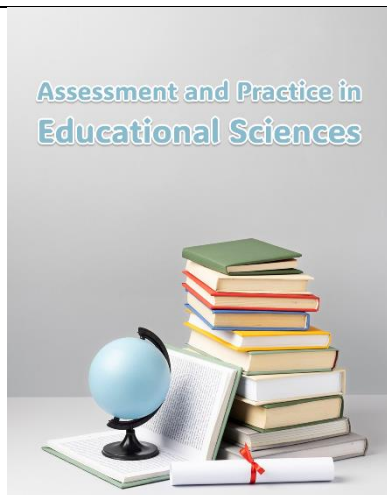




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Design and Validation of a Common Mathematics Curriculum Planning Model Across Different Educational Levels Using a Blended Approach

ABSTRACT

This study aimed to design and validate a common mathematics curriculum planning model applicable across different educational levels based on a blended learning approach. This applied study employed an exploratory sequential mixed-methods design. In the qualitative phase, relevant articles, books, theses, dissertations, and upstream documents published between 2014 and 2025 were reviewed, and semi-structured interviews were conducted with 30 participants selected through purposive and snowball sampling to theoretical saturation, including 15 curriculum planning specialists and 15 experienced mathematics teachers in Fars Province. The qualitative data were analyzed using thematic analysis. In the quantitative phase, the statistical population consisted of mathematics teachers working at elementary, lower secondary, and upper secondary levels in Lamerd and Mohr during the 2024–2025 academic year. A stratified random sample of 271 teachers was selected, including 195 elementary, 45 lower secondary, and 31 upper secondary teachers. Data were collected using a 60-item researcher-developed questionnaire. SPSS and SmartPLS were used for descriptive statistics, confirmatory factor analysis, reliability and validity assessment, and structural equation modeling. The qualitative phase identified four overarching themes, 16 organizing themes, and 48 basic themes encompassing curriculum objectives, content, teaching strategies, and assessment. In the quantitative phase, factor loadings were .982 for objectives, .805 for content, .891 for teaching strategies, and .859 for assessment. Cronbach's alpha coefficients ranged from .82 to .92, composite reliability from .78 to .95, and AVE from .69 to .80. R^2 values ranged from .76 to .91, Q^2 values from .367 to .403, and GOF values from .39 to .53, indicating satisfactory reliability, validity, explanatory power, predictive relevance, and overall model fit. The validated model provides a coherent and empirically supported framework for integrating objectives, content, teaching strategies, and assessment in mathematics curriculum planning across educational levels within blended learning environments.

Keywords: Mathematics Curriculum Planning, Blended Learning, Curriculum Objectives, Teaching Strategies, Assessment, Mixed Methods, Model Validation

Introduction

Mathematics education occupies a central position in school curricula because it contributes not only to the acquisition of numerical and computational knowledge but also to the development of reasoning, abstraction, problem-solving, communication, decision-making, and the capacity to interpret complex phenomena. The effectiveness of mathematics education, however, is not determined solely by the quality of individual textbooks or classroom activities. It depends substantially on the coherence of curriculum planning across educational levels, including the alignment of objectives, content, instructional strategies, learning environments, and assessment procedures. A curriculum that lacks continuity between elementary, lower secondary, and upper secondary education may produce conceptual fragmentation, unnecessary repetition, abrupt increases in cognitive demand, and inconsistencies in instructional expectations. In contrast, a coherent curriculum framework can facilitate the gradual development of mathematical understanding by connecting foundational knowledge with increasingly complex concepts and practices. Contemporary curriculum theory therefore emphasizes the need to move beyond fragmented lists of subject matter toward systematic structures that establish meaningful relationships among knowledge, learning experiences, pedagogy, and educational purposes (1).

Curriculum planning is particularly important in mathematics because mathematical knowledge is cumulative, hierarchical, and highly interdependent. Many advanced concepts depend directly on learners' mastery of earlier ideas, representations, procedures, and reasoning strategies. Consequently, weaknesses in the vertical organization of mathematics curricula can create persistent learning difficulties that become increasingly difficult to remediate at later stages of schooling. At the same time, horizontal coherence is also necessary so that mathematical concepts taught within a particular grade or educational stage are connected meaningfully rather than presented as isolated topics. Effective mathematics curriculum planning must therefore coordinate developmental appropriateness, conceptual progression, instructional opportunities, assessment expectations, and the evolving cognitive needs of learners. Research on teachers' specialized mathematical content knowledge further demonstrates that successful mathematics instruction requires much more than mastery of mathematical procedures; teachers must understand how mathematical ideas can be represented, explained, connected, interpreted, and adapted for learners at different developmental stages (2, 3). This reinforces the need for curriculum models that provide a shared structure across educational levels while allowing appropriate differentiation in depth, complexity, and instructional practice.

The increasing complexity of educational environments has added another dimension to curriculum planning. Schools are no longer confined to conventional classroom-based teaching. Digital technologies, online platforms, multimedia resources, learning management systems, interactive software, virtual communication tools, and adaptive educational resources have expanded the environments in which teaching and learning can occur. These changes have contributed to the rapid development of blended learning, which generally refers to the purposeful integration of face-to-face and technology-mediated or online learning experiences rather than the simple addition of digital tools to traditional instruction (4). The defining feature of blended learning is therefore pedagogical integration. A successful blended design requires deliberate decisions about which learning activities should occur in physical classrooms, which can be supported through digital environments, how students move between these modes, how teachers maintain instructional coherence, and how assessment and feedback function across learning settings (5).

Blended learning has developed from an instructional alternative into an important organizational and pedagogical framework within contemporary education. Its potential advantages include increased flexibility, greater access to diverse resources, enhanced opportunities for learner autonomy, extended interaction beyond classroom time, and the possibility of combining direct teacher guidance with individualized digital learning activities. Nevertheless, blended learning should not be

regarded as automatically effective merely because technology is involved. Evidence suggests that the quality of the face-to-face component, the nature of the digital component, and the integration between them substantially influence learning outcomes (6). Similarly, institutional and instructional studies of blended learning have emphasized that effective implementation requires careful coordination among technology, pedagogy, curriculum design, teacher capabilities, student readiness, and organizational support (7). Thus, the central question is no longer whether face-to-face and online education should be combined, but how they should be designed as an integrated learning system.

This issue is especially significant in mathematics education. Mathematical learning requires repeated opportunities for explanation, practice, feedback, representation, discussion, exploration, and application. Digital environments can support many of these processes through dynamic visualization, interactive exercises, automated feedback, simulations, educational games, recorded explanations, collaborative platforms, and individualized practice. At the same time, face-to-face interaction remains highly valuable for mathematical dialogue, diagnostic questioning, teacher scaffolding, collaborative problem-solving, and the clarification of misconceptions. Accordingly, blended mathematics education can potentially combine the strengths of direct classroom interaction with the flexibility and interactivity of digital environments. Studies of blended instructional environments have shown that combining classroom and technology-mediated learning can support active participation and provide alternative learning pathways, although implementation quality remains dependent on instructional planning and learner support (8). This suggests that blended learning should be embedded within curriculum planning rather than treated as an independent technological intervention.

Meaningful mathematics learning further depends on the quality of teaching approaches used to engage students with mathematical concepts. A synthesis of mathematics education research indicates that meaningful learning emerges when students actively connect new mathematical ideas with prior knowledge, interpret relationships among concepts, explain reasoning, engage in problem-solving, and encounter opportunities to construct understanding rather than merely memorize procedures (9). These principles are highly compatible with blended learning because the integration of synchronous and asynchronous activities can create additional opportunities for inquiry, reflection, practice, interaction, and differentiated learning. However, the pedagogical value of such opportunities depends on their relationship with curricular objectives and content. Without a coherent curriculum structure, digital activities may become supplementary tasks with little contribution to conceptual development. Therefore, the design of blended mathematics curricula requires explicit alignment among intended outcomes, mathematical content, instructional activities, digital resources, learner participation, and assessment.

The social dimension of mathematical learning is equally important. Mathematical understanding is often strengthened when students explain their reasoning, compare solution strategies, question one another's assumptions, and collaboratively construct interpretations. Research on mathematical discussion has emphasized the instructional value of comparison while also demonstrating that such tasks must be designed carefully because students' cognitive load can affect their capacity to benefit from simultaneous representations and competing solution approaches (10). Similarly, studies of collaborative mathematical problem-solving indicate that metacognitive processes can emerge through group interaction when students plan, monitor, evaluate, and regulate their joint reasoning (11). These findings have direct implications for curriculum planning. If collaboration and mathematical discourse are considered important learning outcomes, they must be reflected not only in teaching methods but also in curriculum objectives, task design, content organization, and assessment practices. A shared curriculum model should therefore account for both individual and collaborative dimensions of mathematical learning.

Self-regulated learning is another important consideration in blended educational environments. Because blended learning frequently requires students to manage learning activities across physical and digital contexts, learners need to regulate time, effort, attention, motivation, and learning strategies with greater independence than in exclusively teacher-directed settings.

Empirical evidence indicates that self-regulated learning and peer learning are significantly related to academic achievement in blended courses, demonstrating that learner autonomy and interaction are central mechanisms through which blended environments can support achievement (12). In mathematics education, these capabilities are especially relevant because students often need to persist through difficult problems, monitor errors, select alternative strategies, and revisit conceptual explanations. Consequently, a common curriculum planning model designed for blended mathematics education should explicitly incorporate the development of self-regulation, responsibility for learning, collaboration, and digital literacy among its objectives rather than focusing solely on disciplinary knowledge.

Technologically mediated learning environments also provide opportunities to diversify mathematics instruction. Game-based learning represents one example of how digital or digitally supported activities can increase engagement and create interactive contexts for practicing mathematical skills and applying concepts. Meta-analytic evidence has shown that game-based learning can have positive effects on students' mathematics achievement when games are aligned appropriately with instructional goals and learning content (13). Nevertheless, the instructional usefulness of educational games, multimedia resources, virtual exercises, or other technologies depends on their curricular positioning. Technology that is disconnected from curricular sequencing may increase novelty without improving conceptual understanding. Thus, technology integration must be guided by explicit principles concerning learning objectives, content progression, student needs, and assessment criteria. This requirement strengthens the argument for developing an overarching curriculum planning model capable of guiding blended mathematics instruction consistently across educational stages.

A further challenge involves differentiation. Mathematics classrooms typically include students with substantial differences in prior knowledge, learning pace, motivation, cognitive strategies, technological competence, and educational support. Curriculum planning must therefore balance common educational standards with responsiveness to individual learner needs. Research on differentiated instruction suggests that teachers' beliefs and mindsets substantially influence how they interpret and implement curricular differentiation, indicating that curriculum planning is not merely a technical process but also a pedagogical and professional one (14). In blended learning environments, differentiation can be supported through flexible pacing, varied digital resources, individualized assignments, alternative representations, and different pathways through learning activities. However, these possibilities require a structured curricular framework to ensure that flexibility does not lead to inconsistency or unequal learning expectations.

Contemporary curriculum planning is also increasingly influenced by data-informed and technology-supported decision-making. The growth of digital learning environments enables educators to access detailed information about learner participation, progress, assessment performance, and patterns of engagement. Data can therefore support more responsive curriculum implementation, including the adaptation of content, learning activities, and instructional support according to learner needs. Recent work on curriculum planning in technology-rich educational contexts has highlighted the potential of data-based approaches for supporting diversified educational experiences and adjusting curriculum implementation to learner characteristics (15). Within mathematics education, such possibilities may be especially valuable because students often display highly variable mastery profiles across mathematical domains. A blended curriculum can potentially use digital evidence to identify learning gaps, provide targeted practice, and support individualized progression, provided that these mechanisms are integrated coherently into the curriculum model.

Despite its advantages, blended learning also presents significant implementation challenges. Teachers may encounter difficulties in coordinating multiple instructional spaces, managing workload, selecting appropriate technologies, monitoring student participation, maintaining interaction, and ensuring that online and face-to-face activities operate as a unified learning sequence. Research has shown that blended learning can create navigational challenges for both teachers and learners when

instructional pathways, expectations, and transitions between learning environments are insufficiently clear (16). Broader analyses of blended learning similarly identify tensions between flexibility and structure, innovation and institutional constraints, technological opportunity and pedagogical coherence (7). These challenges indicate that successful blended education requires more than teacher improvisation. It requires a curriculum architecture that clearly specifies the relationships among educational goals, content, methods, learner roles, teacher roles, digital resources, and assessment.

The need for such an architecture is amplified when a curriculum must function across multiple educational stages. Elementary, lower secondary, and upper secondary mathematics differ substantially in cognitive complexity, instructional emphasis, learner independence, and disciplinary specialization. Nevertheless, these stages are not isolated systems; they form a continuous developmental trajectory. A common curriculum planning model should therefore identify principles that remain stable across levels while allowing their implementation to vary according to students' developmental characteristics. For example, problem-solving, mathematical reasoning, collaborative learning, self-regulation, digital literacy, and formative feedback may be important across all stages, yet the nature of tasks, degrees of independence, mathematical representations, and technological environments should evolve with learners' capabilities. Curriculum renewal at the school level similarly requires alignment among policy expectations, institutional capacity, teacher practice, and student needs, emphasizing that curricular reform is most effective when it is treated as a coordinated management and educational process rather than a set of disconnected modifications (17).

The development of a common framework is also important because curriculum innovation frequently occurs in fragmented forms. New technologies may be introduced without corresponding changes in assessment; active teaching strategies may be encouraged without revisions to curricular content; or curriculum objectives may emphasize higher-order thinking while classroom assessment continues to reward procedural reproduction. Such inconsistencies weaken curriculum implementation. A coherent blended curriculum model must therefore establish constructive alignment among objectives, content, instructional strategies, and assessment. The four dimensions are analytically distinguishable, yet they function interdependently. Objectives define the desired cognitive, skill-based, and attitudinal outcomes; content specifies the mathematical knowledge and experiences through which those outcomes are pursued; teaching strategies organize learner engagement with that content; and assessment provides evidence regarding the achievement of intended learning outcomes and informs subsequent instructional decisions.

Teacher expertise remains a critical condition for implementing such a model. Mathematics teachers need specialized knowledge for explaining mathematical concepts, interpreting students' reasoning, choosing representations, anticipating misconceptions, designing tasks, and connecting concepts across topics and grade levels (2, 3). In blended environments, these demands are extended by the need to select digital resources, design online learning activities, provide remote feedback, monitor student progress through technological platforms, and coordinate virtual and face-to-face instructional experiences. Therefore, curriculum planning models must be usable by teachers and sufficiently explicit to support instructional decision-making while remaining flexible enough to accommodate contextual variations. The curriculum should guide rather than rigidly prescribe teaching, enabling teachers to adapt implementation to learner needs without losing coherence with broader educational goals.

Another important consideration is the distinction between technology use and pedagogical transformation. The presence of online resources, electronic tests, or multimedia presentations does not in itself create meaningful blended learning. Blended learning becomes pedagogically significant when technological and face-to-face elements are deliberately integrated to improve learning opportunities, participation, interaction, feedback, and accessibility (4, 5). Experimental evidence concerning face-to-face components of blended courses further suggests that outcomes depend on how instructional components are

combined, rather than simply on the amount of online or classroom exposure (6). Consequently, mathematics curriculum planning should specify not only what technology is used but why, when, and how it contributes to mathematical learning.

The available literature therefore points to several interconnected requirements for contemporary mathematics curriculum planning: continuity across educational levels, coherent organization of mathematical knowledge, attention to specialized teaching knowledge, active and meaningful learning, opportunities for collaborative and metacognitive interaction, development of learner self-regulation, appropriate use of game-based and technology-mediated learning, differentiated instruction, data-informed flexibility, and systematic integration of physical and virtual learning environments (9, 11-15). At the same time, research on blended learning demonstrates that implementation can be weakened by fragmented design, unclear instructional pathways, insufficient integration, and failure to align technological possibilities with pedagogical purposes (8, 16). These concerns reveal a need to conceptualize blended mathematics education at the curriculum level rather than merely at the level of individual lessons or technologies.

Although existing studies provide valuable evidence concerning blended learning, mathematics pedagogy, curriculum theory, teacher knowledge, learner regulation, and technology-supported instruction, these areas are often examined separately. Relatively less attention has been devoted to identifying a unified set of curriculum planning components that can be applied across multiple stages of mathematics education while simultaneously incorporating the requirements of blended learning. A model developed exclusively for one educational stage may not address issues of vertical continuity, and a general blended learning model may not adequately reflect the cumulative and conceptually structured nature of mathematics. Similarly, curriculum models that were developed primarily for conventional classroom environments may not sufficiently address digital content, virtual interaction, online assessment, self-directed learning, or the changing roles of teachers and students. Addressing this gap requires an empirically grounded framework that integrates curriculum theory with the pedagogical and technological requirements of blended mathematics education and that is validated by practitioners representing different educational levels.

Accordingly, the aim of the present study was to design and validate a common mathematics curriculum planning model across different educational levels based on a blended learning approach.

Methods and Materials

Study Design and Participants

The present study was applied in terms of its purpose and employed an exploratory mixed-methods design with a sequential exploratory strategy for data collection and implementation. This methodological approach was selected because the development of a comprehensive curriculum planning model required an in-depth exploration and identification of its underlying components in the qualitative phase, followed by quantitative validation and examination of the generalizability of the proposed model. Accordingly, the study was conducted in two consecutive qualitative and quantitative phases. Data were collected through both library-based and field methods. In the qualitative phase, the study population consisted of relevant scientific and academic sources, including journal articles, books, theses, dissertations, and upstream educational documents addressing mathematics curriculum planning and blended education published between 2014 and 2025, as well as experts with specialized knowledge and professional experience in mathematics education and curriculum planning. The expert participants were selected using purposive sampling supplemented by the snowball technique, and sampling continued until theoretical saturation was achieved. The final qualitative sample consisted of 30 participants, including 15 curriculum planning specialists from Fars Province and 15 experienced mathematics teachers from the province. The participating mathematics teachers had more than 10 years of teaching experience and held doctoral degrees in mathematics. Individual semi-structured interviews

were conducted with these participants to obtain detailed accounts of the principles, components, requirements, and characteristics that should be incorporated into a common mathematics curriculum planning model applicable across different educational levels. The documentary evidence and interview data collectively constituted the empirical basis for developing the initial conceptual model.

The quantitative phase was conducted to validate the model developed through the qualitative findings. The statistical population in this phase consisted of all mathematics teachers working at the elementary, lower secondary, and upper secondary educational levels in Lamerd and Mohr during the 2024–2025 academic year. Stratified random sampling was employed to ensure proportional representation of teachers from the different educational levels, and the required sample was determined using Cochran's formula. The final quantitative sample comprised 271 teachers, including 195 elementary school teachers, 45 lower secondary mathematics teachers, and 31 upper secondary mathematics teachers. The use of stratified random sampling was intended to ensure that the proposed model was evaluated by teachers working across the principal stages of school education rather than being restricted to a single educational level. This procedure was particularly important because the central objective of the study was to formulate and validate a common mathematics curriculum planning framework capable of accommodating the shared curricular requirements of different educational stages while preserving the specific instructional characteristics of mathematics education at each level.

Data Collection Tools

Data collection in the qualitative phase was based on documentary review and individual semi-structured interviews. The documentary component included systematic examination of relevant articles, academic books, theses, dissertations, policy documents, and upstream educational documents related to mathematics curriculum planning and blended education within the specified publication period. This review provided the theoretical and conceptual foundation for identifying preliminary dimensions of the model and informed the development of the interview framework. Semi-structured interviews were subsequently conducted with curriculum planning specialists and experienced mathematics teachers. The interview format allowed the researcher to address predetermined areas related to mathematics curriculum goals, content organization, teaching and learning methods, assessment procedures, and the requirements of blended education while retaining sufficient flexibility to explore emerging concepts and participants' professional experiences in greater depth. Interviews continued until theoretical saturation, meaning that additional interviews no longer produced substantively new concepts or categories relevant to the proposed model.

In the quantitative phase, a researcher-developed questionnaire was used to assess and validate the components identified during the qualitative phase. The questionnaire was developed directly from the findings of the thematic analysis and was refined on the basis of the views of curriculum specialists, educational experts, and experienced mathematics teachers. The first section collected demographic and professional information, including gender, academic rank or professional status, field of study, age, and work experience. The second section consisted of 60 items designed to measure the components of the proposed mathematics curriculum planning model. Responses were recorded using a five-point Likert scale, enabling participants to indicate the extent to which they agreed with or endorsed each statement. The instrument operationalized the principal dimensions of the model, particularly curriculum objectives, curriculum content, teaching methods, and assessment, within the context of a blended mathematics curriculum.

The measurement quality of the questionnaire was evaluated through construct validity and reliability analyses. Convergent validity was examined using the average variance extracted, or AVE, to determine whether the indicators associated with each latent construct explained an acceptable proportion of the variance in that construct. The AVE values obtained for the model

components were within acceptable ranges, indicating adequate convergence among the indicators belonging to each component and providing empirical support for the coherence of the dimensions initially identified in the qualitative phase. Discriminant validity was assessed using the Fornell–Larcker criterion. The results demonstrated that the four principal components of the model, although significantly related to one another, represented empirically distinguishable constructs. This distinction was theoretically important because curriculum objectives, content, teaching methods, and assessment are expected to function interactively within mathematics curriculum planning while simultaneously retaining separate conceptual and operational roles. Reliability was assessed using Cronbach’s alpha and composite reliability. Both coefficients exceeded 0.70 for all study constructs, indicating satisfactory internal consistency and adequate reliability of the measurement instrument for subsequent structural analyses.

Data Analysis

Qualitative data obtained from the documentary sources and individual interviews were analyzed using thematic analysis. The analytical process involved repeated examination of the qualitative material, identification of meaningful units, generation of initial codes, comparison and integration of conceptually related codes, and their organization into higher-order themes and components. Particular attention was paid to recurring concepts concerning the objectives, content, instructional processes, and assessment requirements of mathematics curricula across educational levels and to the integration of face-to-face and technology-supported learning within a blended educational approach. Through continuous comparison and refinement of the extracted concepts, the initial codes were organized into coherent thematic categories that formed the conceptual architecture of the proposed common mathematics curriculum planning model. The resulting qualitative model was subsequently used as the basis for developing the quantitative questionnaire and specifying the measurement and structural models tested in the second phase.

Quantitative data were analyzed using both descriptive and inferential statistical procedures. Descriptive statistics were used to summarize the demographic characteristics of the participants and the distribution and central tendency of responses to the questionnaire items and model components. Inferential analysis focused on the empirical validation of the proposed model. Confirmatory factor analysis was performed to determine whether the observed indicators adequately represented the latent dimensions derived from the qualitative phase. Structural equation modeling was then used to evaluate the relationships among the model components and to assess the overall explanatory and predictive adequacy of the proposed curriculum planning framework. Measurement-model assessment included examination of indicator performance, internal consistency reliability, composite reliability, convergent validity through AVE, and discriminant validity based on the Fornell–Larcker criterion. The structural model was subsequently examined to determine the strength and significance of the relationships among the proposed dimensions and to establish whether the empirically observed structure supported the conceptual model developed during the qualitative phase. Statistical analyses were performed using SPSS for descriptive analyses and preliminary data processing and SmartPLS for measurement-model evaluation, confirmatory analyses, and partial least squares structural equation modeling.

Findings and Results

Given the mixed-methods nature of the study, the findings were analyzed and reported in two complementary stages: qualitative analysis and quantitative analysis. The qualitative phase was concerned with identifying and organizing the shared components of mathematics curriculum planning within a blended educational approach, whereas the quantitative phase focused on validating the extracted structure and assessing the measurement quality, reliability, validity, predictive relevance, and overall fit of the proposed model.

The qualitative data obtained from the semi-structured interviews were analyzed using thematic analysis. The coding and theme-development process resulted in a hierarchical conceptual framework consisting of four overarching themes, 16 organizing themes, and 48 basic themes. The four overarching themes represented the principal components of the common mathematics curriculum planning model and included curriculum objectives, content, teaching methods, and assessment. Each overarching theme incorporated four organizing themes, and each organizing theme was represented by three basic themes. The resulting thematic structure is presented in Table 1.

Table 1. Key Common Components of Mathematics Curriculum Planning Derived from the Semi-Structured Interviews

Overarching Theme	Organizing Theme	Basic Themes
Curriculum Objectives	Cognitive objectives	Enhancement of critical thinking; development of problem-solving and self-directed thinking; cultivation of creativity
Curriculum Objectives	Skill-based objectives	Strengthening digital literacy; development of self-directed learning; enhancement of collaborative skills
Curriculum Objectives	Attitudinal objectives	Responsibility for learning; enhancement of motivation; strengthening lifelong learning
Curriculum Objectives	Objectives appropriate to educational level	Attention to developmental characteristics; flexibility of objectives; alignment with learners' needs
Content	Content organization	Vertical continuity; horizontal coherence; logical sequencing
Content	Characteristics of blended content	Integration of face-to-face and virtual resources; multimedia content; interactive content
Content	Content appropriateness	Alignment with educational level; alignment with individual needs; alignment with technology
Content	Content updating	Flexibility in content revision; use of online resources; continuous updating
Teaching Methods	Active teaching strategies	Collaborative learning; project-based learning; problem-based learning
Teaching Methods	Blended learning	Integration of face-to-face and virtual instruction; instructional time management; diversity of learning environments
Teaching Methods	Teacher's role	Learning facilitation; guidance of the learning process; continuous feedback
Teaching Methods	Student's role	Active participation; self-regulated learning; continuous interaction
Assessment	Formative assessment	Continuous feedback; process-based assessment; improvement of learning
Assessment	Summative assessment	Performance assessment; competency assessment; blended examinations
Assessment	Assessment tools	Electronic testing; electronic portfolios; performance-based projects
Assessment	Assessment quality	Educational equity; validity and reliability; diversity of assessment methods

The qualitative findings indicated that the proposed model was not limited to the transmission of mathematical content. Rather, it reflected an integrated curriculum architecture in which objectives, content, teaching processes, and assessment mechanisms were mutually connected. Within the objectives dimension, the participants emphasized cognitive development, skill acquisition, learner attitudes, and adaptation to the developmental requirements of different educational levels. The content dimension emphasized curricular continuity, appropriate sequencing, integration of physical and digital resources, responsiveness to individual and technological requirements, and continuous updating. Teaching methods were characterized by active learning, integration of face-to-face and virtual environments, a facilitative role for teachers, and active and self-regulated participation by students. Finally, assessment was conceptualized as a multidimensional process incorporating formative and summative procedures, technology-supported assessment tools, performance-oriented tasks, and attention to equity, validity, reliability, and methodological diversity.

Following development of the qualitative framework, the proposed model was quantitatively evaluated using partial least squares structural equation modeling in SmartPLS. One of the capabilities of PLS-SEM is the evaluation of hierarchical or higher-order latent-variable structures. In higher-order factor models, first-order latent constructs measured through observed indicators are themselves conceptualized as manifestations of a more general underlying construct. In the present study, the four dimensions of curriculum objectives, content, teaching strategies, and assessment were considered indicators of the higher-

order construct of common mathematics curriculum planning based on a blended approach. Accordingly, higher-order confirmatory analysis was performed to examine the measurement structure and empirical validity of the proposed model.

The PLS output for the overall confirmatory model is represented conceptually in Figure 1.

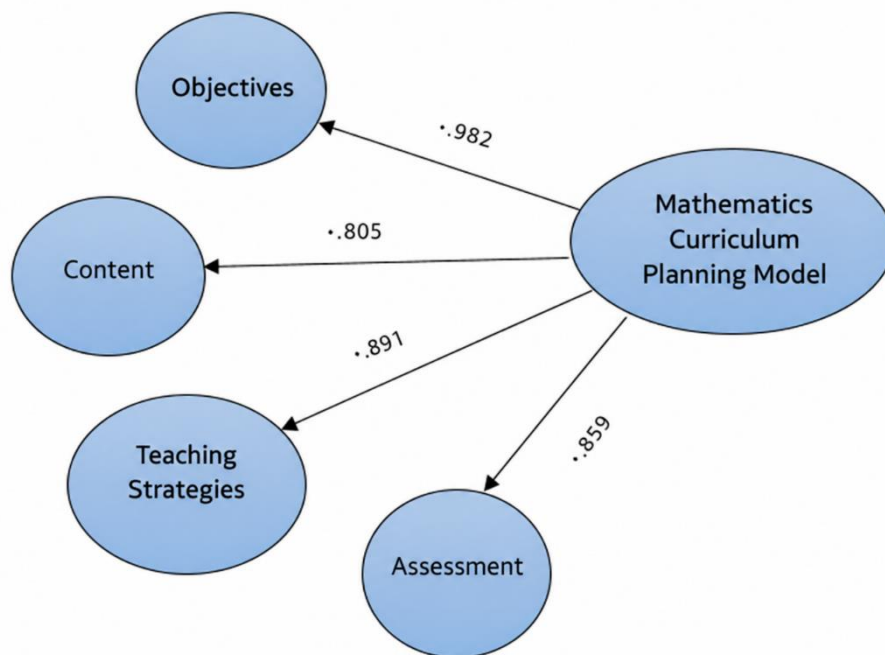


Figure 1. PLS Output for Confirmatory Factor Analysis of the Overall Common Mathematics Curriculum Planning Model Based on a Blended Approach

The results of the confirmatory analysis showed that all four dimensions were strongly associated with the higher-order mathematics curriculum planning construct. Among the dimensions, curriculum objectives exhibited the largest factor loading, with a value of .982, indicating that this dimension had the strongest contribution to the overall construct. Content exhibited the smallest loading, although its loading of .805 remained high and clearly exceeded the minimum acceptable threshold. Teaching strategies and assessment also demonstrated strong factor loadings of .891 and .859, respectively. The corresponding *t* values were also sufficiently large, supporting the statistical significance of the measurement relationships. The results are reported in Table 2.

Table 2. Factor Loadings, Explained Variance, and *t* Values for the Common Mathematics Curriculum Planning Model

Dimension	Factor Loading	R ²	<i>t</i>
Curriculum Objectives	.982	.82	32.50
Content	.805	.79	25.32
Teaching Strategies	.891	.72	26.85
Assessment	.859	.68	22.78

As shown in Table 2, all factor loadings were considerably greater than .40. The findings therefore supported the adequacy of the indicators in representing the higher-order curriculum planning construct. The magnitude of the loadings also demonstrated that the four dimensions made substantial contributions to the overall model, with curriculum objectives showing the strongest standardized loading, followed by teaching strategies, assessment, and content.

The reliability of the proposed model was first evaluated using Cronbach's alpha. All Cronbach's alpha coefficients exceeded the commonly accepted criterion of .70. Content obtained the highest Cronbach's alpha coefficient at .92, followed by curriculum objectives at .90, teaching strategies at .89, and assessment at .82. These findings indicate satisfactory to very high internal consistency across all dimensions of the instrument.

Table 3. Cronbach's Alpha Coefficients for the Components of the Common Mathematics Curriculum Planning Model

Curriculum Component	Cronbach's Alpha
Content	.92
Curriculum Objectives	.90
Teaching Strategies	.89
Assessment	.82

Composite reliability was also calculated because it provides an additional estimate of internal consistency that is particularly appropriate for latent-variable modeling in PLS-SEM. As presented in Table 4, all composite reliability coefficients exceeded .70. Content demonstrated the highest composite reliability at .95, followed by teaching strategies at .92, curriculum objectives at .89, and assessment at .78. Therefore, both Cronbach's alpha and composite reliability supported the reliability of the measurement model.

Table 4. Composite Reliability of the Components of the Common Mathematics Curriculum Planning Model

Curriculum Component	Composite Reliability
Curriculum Objectives	.89
Content	.95
Teaching Strategies	.92
Assessment	.78

Convergent validity was examined using the average variance extracted. AVE reflects the proportion of variance in the indicators that is explained by their corresponding latent construct. Values above .50 indicate that a construct explains more than half of the variance of its indicators and are generally considered evidence of acceptable convergent validity. As presented in Table 5, the AVE values were .78 for content, .69 for curriculum objectives, .75 for teaching strategies, and .80 for assessment. All values therefore exceeded the .50 criterion and supported satisfactory convergent validity for each dimension.

Table 5. Convergent Validity of the Components of the Common Mathematics Curriculum Planning Model

Curriculum Component	AVE
Content	.78
Curriculum Objectives	.69
Teaching Strategies	.75
Assessment	.80

The AVE findings further indicated that the indicators derived from the qualitative phase demonstrated adequate empirical coherence in the quantitative phase. Assessment showed the highest AVE value, followed by content, teaching strategies, and curriculum objectives. Nevertheless, all four dimensions were substantially above the recommended threshold, indicating that the indicators within each construct shared a sufficient proportion of common variance.

Discriminant validity was subsequently examined to determine whether the four curriculum components represented distinguishable dimensions rather than empirically redundant constructs. The interconstruct relationships reported for the model are presented in Table 6. Although relatively strong associations were observed among the dimensions, the analysis indicated

that curriculum objectives, content, teaching strategies, and assessment retained distinct conceptual roles within the proposed model.

Table 6. Discriminant Validity Matrix for the Components of the Common Mathematics Curriculum Planning Model

Curriculum Component	Content	Curriculum Objectives	Teaching Strategies	Assessment
Content	1.00			
Curriculum Objectives	.78	1.00		
Teaching Strategies	.84	.90	1.00	
Assessment	.89	.88	.85	1.00

The matrix demonstrated substantial relationships among the four dimensions, which was theoretically expected because they constitute interconnected elements of a unified curriculum planning framework. At the same time, the model treated each component as conceptually distinct. Thus, objectives determine the intended learning outcomes, content represents what is to be learned, teaching strategies specify how learning is facilitated, and assessment provides evidence regarding the extent and quality of learning achievement.

The structural quality of the model was also examined through the coefficient of determination, R^2 . This statistic represents the proportion of variance in an endogenous construct explained by its predictors. Greater R^2 values indicate stronger explanatory performance of the structural model. Following commonly used PLS-SEM interpretations in which values around .19, .33, and .67 have been described as weak, moderate, and substantial, respectively, the coefficients obtained in this study indicated substantial explanatory power.

As shown in Table 7, the R^2 value was .76 for content, .83 for curriculum objectives, .91 for teaching strategies, and .78 for assessment. Teaching strategies therefore exhibited the highest explained variance, while content had the lowest; nevertheless, all four coefficients were high. These findings indicate that the proposed model explained a substantial proportion of variance in each of its major curriculum components.

Table 7. Coefficient of Determination for the Components of the Common Mathematics Curriculum Planning Model

Curriculum Component	R^2
Content	.76
Curriculum Objectives	.83
Teaching Strategies	.91
Assessment	.78

Predictive Relevance of the Model

The Q^2 index was used to evaluate the predictive relevance of the structural model. This criterion assesses whether the model possesses sufficient predictive capacity with respect to its endogenous constructs. Positive Q^2 values indicate predictive relevance, and values of approximately .02, .15, and .35 are commonly interpreted as reflecting small, medium, and large predictive relevance, respectively. The values obtained in this study were all above .35, indicating strong predictive relevance for the four principal dimensions.

The detailed results of the predictive relevance assessment, including the sum of squares of observations, the sum of squares of prediction errors, and the resulting Q^2 values, are presented in Table 8. Q^2 values ranged from .367 to .403. Curriculum objectives produced the highest predictive relevance value at .403, followed by assessment at .398, teaching strategies at .387, and content at .367. Therefore, the structural model demonstrated strong predictive capacity across all components.

Table 8. Predictive Relevance Analysis for the Components of the Common Mathematics Curriculum Planning Model

Curriculum Component	SSO	SSE	Q ² (1 – SSE/SSO)
Content	2201.60	1361.66	.367
Curriculum Objectives	1164.00	591.34	.403
Teaching Strategies	1059.00	646.95	.387
Assessment	903.40	876.87	.398

The positive Q² coefficients confirmed that the proposed model was not limited to explaining relationships within the observed sample but also possessed meaningful predictive relevance. In particular, all four Q² coefficients exceeded the threshold associated with strong predictive performance, providing further support for the structural adequacy of the proposed common mathematics curriculum planning model.

Finally, the overall goodness of fit of the PLS model was evaluated using the GOF index. This index provides an overall assessment of the quality of the PLS model by integrating information related to both the measurement and structural components of the model. The index is generally calculated from the geometric mean of the average communality and the average coefficient of determination:

$$GOF = \sqrt{Comm\bar{unality} \times \bar{R}^2}$$

GOF values range between zero and one, with larger values representing stronger overall model quality. Values of approximately .10, .25, and .36 are commonly interpreted as indicating small, medium, and large goodness of fit, respectively. In the present study, all obtained values exceeded .36, demonstrating strong overall model fit. The component-specific GOF values are presented in Table 9.

Table 9. Goodness-of-Fit Analysis for the Components of the Common Mathematics Curriculum Planning Model

Curriculum Component	GOF
Content	.39
Curriculum Objectives	.53
Teaching Strategies	.48
Assessment	.49

As shown in Table 9, curriculum objectives achieved the highest GOF value at .53, followed by assessment at .49, teaching strategies at .48, and content at .39. Since all values exceeded the criterion associated with strong goodness of fit, the findings supported the overall quality of the proposed PLS model. Taken together, the factor loadings, internal consistency coefficients, composite reliability values, AVE coefficients, discriminant validity results, coefficients of determination, predictive relevance indices, and GOF statistics provided empirical support for the quantitative validation of the common mathematics curriculum planning model based on a blended approach.

Discussion and Conclusion

The present study was conducted to design and validate a common mathematics curriculum planning model across different educational levels based on a blended learning approach. The findings produced a multidimensional model consisting of four overarching components: curriculum objectives, content, teaching strategies, and assessment. These components were further represented by 16 organizing themes and 48 basic themes identified through thematic analysis of the qualitative data. The quantitative phase subsequently confirmed the empirical adequacy of the proposed model. The higher-order confirmatory analysis showed that all four components had strong factor loadings on the overall mathematics curriculum planning construct. Curriculum objectives had the highest factor loading (.982), followed by teaching strategies (.891), assessment (.859), and

content (.805). All loadings were substantially above the minimum acceptable level, indicating that the identified components represented the overarching construct adequately. Reliability was also satisfactory, with Cronbach's alpha coefficients ranging from .82 to .92 and composite reliability coefficients ranging from .78 to .95. Convergent validity was supported by AVE values between .69 and .80, while the structural indices indicated substantial explanatory and predictive capacity. The R^2 coefficients ranged from .76 to .91, Q^2 values ranged from .367 to .403, and GOF values ranged from .39 to .53. Taken together, these findings demonstrate that the proposed model possesses satisfactory internal consistency, construct coherence, predictive relevance, and overall structural quality.

One of the most important findings was the central position of curriculum objectives in the proposed framework. The objectives dimension had the highest factor loading and the largest GOF value among the four components, indicating that the direction and coherence of mathematics curriculum planning are strongly dependent on clearly formulated learning objectives. The qualitative findings showed that these objectives should encompass cognitive, skill-based, attitudinal, and developmental dimensions. Specifically, critical thinking, problem-solving, creativity, digital literacy, self-directed learning, collaboration, responsibility for learning, motivation, lifelong learning, and developmental appropriateness emerged as important components. This result is consistent with contemporary curriculum theory, which emphasizes that curriculum planning should move beyond the transmission of isolated subject matter and instead articulate purposeful educational outcomes that organize content, pedagogy, and assessment around broader forms of knowledge and capability (1). The result also corresponds with recent approaches to curriculum renewal that emphasize flexibility, learner-centeredness, and responsiveness to changing educational and social requirements (17).

The prominence of objectives can also be understood in relation to the specific nature of mathematics education. Mathematics learning involves more than procedural accuracy; it requires conceptual understanding, reasoning, problem-solving, explanation, and the capacity to apply knowledge in unfamiliar situations. Research on mathematics teaching has emphasized that teachers require specialized content knowledge to transform mathematical concepts into learnable forms and to support students' progressive development of mathematical understanding (2, 3). Accordingly, a curriculum model that explicitly defines cognitive and skill-based objectives can provide a clearer basis for choosing content, designing learning experiences, and determining appropriate assessment procedures. The present findings suggest that a common curriculum across educational levels should preserve continuity in broad learning aims while allowing the complexity and manifestation of those aims to change according to developmental level.

The content dimension also constituted a significant component of the proposed model. The qualitative findings indicated four major requirements: appropriate organization of content, characteristics of blended content, alignment of content with learners and educational levels, and continuous updating. Vertical continuity, horizontal coherence, logical sequencing, integration of face-to-face and digital resources, multimedia and interactive content, responsiveness to individual needs, and ongoing revision were all identified as essential. Although content had the lowest factor loading among the four components, its loading remained high, indicating a substantial contribution to the overall model. This finding is compatible with curriculum perspectives that regard content as meaningful only when it is organized in relation to educational purposes, pedagogical processes, and the structure of disciplinary knowledge (1). In mathematics in particular, where knowledge is cumulative, vertical coherence is indispensable because weaknesses in foundational concepts can restrict later understanding.

The emphasis on interactive and technology-supported content is also consistent with the theoretical basis of blended learning. Blended learning has been defined as a deliberate integration of face-to-face instruction with online or technologically mediated learning rather than a simple coexistence of two modes (4). Therefore, blended mathematics content must be structured so that digital and classroom materials complement rather than duplicate one another. Graham and Halverson argue

that the quality of blended learning depends fundamentally on purposeful integration among learning environments, pedagogical intentions, and technological affordances (5). Similarly, Buhl-Wiggers and colleagues showed that the effectiveness of blended education depends not merely on adding online components but on how face-to-face and digital components are designed in relation to one another (6). The present findings support this view by demonstrating that blended content should be interactive, adaptable, continuously updated, and appropriate to both learners' educational level and technological conditions.

The teaching strategies component was another strongly supported dimension of the model and showed the second-highest factor loading. The qualitative findings emphasized active teaching strategies, blended learning, the changing role of the teacher, and the active role of the student. Collaborative learning, project-based learning, problem-based learning, integration of virtual and face-to-face instruction, instructional time management, diversity of learning environments, facilitation by teachers, continuous feedback, active participation, and self-regulated learning were identified as essential features. This result is consistent with research showing that meaningful mathematics learning is strengthened when students actively construct relationships among concepts, engage in problem-solving, and participate in cognitively meaningful learning activities (9). It also aligns with evidence showing that mathematical discussion and comparison can support deeper reasoning when cognitive demands are appropriately managed (10).

The importance attributed to collaborative and self-regulated learning is particularly noteworthy. Mathematics learning often requires students to articulate reasoning, compare strategies, identify errors, and revise their understanding through interaction. Smith and Mancy found that collaborative mathematical problem-solving can involve important forms of shared metacognitive regulation in which learners jointly monitor, evaluate, and direct their reasoning processes (11). Likewise, Lim and colleagues reported meaningful associations among peer learning, self-regulated learning, and academic achievement in blended learning contexts (12). These findings help explain why the present model places active participation, continuous interaction, and self-regulation within the teaching strategies dimension. In a blended mathematics curriculum, learners must often manage part of their learning outside direct classroom supervision, making self-regulatory competence especially important.

The results further support the idea that the role of the teacher changes within blended learning environments. Rather than functioning primarily as a transmitter of content, the teacher increasingly assumes responsibility for facilitating learning, organizing interactions, diagnosing learning difficulties, guiding students between digital and face-to-face activities, and providing timely feedback. This interpretation is consistent with studies showing that blended learning creates both pedagogical opportunities and implementation challenges that require teachers to navigate multiple instructional environments effectively (7, 16). The findings of Darmawan and colleagues similarly indicate that blended approaches can create flexible and participatory learning opportunities when instructional activities are deliberately coordinated across technological and classroom contexts (8). Therefore, the strong loading of the teaching strategies dimension in the present study appears theoretically justified.

The findings concerning assessment also constitute an important contribution. Assessment was represented by formative assessment, summative assessment, assessment tools, and assessment quality. Continuous feedback, process-oriented measurement, improvement of learning, performance assessment, competency assessment, electronic tests, electronic portfolios, performance-based projects, educational equity, validity, reliability, and methodological diversity were all identified as necessary components. The relatively high factor loading of the assessment dimension indicates that assessment should be considered an integral part of curriculum architecture rather than an endpoint added after instruction. In blended mathematics education, assessment must capture not only final achievement but also learning processes, strategy use, participation, collaboration, and performance across physical and digital environments.

This finding is consistent with the broader logic of blended learning research. Because learners operate across multiple learning environments, assessment systems must also be sufficiently flexible to collect evidence from different forms of activity. The integration of online and face-to-face assessment can provide more frequent feedback and allow students to monitor their own progress. This is particularly relevant to self-regulated learning, which depends on learners receiving information about performance and using that information to adjust subsequent strategies (12). Technology-supported environments can further extend assessment through electronic tests, digital portfolios, interactive tasks, and data generated by learning platforms. Recent work on data-informed curriculum planning has highlighted the potential of digital information to support more responsive and differentiated educational decisions (15). The present findings extend this perspective by situating technology-supported assessment within a unified mathematics curriculum framework.

The model's emphasis on differentiated and flexible curriculum design is also supported by previous research. The qualitative results showed that content and objectives should be adapted to learners' needs, developmental characteristics, educational stage, and technological circumstances. Maia and Freire demonstrated that teachers' orientations toward differentiated instruction influence how curriculum planning is interpreted and implemented in practice (14). This is relevant to mathematics education because learners frequently differ substantially in prior knowledge, pace of learning, confidence, and preferred forms of representation. A common curriculum model should therefore establish shared principles without requiring identical implementation for all students or stages. The model developed in this study appears to accommodate this requirement through flexibility in objectives, content adaptation, multiple teaching methods, and diverse assessment strategies.

The emphasis on digital and interactive learning also corresponds with research on technology-enhanced mathematics instruction. Tokac and colleagues found that game-based learning can positively influence mathematics achievement, illustrating the potential value of technology-mediated, interactive learning experiences when these are aligned with educational objectives (13). However, such approaches are likely to be most effective when they are incorporated coherently into the curriculum rather than introduced as isolated innovations. This interpretation supports the structure of the present model, in which digital tools are not treated as a separate component but are embedded across objectives, content, teaching strategies, and assessment.

The quantitative validation results further reinforce the conceptual coherence of the model. High Cronbach's alpha and composite reliability coefficients indicate that the components were measured consistently, while AVE values above .50 provide support for convergent validity. The substantial R^2 coefficients suggest that the structural model explains a large proportion of variance in its key dimensions, particularly teaching strategies. The Q^2 values above .35 indicate strong predictive relevance, while the GOF values above .36 support strong overall model quality. These findings are important because they suggest that the four dimensions identified qualitatively are not merely descriptive categories but form a coherent empirical structure. The strong relationships among the components also reflect the interconnected nature of curriculum planning: objectives guide content selection, content shapes pedagogical possibilities, teaching strategies influence how learners encounter that content, and assessment determines the extent to which intended learning outcomes have been achieved.

The interdependence among these dimensions is consistent with the broader literature on blended learning. Effective blended learning requires alignment among technology, instructional design, pedagogy, learner activity, and assessment (5). When these dimensions are poorly coordinated, learners may experience fragmented learning pathways and uncertainty regarding expectations, tasks, and modes of participation (16). Hill and Smith similarly emphasize that blended learning presents both opportunities and challenges at institutional and pedagogical levels, particularly when technological innovation is introduced without sufficient structural coherence (7). The model validated in the present study addresses this issue by providing a curriculum-level framework rather than focusing solely on isolated instructional techniques.

Another important contribution of the study is its cross-level orientation. Much of the existing literature has examined blended learning in particular educational settings or specific courses, whereas the present study sought to identify shared curriculum planning principles applicable across elementary, lower secondary, and upper secondary mathematics education. The findings suggest that common principles can indeed be identified, particularly in relation to critical thinking, problem-solving, active learning, blended content, teacher facilitation, learner self-regulation, formative feedback, and diverse assessment. At the same time, the model allows these principles to be adjusted according to developmental characteristics and educational stage. This balance between continuity and flexibility may be particularly valuable in mathematics, where conceptual progression across grades is essential.

The present study has several limitations that should be considered when interpreting its findings. The qualitative participants were selected from Fars Province, and the quantitative phase was restricted to mathematics teachers in Lamerd and Mohr; therefore, the findings may reflect contextual characteristics of these educational settings and should not automatically be generalized to all regions or educational systems. In addition, the quantitative validation relied primarily on teachers' responses to a researcher-developed questionnaire, which may be influenced by self-report bias, professional expectations, or participants' familiarity with blended learning. The study validated the structural relationships among the proposed curriculum components but did not examine the model through direct classroom implementation or longitudinal evaluation of student outcomes. Moreover, technological infrastructure, school resources, teacher digital competence, and access inequalities were not examined as independent contextual variables, although they may substantially influence the feasibility of blended curriculum implementation.

Future studies should validate the proposed model in broader and more diverse samples drawn from different provinces, school systems, and socioeconomic contexts. Comparative studies across elementary, lower secondary, and upper secondary education could examine whether the relative importance of the model components changes across educational stages. Further research could also employ longitudinal or experimental designs to determine whether implementation of the model improves mathematics achievement, problem-solving, critical thinking, self-regulated learning, motivation, or digital competence. Researchers may additionally examine the perspectives of students, school administrators, curriculum designers, and parents to complement teacher-based evidence. Multi-group structural equation modeling could be used to investigate measurement invariance across gender, teaching experience, educational level, or school type. Future studies should also explore how technological readiness, access to digital resources, teacher professional competence, and organizational support moderate the effectiveness of the proposed curriculum model.

In practice, curriculum planners should use the proposed model as an integrated framework in which objectives, content, teaching strategies, and assessment are designed concurrently rather than independently. Mathematics objectives should include conceptual, cognitive, skill-based, and attitudinal outcomes appropriate to each educational level, while maintaining continuity across grades. Curriculum content should combine face-to-face and digital resources, employ interactive and multimedia materials, and be updated regularly. Teachers should be supported through professional development focused on active learning, blended instructional design, facilitation, formative feedback, and management of digital learning environments. Schools should also provide reliable technological infrastructure and equitable student access to digital resources. Assessment systems should combine formative, summative, performance-based, and electronic methods and should provide continuous feedback that supports learning improvement. Finally, curriculum implementation should preserve a shared framework across educational levels while allowing teachers sufficient flexibility to adapt activities, resources, pacing, and assessment procedures to the developmental and individual needs of their students.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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