Supplementary File S1

Item-Level Results of the Formative Expert Evaluation (Content Validity Ratios)

Section SA. Purpose and Relation to the Main Text

This supplementary resource reports the item-level results of the formative expert evaluation summarized in Section 5.5 of the main text. The evaluation procedure, panel composition, instrument structure, and decision criterion are described in Section 4.5; this resource provides the full wording of the ten review items together with the content validity ratio (CVR) and the resulting decision for each item. All values are reproduced from the documented materials of the original doctoral design and development study (Park, 2026; instrument in Table III-2, p. 101; results in Table IV-3, pp. 127–128).

Section SB. Instrument and Panel

Ten experts participated in the evaluation of the draft model (Park, 2026, Table III-1, p. 100). All panelists held doctoral degrees; nine were university professors in computer education, informatics education, software education, or artificial intelligence education, and one was an elementary school vice principal. Eight of the ten had ten or more years of professional experience in education and research. The review instrument comprised ten items in two blocks: five items on model characteristics (two on validity and one each on usefulness, universality, and clarity of expression) and five items on phase-specific activity content (one per phase and one on the logical coherence of the procedure). Each item was rated on a five-point Likert scale, and open-ended comments were collected alongside the ratings. The items were administered in Korean; the English wording in Table S1 is the authors' translation, and the original Korean wording is documented in the dissertation.

Section SC. CVR Computation and Decision Criterion

For each item, ratings of 4 and 5 on the five-point scale were dichotomized as endorsements of adequacy, and the CVR was computed following Lawshe (1975) as $CVR = (ne - N/2) / (N/2)$, where ne is the number of panelists endorsing the item and N is the panel size. Items with $CVR \geq 0.62$ were judged to show adequate content validity; Lawshe (1975) reported 0.62 as the critical value for a ten-member panel. Because the attainable CVR values for $N = 10$ occur in increments of 0.20, meeting this criterion operationally required endorsement by at least nine of the ten panelists ($CVR = 0.80$), and the exact binomial approach reported by Ayre and Scally (2014) yields the same minimum number of endorsements. Items below the criterion were not treated as grounds for removing framework elements; they informed the direction of revision, as reported in Section 5.5 of the main text.

Section SD. Item-Level Results

Table S1. Review Items, Content Validity Ratios, and Decisions for the Draft Instructional Model (N = 10)

Area	No.	Item	CVR	Decision
Model characteristics	1	This instructional model can contribute to the development of learners' algorithmic thinking.	1.00	Met
	2	This instructional model appropriately includes the elements required for instruction aimed at developing algorithmic thinking.	1.00	Met
	3	This instructional model can be applied effectively to algorithmic thinking education in diverse instructional contexts.	1.00	Met
	4	This instructional model can be used universally in instruction for improving algorithmic thinking across learning contexts.	1.00	Met
	5	This instructional model presents an approach to algorithm instruction centered on algorithmic complexity in a readily understandable way.	0.60	Review required
Phase-specific activities	6	Phase 1, Recognizing Problems in Context, and its activity content are appropriate.	1.00	Met
	7	Phase 2, Exploring Analytical Solution Strategies, and its activity content are appropriate.	0.80	Met

	8	Phase 3, Implementing Condition-Responsive Procedures, and its activity content are appropriate.	1.00	Met
	9	Phase 4, Reflective Evaluation and Optimization, and its activity content are appropriate.	0.80	Met
	10	The procedures and phases of the instructional model are logically coherent.	1.00	Met

Note. CVR = content validity ratio. The decision criterion was CVR ≥ 0.62 for a ten-member panel (Lawshe, 1975; see also Ayre & Scally, 2014). Items were administered in Korean; English wording is the authors' translation. Phase names follow the four-phase model reported in the main text. Source: Park (2026), Tables III-2 (p. 101) and IV-3 (pp. 127–128).

Nine of the ten items met the criterion: seven items obtained CVR 1.00 and two items (Items 7 and 9, on the Phase 2 and Phase 4 activities) obtained CVR 0.80. The only item below the criterion was Item 5 (CVR = 0.60), concerning the clarity with which the model presents the approach to algorithm instruction centered on algorithmic complexity. Consistent with the interpretation documented in the original study (Park, 2026, p. 128), this result was read not as indicating that the theoretical direction or the phase structure of the model was inappropriate, but as indicating the need to present more clearly how concepts such as algorithmic complexity, efficiency comparison, and optimization inquiry are realized as learner-level activities. The corresponding revisions are reported in Section 5.5 of the main text. The revised model was not re-evaluated; the reported refinement should therefore be interpreted as formative revision aimed at improving clarity of expression and appropriateness for the learners' level, rather than as evidence that the identified issue had been eliminated.

References

Ayre, C.; Scally, A.J. Critical values for Lawshe's content validity ratio: Revisiting the original methods of calculation. Meas. Eval. Couns. Dev. 2014, 47, 79–86. https://doi.org/10.1177/0748175613513808

Lawshe, C.H. A quantitative approach to content validity. Pers. Psychol. 1975, 28, 563–575. https://doi.org/10.1111/j.1744-6570.1975.tb01393.x

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