ISSN: 3116-3475
International Journal
of Education, Research, and Innovation Perspectives
Volume 2 Issue 9 (September 2026)

Responsive Digital Pedagogy for Elementary Learner Engagement

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Date Submitted:
March 13, 2026

Date Accepted:
July 27, 2026

Date Published:
September 24, 2026

DOI:
10.5281/zenodo.22952349

ABSTRACT

This study explored the predictive role of responsive digital pedagogy in shaping elementary learner engagement in Baggao, Cagayan. It focused on four dimensions of digital teaching: adaptive digital task design, responsive feedback, participatory digital interaction, and access-sensitive instructional support. An explanatory-predictive path design was applied to data from 90 public elementary school teachers selected through stratified criterion-random sampling. Responses were analyzed using partial least squares structural equation modeling, bootstrapping with 10,000 resamples, PLSpredict, and importance-performance map analysis. The measurement model established acceptable reliability, convergent validity, and discriminant validity. Results showed that responsive digital pedagogy explained 62.4% of the variance in learner engagement. Responsive feedback exerted the strongest positive effect, followed by participatory digital interaction and adaptive digital task design. Access-sensitive instructional support, however, did not significantly predict engagement and emerged as the weakest area of implementation. Predictive analysis further showed that the model performed better in explaining active participation, sustained attention, and learning effort than cognitive involvement. These findings suggest that the effectiveness of digital instruction depends less on technology use itself and more on how teachers adapt digital experiences, provide timely feedback, and create meaningful opportunities for participation. Strengthening access-sensitive practices and designing tasks that promote deeper cognitive engagement are recommended to improve responsive digital teaching in elementary classrooms.

Keywords: *access-sensitive support; adaptive digital tasks; digital pedagogy; elementary education; learner engagement; responsive feedback*

INTRODUCTION

Digital technologies have become part of everyday teaching, yet their educational value depends on how thoughtfully they are used. Access to devices, applications, and online resources does not automatically lead to meaningful learning. What matters is whether technology supports clear learning goals, interaction, feedback, and opportunities for learners to participate actively. UNESCO has emphasized that educational technology should serve learners and strengthen human interaction rather than replace the teacher's role in the learning process (UNESCO, 2023). This places greater importance on pedagogy, particularly on how teachers make instructional decisions while using digital resources.

Responsive digital pedagogy builds on this principle by treating technology as a flexible instructional resource rather than a fixed method of delivery. Teachers need more than the technical ability to operate digital tools. They must be able to select appropriate resources, connect them with curriculum objectives, recognize learner difficulties, and adjust activities according to learner responses. Falloon (2020) explains that teacher digital competence involves pedagogical, curricular, ethical, and professional judgment alongside technical knowledge. Such competence becomes especially important in elementary education, where learners differ in readiness, attention, confidence, pace, and familiarity with digital learning environments.

Learner engagement provides an important basis for examining whether digital instruction is working as intended. Engagement involves learners' attention, participation, persistence, emotional involvement, and cognitive investment in learning activities. D'Mello (2021) argues that sustained engagement is essential to meaningful learning and that digital environments can support engagement when instruction responds to signs of interest or disengagement. Evidence from primary education also indicates that carefully designed digital activities can strengthen learners' interest and participation. Deng et al. (2020), for example, found that digital game-based learning increased engagement and interest among primary school learners, although its effectiveness depended on how the teacher connected the digital activity with classroom instruction. These findings suggest that the quality of teacher mediation remains central even when technology is highly interactive.

For Philippine basic education, the need to strengthen instructional quality, access, equity, and resilience is reflected in the Basic Education Development Plan 2030 (Department of Education, 2022). Within elementary schools in Baggao, Cagayan, examining how teachers make digital instruction responsive to learners may provide a more grounded understanding of technology-supported engagement. Responsive teaching gives value to learners' ideas and experiences and uses them to guide instructional decisions, creating stronger opportunities for participation and shared meaning-making (Silseth & Furberg, 2024). Guided by these considerations, the study on Responsive Digital Pedagogy for Elementary Learner Engagement seeks to determine how responsive uses of digital pedagogy are associated with the engagement of elementary learners and to provide evidence that may guide more purposeful digital teaching practices.

Literature Review

Digital Pedagogy as Instructional Practice

Digital pedagogy extends beyond the presence of devices or software in the classroom because its value rests on how teachers organize learning through technology. Effective integration requires decisions about when digital resources are appropriate, how they support lesson objectives, and how learners are guided while using them. Wohlfart and Wagner (2023), in an umbrella review covering systematic reviews and more than a thousand primary studies, identified teachers as central actors in educational digitalization and emphasized the importance of linking technological knowledge with sound pedagogical practice. Their findings suggest that meaningful technology integration depends on teachers who can move between instructional goals, learner needs, and available digital resources rather than simply increasing technology use. This perspective supports responsive digital pedagogy as a teaching practice shaped by purposeful instructional decisions.

Teacher Digital Competence and Responsiveness

Teachers' ability to respond effectively within technology-supported lessons is closely related to their digital competence. This competence includes preparing digital instruction, delivering lessons, supporting learners, evaluating learning, revising strategies, and using technology for professional and instructional improvement. Tzafilkou et al. (2023) found that digital competence among primary and secondary teachers involved several interconnected pedagogical and professional dimensions, with particular importance placed on teaching delivery and learner support. Their findings indicate that digital competence should not be understood only as technical proficiency because teachers must also determine how technology can be adjusted according to learner performance and instructional demands. For elementary classrooms, this capacity is particularly important because learners often require varying levels of guidance, explanation, and assistance during digital activities.

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International Journal
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Digital Learning and Elementary Learner Engagement

Learner engagement is influenced not only by exposure to digital technology but also by the instructional conditions surrounding its use. In a study involving 1,977 elementary pupils across 20 schools implementing one-to-one iPad programs, Tirado-Morueta et al. (2020) found that pedagogical methods mediated the relationship between technology use and student engagement. This finding is significant because it shows that devices alone cannot account for learners' participation, interest, or involvement in classroom activities. Digital learning becomes more engaging when teachers structure activities in ways that encourage interaction, participation, and purposeful use of learning resources. Thus, examining learner engagement alongside responsive digital pedagogy can reveal how teacher decisions transform technology from a classroom resource into an active part of the learning experience.

Responsive Scaffolding in Digital Learning

Responsiveness becomes visible when teachers recognize learner difficulties and provide support suited to the demands of a digital task. Such support may include clarification, prompts, feedback, demonstrations, questioning, or individualized assistance while learners interact with digital materials. Sun et al. (2023), through a systematic review of teacher scaffolding in game-based learning in primary education, found that teacher scaffolding influenced learners' knowledge development, engagement, skills, and enjoyment. The review further showed that scaffolding can occur at different stages of digital learning and may be adjusted according to learners' needs. These findings strengthen the argument that effective digital pedagogy requires continuous teacher involvement, particularly in elementary classrooms where responsive support can sustain participation and help learners remain engaged when digital tasks become challenging.

METHODS

Research Design

The study employed an explanatory-predictive path design to examine how responsive digital pedagogy accounted for variations in elementary learner engagement. Rather than limiting the analysis to the strength of associations, the design estimated the relative contribution and predictive relevance of adaptive digital task design, responsive feedback, participatory digital interaction, and access-sensitive instructional support. The approach was nonexperimental because the variables were examined as they occurred in regular teaching practice. Partial least squares structural equation modeling was incorporated into the design to assess both explanatory relationships and prediction beyond the observed sample.

Research Locale

The study was conducted in Baggao, Cagayan, within the public elementary education sector. The municipality provided an appropriate setting because elementary education operated across the officially recognized Baggao administrative districts under the Schools Division of Cagayan. Official DepEd records confirmed the presence of public elementary institutions serving communities across these areas. The locale allowed the study to examine digital pedagogy under varying conditions of connectivity, resource availability, and classroom access without identifying individual schools.

Participants and Sampling Technique

The participants consisted of 90 public elementary school teachers who had incorporated digital resources, applications, multimedia materials, or device-supported activities into classroom instruction. The number was guided by an a priori power calculation for four principal predictors using a medium effect size of $f^2 = .15$, an alpha level of .05, and statistical power of .80, which produced a minimum requirement of 85 participants. The sample was increased to 90 to provide adequate usable cases for predictive modeling. A stratified criterion-random sampling procedure was used. Eligible teachers were first grouped according to the elementary administrative areas of Baggao, after which qualified participants were selected randomly. Only teachers with direct experience using digital resources for elementary instruction were included. No demographic profile was incorporated into the analysis.

Research Instrument

Data were obtained through a structured questionnaire composed of two major scales. The Responsive Digital Pedagogy Scale measured adaptive digital task design, responsive feedback, participatory digital interaction, and access-sensitive instructional support. The Elementary Learner Engagement Scale measured teachers' observations of learners' active participation, sustained attention, learning effort, and cognitive involvement during digitally supported instruction. Responses were recorded on a five-point scale ranging from 1, representing *strongly disagree*, to 5, representing *strongly agree*.

The digital pedagogy items were anchored on the pedagogical components of the DigCompEdu framework and its validated Check-In instrument. Published validation of the instrument produced an overall Cronbach's alpha of α = .946 and McDonald's omega of ω = .967. Relevant dimensions also demonstrated acceptable to strong internal consistency, including digital pedagogy at α = .841, assessment and feedback at α = .788, and student empowerment at α = .733. Exploratory and confirmatory factor analyses further supported its construct validity (Llorente-Cejudo et al., 2023). The engagement component was informed by established engagement measures used in Philippine educational research. Dacillo et al. (2022) reported an overall reliability coefficient of α = .909, with domain coefficients ranging from α = .767 to .812, providing psychometric support for the engagement indicators used as the basis for adaptation.

For the local adaptation, the instrument was pilot-tested with 30 public elementary school teachers who were not included in the final sample. Content validation was conducted by five specialists in elementary education, educational technology, research, and measurement. The scale obtained an S-CVI/Ave of .94, while the individual item content validity indices ranged from .80 to 1.00. Reliability analysis yielded an overall Cronbach's alpha of .931 and McDonald's omega of .934. The Responsive Digital Pedagogy Scale produced α = .918 and ω = .921, while the Elementary Learner Engagement Scale obtained α = .903 and ω = .907. Corrected item-total correlations ranged from .421 to .782, indicating that all retained items contributed adequately to their respective constructs. These results supported the content validity and internal consistency of the adapted instrument for use in the main study.

Data Gathering Procedure

Permission to conduct the study was secured from the appropriate education authorities before participant recruitment. Eligible teachers received an explanation of the purpose, procedures, voluntary nature, and confidentiality provisions of the research. Questionnaires were distributed through an appropriate printed or secure digital format depending on accessibility. Completed instruments were checked for completeness without collecting information that could reveal the identity of individual teachers or schools. Responses were encoded, screened for missing entries and response irregularities, and prepared for statistical analysis.

Data Analysis

The data were analyzed through partial least squares structural equation modeling with out-of-sample predictive assessment. The measurement model was first examined through indicator loadings, composite reliability, rho_A, average variance extracted, and heterotrait-monotrait ratios. The structural model was then evaluated through variance inflation factors, standardized path coefficients, coefficient of determination (R^2), effect sizes (f^2), and predictive relevance (Q^2). Statistical significance was established through bootstrapping with 10,000 resamples.

To move beyond conventional association testing, PLSpredict was used to determine whether responsive digital pedagogy could predict learner engagement in observations not used directly to estimate the model. This procedure provided a stronger assessment of predictive usefulness than relying solely on explanatory fit measures

(Shmueli et al., 2019). An importance-performance map analysis was also applied to determine which dimensions of responsive digital pedagogy combined strong influence on learner engagement with comparatively lower performance, thereby identifying instructional areas with the greatest potential for improvement.

Ethical Considerations

The study observed voluntary participation, informed consent, confidentiality, and responsible data management. Teachers were informed that participation or refusal would have no bearing on their employment or professional standing. No individual school, teacher, or learner was identified in the dataset or report. Digital and printed records were secured and used only for research purposes, and findings were presented in aggregated form to prevent attribution to individual participants.

RESULTS AND DISCUSSION

Table 1. *Measurement Model and Construct-Level Results*

Construct	Mean	SD	Loading Range	Cronbach's α	rho_A	CR	AVE
Adaptive Digital Task Design	3.71	0.55	.721-.864	.842	.849	.887	.611
Responsive Feedback	4.02	0.53	.748-.881	.867	.873	.905	.656
Participatory Digital Interaction	3.84	0.58	.732-.872	.854	.861	.896	.633
Access-Sensitive Instructional Support	3.21	0.69	.708-.850	.821	.829	.875	.584
Elementary Learner Engagement	3.79	0.52	.756-.889	.878	.883	.912	.675

Table 1 presents the measurement quality and observed levels of the study constructs. Responsive feedback obtained the highest mean of 4.02, suggesting that teachers commonly used digital resources to clarify tasks, respond to learner difficulties, and provide timely instructional guidance. Participatory digital interaction also registered a relatively high mean of 3.84. In contrast, access-sensitive instructional support recorded the lowest mean of 3.21 and the largest variation among teachers. This finding indicated an uneven capacity to modify digital activities when learners faced limitations involving devices, connectivity, or the usability of digital materials. All constructs demonstrated satisfactory internal consistency and convergent validity, with composite reliability values from .875 to .912 and AVE values from .584 to .675. The pattern supported the view that technology can contribute to elementary learning, but the benefit depends on how digital instruction is structured and matched with learner needs, as also observed in the meta-analysis of technology-delivered elementary instruction by Dahl-Leonard et al. (2024).

Table 2. *Discriminant Validity Using the HTMT Criterion*

Construct	ADTD	RF	PDI	ASIS	ELE
Adaptive Digital Task Design (ADTD)	1.000				
Responsive Feedback (RF)	.712	1.000			
Participatory Digital Interaction (PDI)	.681	.744	1.000		
Access-Sensitive Instructional Support (ASIS)	.558	.601	.576	1.000	
Elementary Learner Engagement (ELE)	.735	.812	.786	.633	1.000

Table 2 shows that the HTMT coefficients ranged from .558 to .812. The values demonstrated that the constructs remained empirically distinguishable from one another despite their conceptual connections. The highest coefficient occurred between responsive feedback and learner engagement at .812, followed by participatory digital interaction and learner engagement at .786. These values suggested close relationships

IJERIP
ISSN: 3116-3475
International Journal
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without indicating construct redundancy. The result supported the retention of the four digital pedagogy dimensions as distinct explanatory components in the structural model.

Table 3. *Structural Model Predicting Elementary Learner Engagement*

Structural Path	β	SE	t	p	95% Bootstrap CI	f^2	VIF	Result
Adaptive Digital Task Design → Engagement	.247	.086	2.872	.004	[.084, .413]	.094	1.84	Significant
Responsive Feedback → Engagement	.356	.078	4.564	< .001	[.201, .508]	.207	2.31	Significant
Participatory Digital Interaction → Engagement	.301	.081	3.716	< .001	[.146, .459]	.132	2.08	Significant
Access-Sensitive Instructional Support → Engagement	.118	.073	1.616	.106	[-.024, .263]	.024	1.68	Not significant

Model statistics: $R^2 = .624$; Adjusted $R^2 = .606$; $Q^2 = .431$
Bootstrapping: 10,000 resamples

Table 3 presents the explanatory paths leading to elementary learner engagement. The model accounted for 62.4% of the variance in engagement, indicating that responsive digital pedagogy explained a meaningful portion of differences in learners' classroom participation. Responsive feedback emerged as the strongest predictor ($\beta = .356$, $p < .001$), followed by participatory digital interaction ($\beta = .301$, $p < .001$) and adaptive digital task design ($\beta = .247$, $p = .004$). The result showed that learners were more engaged when teachers responded to their learning needs, created opportunities for digital participation, and modified tasks rather than using technology through a fixed instructional routine. The prominence of responsive feedback was consistent with Stevens et al. (2023), who emphasized the instructional value of specific teacher feedback and showed that elementary classrooms still needed stronger feedback directed toward learning processes and self-regulation.

Access-sensitive instructional support did not produce a statistically significant direct effect on engagement ($\beta = .118$, $p = .106$). This was an important problem revealed by the model. Although teachers attempted to accommodate differences in access, such adjustments alone did not guarantee active engagement. Access appeared to function more as a condition that allowed digital learning to occur than as an instructional mechanism capable of sustaining learner involvement by itself. The finding suggested that providing alternatives for connectivity or devices needed to be accompanied by interaction, feedback, and purposeful task adaptation.

Table 4. *PLSpredict Assessment of Learner Engagement*

Engagement Indicator	Q^2predict	PLS-SEM RMSE	LM RMSE	Difference	Predictive Result
Active Participation	.412	.483	.512	-.029	PLS-SEM better
Sustained Attention	.386	.506	.529	-.023	PLS-SEM better
Learning Effort	.347	.544	.558	-.014	PLS-SEM better
Cognitive Involvement	.321	.571	.562	.009	LM better

Table 4 presents the out-of-sample predictive assessment. All Q^2predict values were positive, indicating predictive relevance for the four engagement indicators. The PLS-SEM model produced lower prediction errors than the linear benchmark for active participation, sustained attention, and learning effort. The model, however, produced a slightly higher RMSE for cognitive involvement. Following the predictive assessment guidance discussed by Hair and Alamer (2022), this pattern indicated medium out-of-sample predictive power, since PLS-SEM outperformed the benchmark for the majority of indicators.

The result revealed a useful distinction between visible engagement and deeper mental involvement. Responsive digital pedagogy predicted participation, attention, and effort more consistently than cognitive involvement. Thus, learners could appear active during digitally supported lessons without necessarily engaging deeply with the ideas presented. This represented an instructional concern because attractive digital activities could stimulate observable participation while still requiring stronger questioning, reflection, problem solving, and meaning-making to deepen learning.

Table 5. *Importance-Performance Map Analysis for Learner Engagement*

Digital Pedagogy Dimension	Importance	Performance	Priority Interpretation
Responsive Feedback	.356	75.5	Strongest influence, high current performance
Participatory Digital Interaction	.301	71.0	Strong influence requiring continued support
Adaptive Digital Task Design	.247	67.8	Practical area for further improvement
Access-Sensitive Instructional Support	.118	55.3	Lowest performance and continuing access concern

Table 5 shows that responsive feedback combined the greatest importance with the highest performance. Participatory digital interaction also occupied a favorable position, indicating that opportunities to respond, collaborate, manipulate digital content, and communicate ideas were closely connected with learner engagement. Adaptive digital task design showed moderate importance but comparatively lower performance, identifying it as a practical area for instructional development. Teachers could therefore strengthen engagement by improving how digital tasks were differentiated according to learners' pace, readiness, and immediate learning responses.

The most evident weakness was access-sensitive instructional support, which obtained a performance score of only 55.3. Although its direct predictive contribution was small, the low performance indicated that equitable participation in digital learning remained unsettled. Fitzgerald and Evans (2024) explained that digital tools can widen access to meaningful elementary learning opportunities when their features and instructional use are deliberately designed around learner differences. Their work also emphasized that technology itself cannot replace teacher mediation and individualized support. Taken together, the findings showed that responsive digital pedagogy was most effective when technology functioned as an adaptable space for feedback, interaction, and responsive task design rather than merely as a means of content delivery. The remaining weakness in access support and the lower predictability of cognitive involvement suggested that improving engagement required attention both to digital equity and to the intellectual quality of technology-supported activities.

CONCLUSION

Responsive digital pedagogy contributed meaningfully to elementary learner engagement, with responsive feedback, participatory digital interaction, and adaptive digital task design emerging as the strongest instructional influences. The model further indicated that digital teaching was more effective when technology was used to respond to learner needs, encourage active participation, and adjust learning tasks rather than simply deliver content. However, access-sensitive instructional support remained a concern, while cognitive involvement was less predictable than visible participation, attention, and effort. These results suggest that digital engagement should not be measured only by how active learners appear during technology-supported activities, but also by the depth of thinking promoted through those experiences. It is therefore recommended that elementary teachers strengthen responsive feedback practices, design more interactive and differentiated digital tasks, and incorporate questioning, reflection, and problem-solving activities that deepen cognitive involvement. School leaders may also provide focused professional development on responsive digital pedagogy and establish practical support mechanisms for learners with limited access to devices or connectivity. Future instructional initiatives should prioritize both digital accessibility and the quality of learner thinking so that technology-supported teaching becomes more equitable, purposeful, and engaging.

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