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Research Article

# Conceptualizing Deep-Inquiry Through Mindful, Meaningful, and Joyful Learning: An Exploratory Study of Elementary School Teachers' Perceptions

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|---|---|---|---|

**Abstract**

This exploratory study examines elementary teachers' perceptions of Deep-Inquiry and Mindful, Meaningful, and Joyful (MMJ) Learning and uses their associations to inform an initial instructional framework. A cross-sectional survey involved 200 elementary teachers from six administrative areas in Lampung, Indonesia. The 63-item instrument measured seven Deep-Inquiry dimensions and three MMJ components; responses were examined descriptively and through Pearson correlations. Overall mean scores were 4.09 for Deep-Inquiry and 4.12 for MMJ Learning. Investigation and Digital Literacy ($M = 4.35$) and Open Collaboration and Discussion ($M = 4.33$) exceeded Initiation and Curiosity ($M = 3.88$) and Connection and Categorization ($M = 3.86$). The two overall constructs were positively associated ($r = 0.603$, $p < 0.001$). The findings inform a provisional integration of contextual, metacognitive, and affective supports for inquiry. They do not establish instructional effectiveness, student outcomes, or causal relationships.

**Keywords:** Deep Inquiry; Mindful Learning; Meaningful Learning; Joyful Learning.

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## INTRODUCTION

Inquiry-oriented learning is central to developing questioning, evidence evaluation, conceptual understanding, and metacognitive awareness in primary education [1], [2]. Yet, research on curriculum materials and classroom activities in Indonesia indicates that opportunities for complex reasoning can be uneven, especially where instruction prioritizes routine procedures over explanation and exploration [3], [4], [5]. A related body of inquiry scholarship suggests that active participation alone does not guarantee substantive learning: how learners are guided to pose questions, evaluate evidence, and construct explanations matters [6], [7]. The growing emphasis on digital literacy and equitable assessment adds another challenge for teachers, who must design activities accessible to students with different backgrounds and learning needs [8], [9], [10], [11].

These challenges are not exclusively cognitive. Inquiry lessons require sustained attention, motivation, social participation, and the capacity to monitor one's own thinking. Reviews of higher-order reasoning and educational environments highlight the interaction between instructional tasks, teacher workload, learning opportunities, and student support [12], [13], [14], [15], [16], [17], [18]. Evidence from science, technology, and inquiry education further indicates that implementation is shaped by instructional design, available resources, and the quality of guidance provided to learners [19], [20], [21], [22], [23], [24], [25]. Consequently, an instructional account based only on the sequence of inquiry activities may overlook the conditions needed for different learners to take part meaningfully.

Mindful, Meaningful, and Joyful (MMJ) Learning provides a useful conceptual vocabulary for articulating some of these conditions. Here, mindful learning refers to awareness, attentional regulation, and reflective monitoring; meaningful learning concerns relationships among prior knowledge, classroom tasks, and authentic contexts; and joyful learning concerns affective safety, interest, and constructive participation. Research on metacognition, school mindfulness, positive psychology, and social-emotional learning offers reasons to study these dimensions alongside classroom inquiry [26], [27], [28], [29], [30]. Meanwhile, investigations of teacher scaffolding, open inquiry, collaborative learning, and learners' agency underscore that favorable learning environments need to be connected to demanding intellectual work rather than treated as substitutes for it [31], [32], [33], [34], [35], [36], [37].

The relationship between inquiry processes and psychosocial learning conditions is important for educational inclusion. Classrooms differ in access to materials, opportunities to participate, available forms of guidance, and students' willingness to express uncertainty. The literature on learning environments and engagement suggests that instructional design should attend to these differences, but does not establish that enjoyment, mindfulness, or contextualization automatically produces better inquiry outcomes [38], [39], [40], [41], [42]. Teachers' accounts can contribute context-sensitive insights into the perceived relevance of such practices, even though self-report measures cannot substitute for direct observation of classrooms or student learning [43], [44], [45], [46].

Against this background, the present study examines the reported characteristics of Deep-Inquiry and MMJ Learning among elementary teachers in Lampung Province and evaluates the associations between their respective dimensions. It contributes a preliminary,

empirically informed conceptual architecture in which meaningful learning anchors inquiry in relevant contexts, mindful learning supports reflective regulation, and joyful learning describes enabling affective and participatory conditions. The inquiry is situated in the Define and Design stages of a development process; it does not claim to validate a teaching model, demonstrate gender-specific outcomes, or establish improved student wellbeing. The contribution is therefore a transparent account of teachers' perceptions and the design questions they raise for more inclusive and supportive inquiry learning.

## METHODS

### *Research Design*

This study employed a cross-sectional correlational survey within the Define and Design phases of the 4D Research and Development (R&D) framework. During the Define phase, a literature review and preliminary needs analysis identified instructional requirements related to inquiry learning, digital literacy, and students cognitive, affective, and metacognitive development. These findings informed construct identification and the initial conceptual framework. During the Design phase, the constructs were operationalized into a questionnaire administered to 200 elementary school teachers across six administrative areas in Lampung Province, Indonesia. Descriptive statistics and Pearson's correlation were used to analyze teachers' perceptions and relationships among the measured dimensions. The survey findings were subsequently synthesized with the literature review to inform the preliminary conceptual framework integrating Deep-Inquiry and Mindful, Meaningful, and Joyful (MMJ) Learning. The study was exploratory and non-interventional; therefore, it did not establish causal relationships or evaluate instructional effectiveness. Further development, expert validation, practicality testing, and effectiveness evaluation are reserved for subsequent R&D phases.

### *Participants and Sampling*

This study involved 200 active elementary school teachers selected through non-probability purposive sampling from six administrative areas in Lampung Province, Indonesia: Bandar Lampung, North Lampung, Tulang Bawang, Tanggamus, Pesawaran, and Way Kanan. Participants were eligible if they were actively teaching and had experience in curriculum implementation, technology-mediated learning, and academic assessment. Data were collected through questionnaires distributed in person at schools and online via Google Forms. The sample of 200 teachers was intended to support exploratory descriptive-correlational analyses of teachers' perceptions across the selected study areas.

### *Operational Definitions of Variables*

This study examined two variables: Deep-Inquiry Strategies and Mindful, Meaningful, and Joyful (MMJ) Learning. Deep-Inquiry comprised seven dimensions covering inquiry processes, digital literacy, critical thinking, collaboration, metacognition, and knowledge transfer, informed by literature on inquiry-based learning [21], [22], [23], higher-order thinking [12], digital learning [16], and metacognition [1], [26]. MMJ Learning comprised Meaningful, Mindful, and Joyful Learning, drawing on research on mindfulness [27], socio-emotional

learning [29], and positive emotions and engagement [40], [41]. The theoretical foundations, indicators, and sample items are provided in the Supplementary Material.

The questionnaire contained 63 items developed in Indonesian: 21 for Deep-Inquiry and 42 for MMJ Learning. Items used a five-point Likert scale with agreement or frequency response options, as appropriate. Experts reviewed the instrument for content relevance, clarity, and dimensional alignment before administration to 200 elementary school teachers in Lampung Province. Translation and back-translation were unnecessary because the instrument was developed directly in Indonesian. Deep-Inquiry represented students' inquiry processes as reported by teachers, whereas MMJ Learning represented teachers' instructional practices. The variables were analyzed separately to examine their relationships without implying causality.

### *Hypotheses Development*

Deep-Inquiry integrates questioning, investigation, evidence analysis, collaboration, and metacognitive reflection as interconnected processes of knowledge construction [22], [23]. These processes provide a theoretical basis for examining the relationship between Deep-Inquiry Strategy and Mindful, Meaningful, and Joyful (MMJ) Learning. Previous studies have addressed metacognition in learning [24], [26], positive psychology and well-being in educational settings [28], and the role of positive emotions and active, playful learning in student engagement [40], [41]. Collectively, these perspectives provide a conceptual rationale for investigating the associations between Deep-Inquiry Strategy and the three dimensions of MMJ Learning. Based on this theoretical rationale, the following hypotheses were formulated:

H1: Deep-Inquiry Strategy is positively correlated with Mindful Learning.

H2: Deep-Inquiry Strategy is positively correlated with Meaningful Learning.

H3: Deep-Inquiry Strategy is positively correlated with Joyful Learning.

These hypotheses concern associations among teacher-reported constructs and are not intended to establish causal relationships or demonstrate instructional effectiveness. Their examination contributes to the preliminary conceptualization of an MMJ-oriented Deep-Inquiry framework within the Define and Design phases of the 4D Research and Development (R&D) process.

### *Data Collection Procedure*

Data were collected between May and June 2024 through paper questionnaires and Google Forms. Paper responses were entered into a common dataset and reportedly checked against the original forms. The source manuscript states that duplicate and inattentive records were screened, that missing values were not imputed, and that no meaningful mode differences were observed before combining formats. However, the number of screened or excluded responses and the corresponding mode-comparison statistics are unavailable in the supplied report. These procedural details should be verified against field records before publication.

### *Data Analysis*

Data analysis began with screening for completeness, missing values, outliers, and potential violations of normality and linearity assumptions. Composite scores for each dimension were

calculated as the mean of the corresponding item scores after checking scoring direction. Descriptive statistics, including means, standard deviations, and percentages, were used to summarize teachers' reported practices. Internal consistency was assessed using Cronbach's alpha. Pearson's product–moment correlation was used consistently to examine associations between Deep-Inquiry dimensions and the Mindful, Meaningful, and Joyful (MMJ) Learning components. Given the exploratory, cross-sectional design, the correlations were interpreted as associations rather than evidence of causal relationships.

The correlation patterns were interpreted alongside the relevant literature to inform the preliminary conceptual framework. The observed associations provided empirical indications of potential conceptual alignment between Deep-Inquiry dimensions and MMJ Learning components, while the literature informed the interpretation of their proposed roles. Accordingly, Meaningful Learning was conceptualized as a contextual anchor, Mindful Learning as a metacognitive-regulatory condition, and Joyful Learning as an affective-social condition supporting inquiry. These roles are theory-informed conceptual interpretations of the exploratory findings, not evidence of causal relationships or instructional effectiveness.

## RESULTS AND DISCUSSION

### *Results*

The results summarize instrument reliability, teachers' reported practices, associations among constructs, and the empirical basis for the preliminary conceptual framework.

#### *Assessment of Instrument Quality*

Instrument quality was assessed through the reported indicator loadings and internal-consistency coefficients. As the manuscript does not document the estimation procedure for indicator loadings or composite reliability, these figures are reported descriptively rather than treated as definitive evidence of factorial validity.

**Table 1.** Reliability and Internal Consistency Estimates

| Construct | Indicator Loading Range | Cronbach's Alpha | Composite Reliability |
|---|---|---|---|
| Deep-Inquiry Strategy | 0.51–0.85 | 0.960 | 0.960 |
| MMJ Learning Principles | 0.73–0.89 | 0.973 | 0.970 |

As presented in Table 1, both instruments demonstrated very high internal consistency. The Deep-Inquiry Strategy scale yielded a Cronbach's alpha of 0.960 and composite reliability of 0.960, with indicator loadings ranging from 0.51 to 0.85. Similarly, the MMJ Learning Principles scale demonstrated a Cronbach's alpha of 0.973 and composite reliability of 0.970, with indicator loadings ranging from 0.73 to 0.89. All reliability values far exceeded the recommended benchmark of 0.70, supporting high internal consistency in this sample; additional validity evidence is needed before confirming construct structure.

*Descriptive Analysis of Teachers' Perceptions*

Descriptive statistics for the seven Deep-Inquiry dimensions and the three MMJ Learning components are summarized together in Table 2. Overall construct scores are included for context. The table reports the means and standard deviations available in the current manuscript; three dimension-level means and standard deviations are unavailable in the supplied manuscript and are therefore marked as not reported.

**Table 2.** Descriptive Statistics for Deep-Inquiry and MMJ Learning

| Construct / dimension | Mean (M) | Standard deviation (SD) |
|---|---|---|
| Deep-Inquiry (overall) | 4.09 | 0.79 |
| 1. Initiation and Curiosity | 3.88 | 0.71 |
| 2. Investigation and Digital Literacy | 4.35 | 0.71 |
| 3. Connection and Categorization | 3.86 | 0.77 |
| 4. Critical Thinking and Analysis | NR* | NR* |
| 5. Open Collaboration and Discussion | 4.33 | 1.00 |
| 6. Metacognitive Reflection | NR* | NR* |
| 7. Transformation and Projection | NR* | NR* |
| MMJ Learning (overall) | 4.12 | 0.54 |
| Meaningful Learning | 4.09 | 0.56 |
| Mindful Learning | 4.10 | 0.58 |
| Joyful Learning | 4.20 | 0.58 |

Among the reported Deep-Inquiry dimensions, Investigation and Digital Literacy had the highest mean (M = 4.35, SD = 0.71), followed by Open Collaboration and Discussion (M = 4.33, SD = 1.00). Initiation and Curiosity (M = 3.88, SD = 0.71) and Connection and Categorization (M = 3.86, SD = 0.77) had comparatively lower means. For MMJ Learning, Joyful Learning had the highest mean (M = 4.20, SD = 0.58), followed by Mindful Learning (M = 4.10, SD = 0.58) and Meaningful Learning (M = 4.09, SD = 0.56). These values describe teachers' reported perceptions and do not independently establish implementation quality or instructional effectiveness.

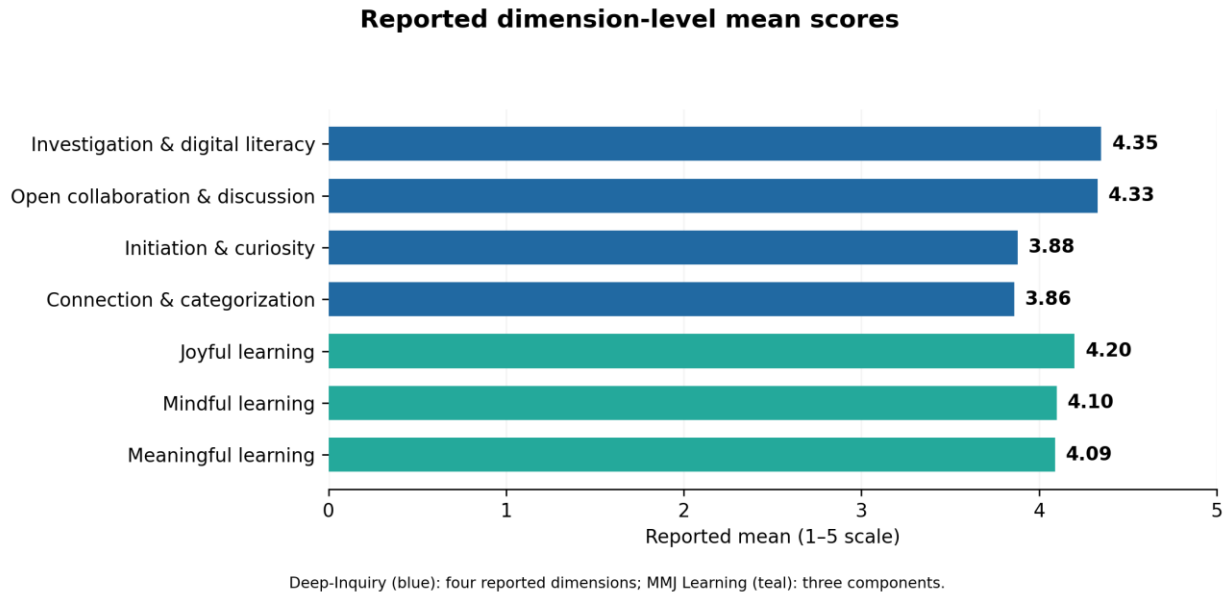


**Figure 1.** Reported dimension means (descriptive visual; unreported dimensions omitted)

### *Correlation Analysis*

Pearson's product–moment correlation analysis identified a statistically significant positive relationship between the overall Deep-Inquiry and MMJ Learning scores ($r = 0.603$, $p < 0.001$). This result indicates that higher reported levels of Deep-Inquiry practices tended to be associated with higher reported integration of MMJ Learning. The association is correlational and does not establish a causal effect. Correlations between the seven Deep-Inquiry dimensions and the three MMJ Learning components are presented in Table 3.

**Table 3.** Correlations Between Deep-Inquiry Dimensions and MMJ Learning Components

| Deep-Inquiry Dimension | Meaningful Learning (r) | Mindful Learning (r) | Joyful Learning (r) |
|---|---|---|---|
| Initiation and Curiosity | 0.570 | 0.487 | 0.536 |
| Investigation and Digital Literacy | 0.371 | 0.300 | 0.402 |
| Connection and Categorization | 0.553 | 0.523 | 0.529 |
| Critical Thinking and Analysis | 0.568 | 0.474 | 0.550 |
| Open Collaboration and Discussion | 0.499 | 0.381 | 0.454 |
| Metacognitive Reflection | 0.540 | 0.486 | 0.525 |
| Transformation and Projection | 0.602 | 0.554 | 0.546 |

As shown in Table 3, all reported coefficients were positive, ranging from $r = 0.300$ to 0.602. Transformation and Projection demonstrated the strongest correlations with Meaningful Learning ($r = 0.602$), Mindful Learning ($r = 0.554$), and Joyful Learning ($r = 0.546$). Investigation and Digital Literacy showed comparatively weaker correlations, ranging from $r = 0.300$ to 0.402. These patterns indicate variation in the strength of the reported associations across dimensions and MMJ components. Because dimension-level significance tests are not reported in the table, the coefficients are interpreted descriptively rather than as evidence that differences between correlations are statistically significant. The positive coefficients provide

preliminary empirical indications of conceptual relatedness between Deep-Inquiry and MMJ Learning, but they do not demonstrate causality, teacher readiness, implementation success, or instructional effectiveness.

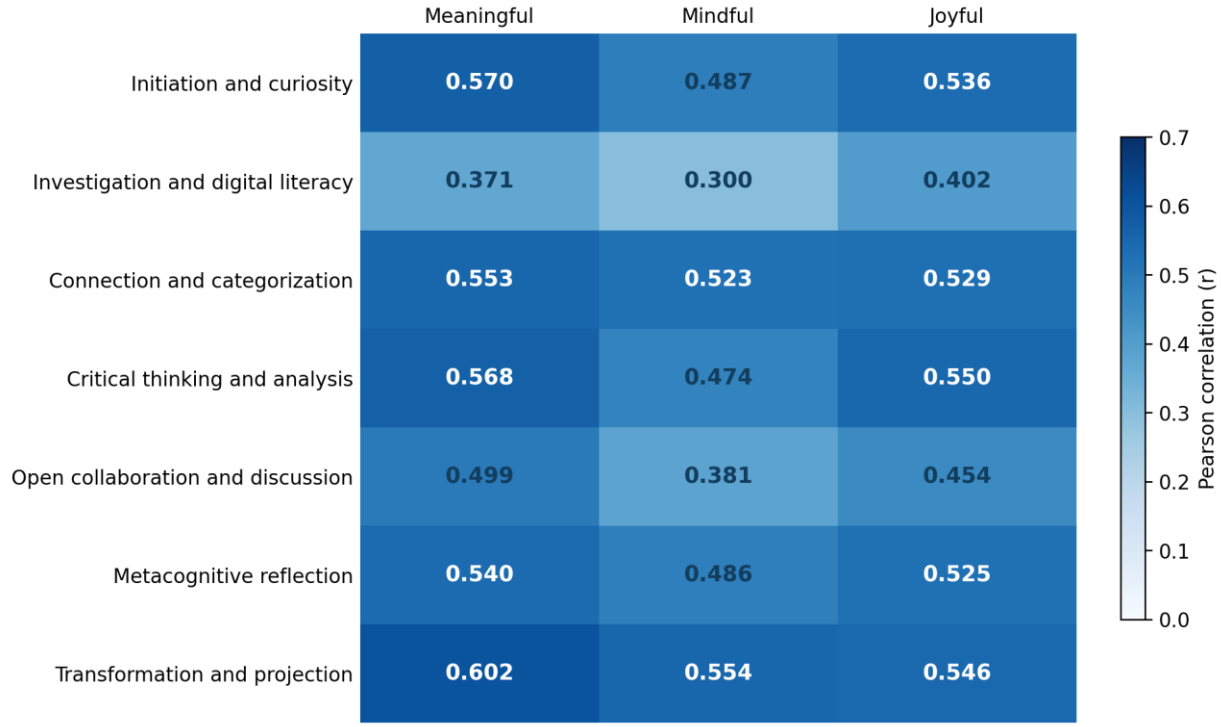


**Figure 2.** Correlation coefficients from the original survey (descriptive; no causal inference)

### *Empirical Findings Informing the Proposed Conceptual Framework*

The descriptive and correlation findings provide complementary empirical input for developing the proposed MMJ-oriented Deep-Inquiry conceptual framework. The descriptive results summarize the dimensions and components that received relatively higher and lower ratings in teachers' reports, while the correlation patterns indicate the degree to which these dimensions and components were associated. The comparatively stronger associations between Transformation and Projection and the three MMJ components offer a point of conceptual alignment for further theoretical consideration. The positive associations across all seven dimensions also provide preliminary evidence that Deep-Inquiry practices and MMJ Learning are related in teachers' perceptions. These patterns were interpreted alongside relevant literature to formulate a preliminary conceptual architecture, not to infer causal pathways.

In the proposed framework, Meaningful Learning is conceptualized as a contextual anchor connecting inquiry with relevant experiences and knowledge; Mindful Learning as a metacognitive-regulatory condition supporting awareness, monitoring, and reflection; and Joyful Learning as an affective-social condition supporting engagement and collaboration. These roles are theory-informed interpretations rather than relationships directly tested by the correlation analysis. Figure 3 summarizes how instrument quality, descriptive findings, correlation patterns, and theoretical interpretation inform the preliminary framework. Further research using classroom observations, student-level data, and additional validation procedures is needed to examine how these conceptual relationships are manifested in instructional practice.

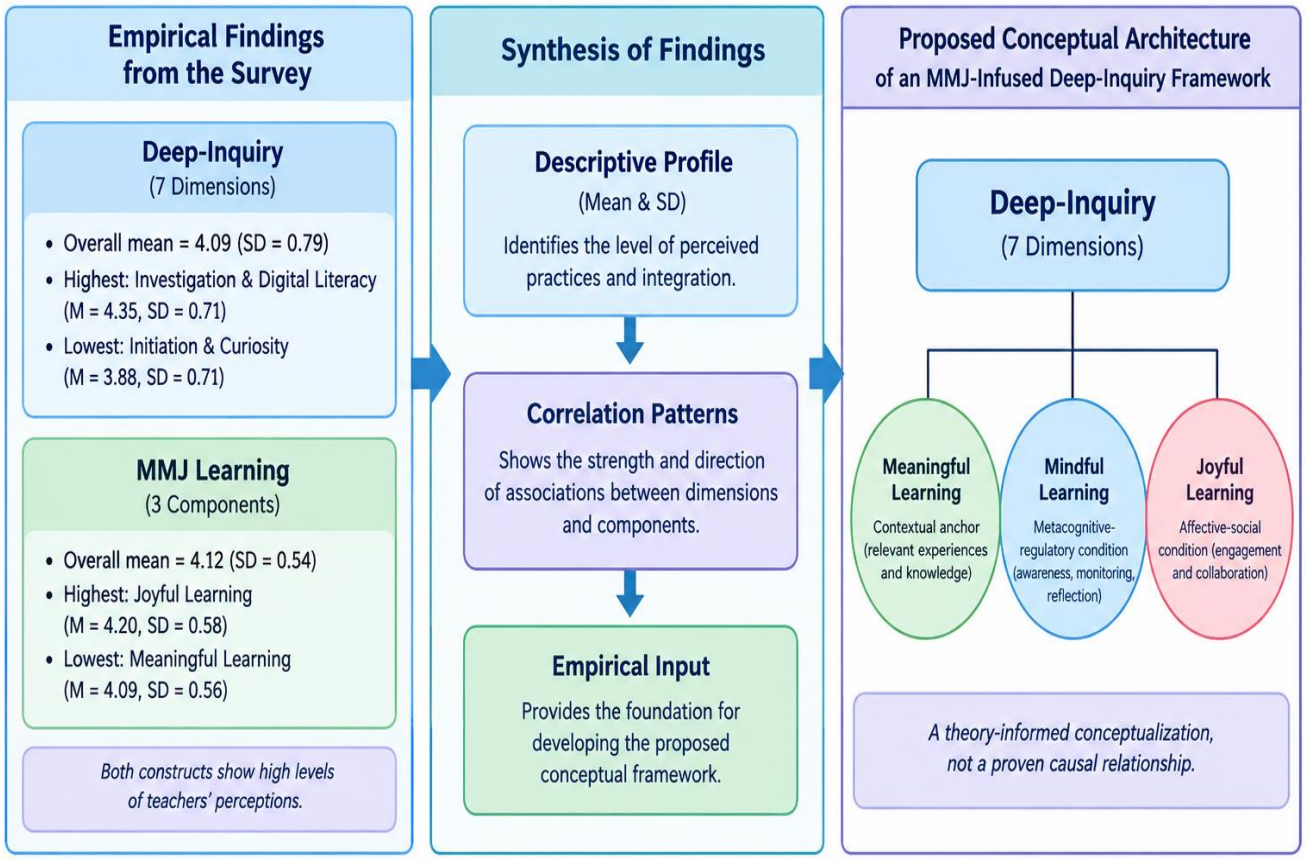


**Figure 3.** Empirical Evidence and the Provisional MMJ-Infused Deep-Inquiry Architecture

## *Discussion*

The findings of this study provide preliminary empirical grounding for conceptualizing Deep-Inquiry as an integrated perspective on inquiry learning in elementary education. The observed patterns suggest that inquiry-related classroom practices encompass multiple dimensions, including question initiation, investigation, evidence analysis, conceptual integration, collaboration, and reflection. This interpretation is consistent with literature emphasizing that authentic inquiry and deep learning extend beyond procedural participation to include question formulation, evidence-based reasoning, higher-order thinking, and the construction of interconnected knowledge [22], [23]. However, the relatively lower reported levels of initiation and curiosity and connection and categorization should be interpreted as characteristics of classroom practices as perceived by teachers, rather than direct evidence of students' difficulties in formulating questions or organizing conceptual knowledge. These patterns provide a rationale for further investigating how instructional designs may support the initiation of inquiry and the development of conceptual relationships. Similarly, the positive correlations among the measured dimensions indicate that these practices tend to be reported together, but they do not establish causal relationships or demonstrate that one dimension produces improvements in another. Because the data were cross-sectional and based on teacher reports, the findings may also be affected by common-method and social-desirability biases. Accordingly, the results should be understood as an initial empirical basis for conceptual development rather than evidence of instructional effectiveness or validation of a learning framework.

The central conceptual contribution of this study is the integration of Meaningful Learning, Mindful Learning, and Joyful Learning (MMJ) into the proposed MMJ-Infused Deep-Inquiry framework. Rather than assuming that these three principles automatically reinforce one another, the framework distinguishes their proposed functions in supporting inquiry learning. Meaningful Learning is positioned as the contextual and knowledge-construction dimension, connecting inquiry questions, evidence, and explanations with students' prior knowledge, experiences, and authentic situations. Such connections provide a theoretical basis for understanding how learners may organize information, recognize relationships among concepts, and construct coherent explanations. The observed associations between Meaningful Learning and several conceptual and analytical dimensions are consistent with this proposed role. Nevertheless, these associations do not establish the direction or underlying mechanisms of the relationships. The contribution of Meaningful Learning to the proposed framework therefore lies in emphasizing the contextual relevance and interconnectedness of knowledge during inquiry, while recognizing that the effects of these processes require further investigation.

Mindful Learning is positioned as the metacognitive-regulatory dimension of Deep-Inquiry. It emphasizes learners' awareness of their thinking, monitoring of understanding, evaluation of evidence, and adjustment of strategies throughout the inquiry process. This conceptual position is consistent with research highlighting the importance of explicit metacognitive strategies in inquiry-based learning, problem-solving, and problem-posing [24]. It also provides a theoretical rationale for considering planning prompts, guided questioning, monitoring routines, and structured reflection as potential instructional strategies within the proposed framework. From this perspective, metacognitive regulation is not limited to reflection at the end of a lesson but may be incorporated throughout the different phases of inquiry. However, the present study did not directly measure these regulatory mechanisms or establish whether metacognition mediates the relationship between inquiry activities and deeper learning outcomes. The proposed role of Mindful Learning should therefore be understood as a theoretically informed proposition that requires further empirical examination.

Joyful Learning is positioned as the affective and participatory dimension of the proposed framework. It emphasizes learning conditions that may support curiosity, confidence, willingness to participate, and persistence when learners encounter uncertainty or challenging questions. Previous studies linking positive affect with learning flow and sustained engagement in elementary education provide a relevant basis for considering affective conditions in inquiry-oriented learning [30], [33]. Related literature also supports examining how supportive learning environments may facilitate participation and engagement [42], [45]. Within the proposed framework, Joyful Learning is not simply equated with entertaining activities; rather, it concerns creating a learning environment in which students can explore ideas, discuss alternative explanations, ask questions, and engage with uncertainty. Exploratory and game-based activities may represent possible instructional strategies for supporting such conditions, but their contributions to inquiry initiation, intellectual risk-taking, and sustained engagement require direct empirical investigation. The present findings do not demonstrate that Joyful Learning reduces anxiety, increases autonomous questioning, or improves critical thinking. These possibilities remain propositions for future research rather than established outcomes of the current study.

The conceptual integration of the three MMJ components is based on their distinct but potentially complementary functions. Meaningful Learning addresses contextual relevance and knowledge construction; Mindful Learning addresses awareness and regulation of the inquiry process; and Joyful Learning addresses the affective and participatory conditions under which inquiry takes place. These dimensions may interact during classroom learning, but their integration does not imply that they necessarily reinforce one another in every instructional context. Meaningful tasks, for example, may provide relevant contexts for investigation without automatically ensuring that learners monitor the quality of their reasoning. Likewise, an enjoyable classroom environment may encourage participation without necessarily resulting in accurate evidence evaluation or well-supported conclusions. Explicit metacognitive guidance may therefore be needed to connect active participation with systematic reasoning and reflection. This interpretation offers a theoretical rationale for considering the three components across inquiry phases while acknowledging that their interactions, boundary conditions, and relative contributions remain to be tested. The proposed framework consequently extends a primarily cognitive and procedural conceptualization of Deep-Inquiry by explicitly distinguishing contextual knowledge construction, metacognitive regulation, and affective engagement as complementary dimensions of inquiry-oriented learning.

The proposed MMJ-Infused Deep-Inquiry framework translates these conceptual distinctions into a preliminary instructional architecture, as illustrated in Figure 3. Contextual anchoring is intended to connect inquiry activities with prior knowledge and authentic problems; metacognitive regulation is intended to support planning, monitoring, and evaluation during investigation; and affective support is intended to encourage participation and persistence during exploration and discussion. These proposed functions may be incorporated into inquiry phases involving question formulation, investigation, evidence interpretation, communication, reflection, and knowledge transfer. The framework thus offers a way to conceptualize how contextual, metacognitive, and affective considerations might be incorporated into a coherent inquiry-learning design. However, the proposed architecture is derived from the synthesis of the observed empirical patterns and relevant theoretical literature; it does not represent a validated sequence of causal mechanisms. Its conceptual contribution lies in specifying the proposed roles of the MMJ components within Deep-Inquiry rather than merely combining three instructional principles.

Interpretation of this preliminary framework should distinguish conceptual plausibility from observed instructional effects. The survey cannot determine whether the three MMJ components act independently, interact statistically, or improve learning beyond an inquiry-only comparison. These questions require direct observation, design validation, and controlled implementation studies.

## CONCLUSION

This study explored teachers' perceptions of Deep-Inquiry and Meaningful, Mindful, and Joyful Learning (MMJ), examined the relationships between the two constructs, and proposed a preliminary conceptual framework for elementary education. Overall, teachers reported positive perceptions of Deep-Inquiry and MMJ Learning, although some inquiry-related dimensions, particularly question initiation and conceptual connection, received relatively lower ratings than investigation, digital literacy, collaboration, and discussion. The findings

also revealed positive associations between Deep-Inquiry dimensions and the three MMJ components, providing an initial empirical basis for proposing the MMJ-Infused Deep-Inquiry framework. The framework conceptualizes Meaningful Learning as supporting contextual relevance and knowledge construction, Mindful Learning as supporting metacognitive awareness and regulation, and Joyful Learning as supporting affective engagement and participation during inquiry. These findings offer preliminary guidance for designing inquiry activities that integrate authentic contexts, reflection, collaboration, and engaging learning experiences. However, the cross-sectional design and reliance on teacher-reported data limit causal interpretation, and the proposed framework has not yet undergone expert validation or empirical testing. Further research should therefore involve expert review and classroom-based investigations using classroom observations, student-level measures, and longitudinal or experimental designs to assess the framework's conceptual coherence, practical feasibility, and potential contribution to students' inquiry processes and learning outcomes.

## LIMITATIONS

The findings should be interpreted cautiously because they are based on self-reported data from 200 elementary school teachers selected through non-probability purposive sampling within a single province, limiting population representativeness and generalizability. Unexamined school-level clustering, common-method variance, and ambiguous measurement referents further constrain interpretation of the scores as teacher perceptions rather than direct indicators of Deep-Inquiry practice. Although the instruments demonstrated high internal consistency, criterion validity was not established through classroom observations, learning artifacts, or external measures. As the study represents an empirical baseline and conceptualization, the findings cannot establish causal relationships, instructional effectiveness, or effects on student outcomes, which were not directly measured. Accordingly, the results are positioned as preliminary, context-bound evidence supporting the conceptualization and design hypotheses of *MMJ-Infused Deep Inquiry*, rather than as validation or broad generalization; further research should employ more diverse samples, multilevel analysis, triangulation, and longitudinal or intervention-based designs.

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## AUTHOR CONTRIBUTIONS

R.A.S. Conceptualization, Methodology, Investigation, Formal Analysis, and Writing – Original Draft. H.H. Methodology, Validation, Data Curation, and Writing – Review & Editing. A.L.A. Supervision, Conceptualization, and Writing – Review & Editing. E.F. Investigation, Data Curation, Formal Analysis, and Visualization. R.A. Methodology and Writing – Review & Editing. D.S. Supervision, Validation, and Writing – Review & Editing. A.H. Specific contribution roles require confirmation by the author team before submission. All contributors must confirm their respective roles and approve the final manuscript.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

Generative AI tools, including ChatGPT, were used to assist with language editing, structural organization, and reference formatting. The authors are responsible for verifying all sources, arguments, and editorial changes and for approving the final manuscript.

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