how to learn more) component and is theoretically aligned with the epistemic demands of statistics and probability in primary mathematics (NSTA, 2006).

2.4. Materials and methods

This study adopts a qualitative document-analysis design. Primary sources include: (i) the 2018 General Education Curriculum for Mathematics (Ministry of Education and Training [MOET], 2018), focusing on learning requirements in the statistics and probability strand for primary grades; and (ii) the official 'Kết nối tri thức với cuộc sống' Mathematics textbooks for Grades 4 and 5, used to illustrate strand alignment and classroom-level task characteristics (Khoái et al., 2023; Khoái et al., 2024). Secondary sources provide theoretical grounding for evidence-based statistics education and formative assessment (American Statistical Association [ASA], 2020; Black & Wiliam, 1998).

Analytically, we proceeded in three steps. First, we operationalized the curriculum's didactic demands into two inquiry cycles: a data investigation cycle (question–data generation/organization–representation–interpretation–generalization) and a random experiment cycle (prediction–repeated trials–counting–frequency/ratio–reflection on variability) (MOET, 2018). Second, we developed five criteria (C1–C5) tailored to data-and-chance learning to evaluate instructional techniques: coverage of inquiry cycles, evidence alignment, traceability of conceptual change, support for formative assessment and differentiation, and classroom feasibility. Third, we conducted a theory-driven comparison between KWLH and five widely used techniques in primary classrooms: Think–Pair–Share, Placemat, mind mapping, problem-based and problem-posing approaches, and the 5E model, leading to the proposed KWLH–E variant and minimal rubrics.

2.5. RESULTS AND DISCUSSION

2.5.1. The C1–C5 criteria framework for statistics–probability instruction in primary grades

C1 (Inquiry-cycle coverage) evaluates whether a technique supports a coherent trajectory from prior knowledge to investigable questions, data manipulation or experimentation, and interpretation consistent with the curriculum's data-and-chance progression (MOET, 2018). C2 (Evidence alignment) captures the extent to which claims are structurally tied to numerical/representational evidence (tables, charts, counts, ratios) (ASA, 2020). C3 (Traceability of conceptual change) assesses whether the technique makes shifts from initial beliefs to evidence-informed conclusions visible, which is essential under randomness and variability (Ben-Zvi, 2004). C4 (Formative assessment and differentiation) concerns whether the produced artifacts provide actionable assessment information and allow differentiated participation. C5 (Feasibility) addresses time, classroom management, and material demands in typical primary settings (Tran, 2024).

2.5.2. Comparative matrix: KWLH versus five instructional techniques

Table 1. Comparative matrix across C1–C5 criteria

Criterion	KWLH	Think–Pair–Share	Placemat	Mind mapping	Problem-based/ posing	5E model
C1: Inquiry-cycle coverage	H	M	M	L	M	H
C2: Evidence alignment	H	M	M	L	M	H
C3: Traceability of conceptual change	H	L	M	L	M	M–H
C4: Formative assessment & differentiation	H	M	M	M	M	H
C5: Feasibility in primary classrooms	H	H	M	H	M	L–M

Table 1 summarizes the comparative analysis across C1–C5 for KWLH and five widely used instructional techniques: Think–Pair–Share (Lyman, 1987), Placemat (Collaborative for Teaching and Learning, n.d.), Mind mapping/concept mapping (Novak & Gowin, 1984), Problem-based learning/ problem posing (Hmelo-Silver, 2004; Silver, 1994), and the 5E model (Bybee et al., 2006). Ratings are interpretive: High (H), Medium (M), and Low (L).

Note. H = High; M = Medium; L = Low. The matrix reflects theory-driven interpretation based on strand-specific requirements for data and chance learning (MOET, 2018; ASA, 2020).

2.5.3. Mechanisms, implications, and boundary conditions

The matrix indicates that KWLH receives consistently high ratings on the two strand-defining criteria: C1 (inquiry-cycle coverage) and C3 (traceability of conceptual change). Mechanistically, KWLH externalizes prior knowledge and beliefs (K), converts learning gaps into investigable questions (W), and consolidates evidence-informed learning (L), thereby producing a 'before–after' trace that can be examined and discussed. This traceability is especially valuable in random experiments where legitimate variability can conflict with students' short-run expectations (Cambridge Mathematics, 2019).

Pedagogically, the KWLH artifact functions as a low-burden formative assessment instrument: K and W support diagnostic assessment and instructional targeting, L provides evidence of current understanding, and H enables extension and self-directed inquiry. This aligns with formative assessment theory emphasizing frequent feedback based on evidence of students' thinking (Black & Wiliam, 1998). Importantly, the comparative advantage is not that KWLH replaces interaction-focused techniques (e.g., Think–Pair–Share) or inquiry models (5E), but that it standardizes student thinking into observable records that can wrap around and strengthen these approaches.

Several boundary conditions warrant attention. First, the quality of W questions determines the depth of inquiry; poorly specified questions can reduce KWLH to a superficial routine. Second, without explicit requirements for evidence, L statements may remain intuitive or narrative rather than data-grounded. Third, scalable implementation requires minimal yet reliable assessment criteria to avoid undue workload for teachers. These boundary conditions motivate the KWLH–E variant and the minimal rubrics proposed below.

2.5.4. KWLH–E (Evidence): a strand-specific adaptation for statistics and probability

To strengthen C2 (evidence alignment) without increasing lesson phases, we propose KWLH–E, where an explicit Evidence component is attached to each L statement (or added as a parallel column). Conceptually, this mirrors KLEW/KLEWS-type organizers developed to foreground the claim–evidence relationship in inquiry (NSTA, 2006). In statistics, E is instantiated as specific numbers, proportions, or chart features that justify a claim. In empirical probability, E is instantiated as count tables and frequency ratios across increasing numbers of trials. KWLH–E therefore operationalizes the epistemic norm that conclusions in data-and-chance contexts must be supported by data.

Within the 'Kết nối tri thức với cuộc sống' progression, KWLH–E is feasible for Grade 4 lessons on bar charts and simple events, and for Grade 5 lessons on pie charts, data investigations, and repeated-trial experiments (Khoái et al., 2023; Khoái et al., 2024). In these settings, E provides a concrete basis for discussing variability, comparing groups, and revising initial beliefs (K) based on empirical patterns (L+E).

Two emblematic examples illustrate concise textbook alignment. First, in Grade 4, the lesson on bar-chart interpretation supports moving from initial interpretations (K) and investigable comparison questions (W) to evidence-referenced claims (L+E) that explicitly cite bar heights or table entries (Khoái et al., 2023). Second, in Grade 5, the lesson sequence introducing empirical chance through repeated random trials can be structured so that predictions (K/W) and conclusions about likelihood or stability are justified with counts and frequency ratios (E) across trials (Khoái et al., 2024).

2.5.5. Minimal rubrics for W and L–E to support light-but-rigorous formative assessment

A. W rubric: Quality of investigable questions (0–3)

0: W is missing, off-task, or unrelated to a data/chance inquiry.

1: W is related but vague (unclear object or comparison/criterion).

2: W is focused with a clear object and criterion, but lacks an implied way to test or check.

3: W is investigable: it specifies the object, criterion, and a plausible way to check (data collection, chart reading, or trial design) appropriate to grade level.

B. L–E rubric: Strength of claim–evidence linkage (0–3)

0: L is unsupported; E is missing or irrelevant.

1: L is partially correct; E is generic and does not point to specific data/features (numbers, bars/slices, counts, ratios).

2: L answers W; E includes at least one concrete piece of evidence, but the linkage is incomplete or lacks comparison/generalization.

3: L directly answers W with a brief justification; E is sufficient and accurate, supporting comparison or generalization (e.g., more trials lead to more stable frequency ratios).

2.5.6. Implementation implications aligned with the textbook sequence

Two practical implications follow from the above framework. First, teachers can position KWLH–E as a ‘metacognitive wrapper’ around interactive routines: for instance, Think–Pair–Share can be used to refine W questions and to debate L statements, while the KWLH–E sheet preserves before–after traces and evidence. Second, in lessons that involve random experiments, teachers can explicitly compare E across groups and trial counts to surface variability and discuss why short-run outcomes differ while long-run frequencies may stabilize. This supports the curriculum’s expectation that students interpret and report results from repeated trials through counting and ratios (MOET, 2018).

III. CONCLUSION

This paper advances a strand-specific rationale for using KWLH in the teaching of statistics and probability in primary mathematics under the 2018 curriculum. Rather than treating KWLH as a generic active-learning routine, the analysis reconceptualizes it as a content-sensitive metacognitive scaffold for data-and-chance learning, where evidence alignment and traceability of conceptual change are central instructional requirements. Within this frame, the proposed C1–C5 framework clarifies the criteria by which teaching techniques can be judged in this strand, while the comparative matrix identifies the particular value of KWLH in making students’ prior beliefs, emerging questions, and evidence-based learning visible. The strand-specific adaptation KWLH–E extends this contribution by offering a practical way to strengthen claim–evidence linkage without overburdening lesson design, thereby connecting theoretical coherence with classroom feasibility.

At the same time, the study remains conceptual and is based primarily on document analysis rather than classroom intervention data. Future research should therefore test KWLH–E through design-based and quasi-experimental studies to examine its effects on students' data reasoning, understanding of variability, and evidence-based explanation, as well as its practicality for teachers under typical primary classroom conditions. Such work would help determine whether the framework can serve not only as an interpretive model for this article, but also as a robust design resource for teaching practice and teacher education.

REFERENCES

American Statistical Association. (2020). *Pre-K–12 guidelines for assessment and instruction in statistics education II (GAISE II): A framework for statistics and data science education [Report]. https://www.amstat.org/education/gaise*

Ben-Zvi, D. (2004). *Reasoning about variability in comparing distributions. Statistics Education Research Journal, 3(2), 42–63. https://www.stat.auckland.ac.nz/~iase/serj/SERJ3%282%29_BenZvi.pdf*

Black, P., & Wiliam, D. (1998). *Assessment and classroom learning. Assessment in Education: Principles, Policy & Practice, 5(1), 7–74. https://doi.org/10.1080/0969595980050102*

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins, effectiveness, and applications [Report]. https://media.bscs.org/bscsmw/5es/bscs_5e_executive_summary.pdf*

Cambridge Mathematics. (2019). *Early concepts of probability (Espresso No. 37) [PDF]. https://www.cambridgemaths.org/Images/espresso_37_early_concepts_of_probability.pdf*

Collaborative for Teaching and Learning. (n.d.). *Placemat. https://ctlonline.org/placemat-2/*

Hmelo-Silver, C. E. (2004). *Problem-based learning: What and how do students learn? Educational Psychology Review, 16, 235–266. https://doi.org/10.1023/B:EDPR.0000034022.16470.f3*

Khoái, H. H., Vinh, L. A., Áng, N., Dương, V. V., Hải, N. M., Hường, H. Q., & Mạnh, B. B. (2023). *Mathematics 4: Kết nối tri thức với cuộc sống [Textbook]. Vietnam Education Publishing House.*

Khoái, H. H., Vinh, L. A., Áng, N., Dương, V. V., Hải, N. M., Hường, H. Q., & Mạnh, B. B. (2024). Mathematics 5: Kết nối tri thức với cuộc sống [Textbook]. Vietnam Education Publishing House.

Lyman, F. (1987). *Think–Pair–Share: An expanding teaching technique. MAA-CIE Cooperative News, 1, 1–2. https://serc.carleton.edu/resources/1313.html*

Ministry of Education and Training. (2018). *General education curriculum: Mathematics [Curriculum]. (Issued with Circular No. 32/2018/TT-BGDĐT, December 26, 2018). https://qnu.edu.vn/Resources/Docs/SubDomain/ksp/3.%20CT_Toan.pdf*

National Council of Teachers of Mathematics. (n.d.). *Some formative assessment classroom techniques [PDF]. https://www.nctm.org/uploadedFiles/Conferences_and_Professional_Development/Annual_Meeting_and_Exposition/03Mathematics%20Formative%20Assessment%20Techniques.pdf*

National Science Teaching Association. (2006). *Evidence helps the KWL get a KLEW. Science and Children. https://www.nsta.org/journals/science-and-children/science-and-children-february-2006/methods-and-strategies-evidence*

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn. Cambridge University Press.*

Ogle, D. M. (1986). *K-W-L: A teaching model that develops active reading of expository text. The Reading Teacher, 39(6), 564–570. https://eric.ed.gov/?id=EJ329558*

Silver, E. A. (1994). *On mathematical problem posing. For the Learning of Mathematics, 14(1), 19–28. https://flm-journal.org/Articles/2A5D152778141F58C1966ED8673C15.pdf*

Tran, L. T. (2024). *Using the KWLH technique in teaching mathematics in primary school toward competency development. Psychology–Education Journal, 30(05), 20–25. https://tamlygiaoduc.com.vn/wp-content/uploads/2024/06/20-25.pdf*