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Validation of a Project-Based Curriculum Model for the Sixth-Grade Work and Technology Course

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ABSTRACT

Purpose: This study aimed to design and validate a project-based curriculum model for the sixth-grade "Work and Technology" course using expert consensus through the fuzzy Delphi method.

Methods and Materials: Adopting a sequential exploratory mixed-methods design, the study began with semi-structured interviews with 15 curriculum experts. Thematic analysis identified initial indicators structured around ten curriculum components. In the quantitative phase, a three-round fuzzy Delphi technique was applied. Indicators were validated using fuzzy aggregation and defuzzification (threshold $D \geq 0.7$). MAXQDA and SPSS were used for data analysis.

Findings: Out of 68 initial indicators, 5 were removed, 3 added, and 3 revised during the qualitative phase. In Delphi round two, 57 indicators were confirmed, and 9 were submitted to round three. Ultimately, 5 additional indicators were validated and 4 rejected. The final model includes 10 core components and 62 validated indicators.

Conclusion: The validated model provides a localized and structured framework for implementing project-based learning in elementary education and can guide curriculum design, content development, and teacher training.

Keywords: *project-based curriculum, work and technology, elementary education, fuzzy Delphi, model design, thematic analysis*

1. Introduction

The rapid transformations in technology, economy, and society in the 21st century have confronted educational systems with new challenges and expectations. Under such circumstances, traditional education models based on the transmission of information no longer address the multilayered and dynamic needs of the new generation of learners. Therefore, educational systems around the world are seeking approaches capable of integrating theoretical knowledge with practical skills, critical thinking, problem-solving, self-directed learning, and teamwork. Project-Based Learning (PBL) has emerged as a transformative, learner-centered approach in education in response to this need (Zhang & Ma, 2023).

Project-Based Learning not only shifts the instructional structure from passive to participatory but also, through the creation of meaningful and real-world contexts, fosters the development of systematic thinking, scientific curiosity, and communication skills among students (Pantiwati et al., 2023; Shekh-Abed, 2024). Numerous studies have confirmed that PBL can enhance deep learning, metacognitive abilities, self-efficacy, and even students' sense of social identity (Ebadi et al., 2024; Palashi et al., 2023). In this framework, the emphasis on designing a coherent and structured curriculum based on projects is considered a necessary prerequisite for the effective implementation of this instructional approach (Bouhaï, 2025).

In Iran, although the concept of project-based education has been mentioned in policy documents and reformative education strategies—particularly in the Fundamental Reform Document of Education—school curricula, especially at the elementary level, continue to focus predominantly on theoretical instruction and the transmission of static content. However, the "Work and Technology" textbook in the sixth grade has been designed with the aim of fostering practical skills, problem-solving, and creativity, and it holds significant potential for implementing a project-based model (Moghami et al., 2023). Nevertheless, the absence of a localized and validated model for the effective implementation of PBL in this subject has left teachers either confused about project implementation or resorting to symbolic applications of projects (Jame Bozorg et al., 2023).

Globally as well, the development of project-based curriculum models requires a clear understanding of the influential components, their interrelationships, and how they should be applied across different cultural contexts and educational levels (Dan, 2025). In this regard, attention to the ten curriculum elements—such as objectives, content, instructional strategies, activities, resources, the roles of teacher and student, learning environment and timing, and assessment systems—is crucial for the effective structuring of PBL (Sun, 2023). Designing such a model requires the active participation of experts and the use of scientific methods for component analysis and screening.

Empirical evidence from various studies has confirmed the advantages of project-based learning in fostering a wide range of cognitive, social, and technological competencies. For example, one study found that using online PBL enhanced students' academic achievement and cognitive engagement. Additionally, (Umar & Ko, 2022), within the framework of virtual education, emphasized the importance of team cohesion, flipped learning, and team synergy in project contexts. Similarly, (Kontsevyi, 2024) addressed the use of virtual teams in project-based organizations for improving productivity and communication skills. Such findings highlight the substantial potential of project-based learning in cultivating 21st-century skills.

On the other hand, components such as learning experience design, scaffolding, formative assessment, and the teacher's active role as a facilitator play a central role in the success of PBL models (Veraksa et al., 2023; Zenkov, 2023). Specifically, the study by (Hou et al., 2023) in the field of green building education using virtual reality demonstrated that integrating technology with practical projects can significantly increase student motivation and engagement. From a psychological perspective, the findings of (Coufal, 2022) indicate that STEM project-based education with the use of educational robots effectively enhances problem-solving and computational thinking skills.

Furthermore, domestic studies such as (Arabloo et al., 2022) have shown the positive impact of using technology in project-based language learning environments on improving students' critical thinking and problem-solving. The study by (Pirzadeh & Lingard, 2021) also focused on the psychological and health-related effects of PBL in work environments, indicating that conflict management, interpersonal interaction, and self-monitoring within project settings contribute to increased resilience.

Despite this evidence, the design of a precise and validated model for implementing PBL in formal education—particularly in the sixth grade—still faces significant challenges. First, most existing models have been developed within academic or secondary education contexts and rarely address the needs of children in elementary education (Lin et al., 2021). Second, many models lack conceptual coherence and a structured integration of curriculum components. Moreover, the successful implementation of these models requires active teacher participation, redesigning of learning environments, use of diverse resources, and the creation of multifaceted assessment systems, elements that are often absent in current educational plans (Prasopsuk et al., 2024).

In response to this gap, the present study aims to design and validate a project-based curriculum model for the sixth-grade "Work and Technology" course. Methods and Materials

The present study sought to examine the effect of authentic listening materials (i.e., the independent variable) on enhancing listening ability of Iranian advanced EFL learners (i.e., the dependent variables) using pretest and posttest design. There were one control and one experimental group in the study. Hence, it was a quasi-experimental research (non-randomized experimental design).

The population of the present study included 120 EFL learners studying English as a foreign language who were conveniently sampled from Setareh language institute in Tehran, Iran. The learners varied in age from 16 to 26 years old with the mean age of 21. Most of the EFL learners studied English for an average period of 2.5 to 3.5 years, mainly through private language institutes. In order to choose a homogenous sample, Oxford Placement Test (OPT) was administered to the whole population of the study. Then those learners whose scores were between 50-60 on the OPT were considered as the advanced learners and participated in this study. Then, the participants were randomly divided into two equal groups, namely one experimental group and one control group. Each group consisted of 30 EFL learners. In order to do the research, some instruments were used which are as follows:

The OPT was administered among the learners to choose participants who were homogenous. The test helped the researcher to make sure if all of the participants were in advanced level of proficiency. The OPT helps language teachers quickly measure a learner's general language ability so they can place him or her into the appropriate level class for a language course. This test consists of 60 multiple-choice items.

The participants of the study were given two versions of listening tests as the pretest and posttest. The researcher used TOEFL Internet based test (IBT), which was a standardized and reliable test to measure the English language ability of non-native speakers of English. The TOEFL IBT measures language learners' ability to use and understand English at different level of language proficiency. The test is considered as a valid test that measures English language learners' proficiency level in English. It is accepted worldwide and its validity has been approved frequently.

In the study, two main teaching materials were used to achieve the purpose of the research. With regard to authentic audio materials, they were a group of online authentic listening sections (8 sections) derived from British radio on L.B.C. 97.3 presented to authentic group to measure their influence on listening comprehension ability. Moreover, they were selected based on the advanced-level course. Regarding non-authentic materials, 8 listening sections were selected from American English File 4 written by Latham-Koenig and Oxenden (2018) because the course book was taught to advanced learners in Setareh Language Institute.

As procedure, having homogenized and classified the learners into the groups, the learners' performance in listening comprehension before the treatment was measured. The listening test was administrated to all participants of the study as the pretest. The next step was to administer the treatment. After administer the listening pretest, both groups (the experimental and control groups) received the treatment. The whole instruction for the experimental and control groups took place in 16 sessions (each group received 8 sessions) and each session lasted for 90 minutes. With regards to the experimental group, the learners received the authentic listening materials. Each session, one listening section was presented to the experimental group. The listening sections were selected from the British radio on LBC. 97.3. The researcher selected the different audios and recorded them. Among them, eight appropriate ones were selected to be presented to the classes. The audios with American English accents were selected. The audios' topics were academic education, air pollution, employment, Iran nuclear agreement etc. In the class, the language teacher and the learners were active participants in learning process. The teacher gave an introduction about the audio. In other words, the teacher provided the learners with background knowledge and warm up activities. Then, she asked her learners to talk about the topic (for example, Iran nuclear agreement). The learners shared their ideas about the topic with each other. That is to say, the researcher tried to activate and stimulate the EFL learners' schemata related to the audio and encourage the EFL learners to listen to the audio carefully. Now, the teacher played the audio and asked the learners to listen carefully. The process was repeated for several times. Having repeated the voice, the learners were asked some questions in order to find out whether they comprehended the audio or not. Generally, the learners comprehended the audio but they did not understand the meaning of some difficult words. To solve the problem, the teacher asked the learners to write the words on the boards. Then, with the cooperation of the learners, the unknown and difficult words were defined. Having finished the steps, the teacher asked the learners to summarize the audio with their own words and the topic were discussed by the teacher and the learners in the class.

Regarding the control group, the learners received non-authentic listening materials from the English course book (e.g., American English File 4) which the contents of this

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book were not authentic. Each session, one non-authentic audio was taught to the control group. It should be noted that method of teaching in both groups were the same and only the materials were different because the researcher intended to know the effect of the materials on listening comprehension. In other words, with regard to the control group, everything was similar to that of experimental group, except that there were different audios, i.e., authentic versus non-authentic audio texts. The last step was to explore the advanced EFL learners' performance in listening ability after the instruction. The listening test was given to all participants of the current research as the posttest.

2. Methods and Materials

This study employed a sequential exploratory mixed-methods design. Initially, qualitative methods were used to design a project-based curriculum model, and subsequently, in the quantitative phase, the model's validity was assessed using the fuzzy Delphi technique. In terms of purpose, this research is applied in nature, and in terms of approach, it is qualitative–quantitative, utilizing a data-driven logic in the qualitative phase and fuzzy decision-making logic in the quantitative phase.

In the qualitative phase, the statistical population consisted of all experts and specialists in the field of curriculum planning and education in Iran. These individuals included university faculty members with relevant specializations and experienced instructional supervisors at the national level. Criterion-based purposive sampling was used to select the sample, and ultimately, 15 experts were chosen as participants. Inclusion criteria included holding a Ph.D. in curriculum planning or educational sciences, having at least five years of teaching or research experience in this field, and possessing a minimum of two scholarly works on project-based curriculum or technology education. In addition to the researcher's active search, the snowball sampling method was also employed to identify experts. Interviews continued until theoretical saturation was reached—i.e., the point at which no new information emerged from additional interviews.

In the validation phase, which was designed based on the fuzzy Delphi method, the same experts who participated in the first phase comprised the statistical population. A fixed panel of 15 experts was retained at this stage due to their prior familiarity with the research framework and to maintain conceptual continuity in the model evaluation. This contributed to the theoretical depth of the analyses and the coherence of the validation process.

For data collection in the qualitative phase, the main instrument was a semi-structured interview. The interview protocol was designed based on Aker's (2004) ten curriculum elements and included 12 open-ended core questions along with several follow-up questions, enabling the researcher to gather in-depth and context-specific insights from the experts in a flexible yet purposeful manner. The content validity of the protocol was reviewed by four curriculum planning specialists and confirmed using the Content Validity Ratio (CVR), with all items scoring above 0.75.

Subsequently, the first-round questionnaire was developed for qualitative analysis and feedback. This instrument included the initial model consisting of 10 components and 68 indicators. For each component, three open-ended analytical questions were posed to enable analysis of necessity, revision, and recommendations for adding indicators. The purpose of this phase was to conduct an initial refinement and enrichment of the model using the collective expertise of the panel.

In the second round, a quantitative questionnaire with a fuzzy structure was developed. This instrument comprised 66 refined indicators and was designed using a 7-point verbal Likert scale. Each response option corresponded to a triangular fuzzy number, allowing for the mathematical analysis of the uncertainty inherent in the experts' linguistic judgments. The scale ranged from "very low importance" to "very high importance."

In the third round, an advanced tool known as the personalized feedback report was used. For each disputed indicator, this report included a reminder of the individual's response from round two, the group's average score, and qualitative arguments from both proponents and opponents. The purpose of this tool was to reduce judgment deviation and achieve stable consensus through reflective thinking and targeted information sharing.

For analyzing the interview data, thematic analysis was employed. The six-phase approach of Braun and Clarke (2006) was used, consisting of familiarization with the data, initial coding, theme identification, review, naming, and final report writing. In the coding phase, 347 initial codes were identified and subsequently categorized under organizing themes. To enhance accuracy in data management, MAXQDA software version 2022 was used.

In the quantitative phase, experts' fuzzy responses were first modeled by converting verbal options into triangular

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fuzzy numbers. Then, the fuzzy mean for each indicator was calculated using the fuzzy averaging method. In the next step, the defuzzified value for each indicator was extracted using the centroid method. A threshold value of 0.7 was set for indicator approval; indicators falling below this value were either referred to the third round or excluded.

Finally, to assess the degree of expert consensus in the final round, Kendall's coefficient of concordance was used, calculated using SPSS software version 26. This coefficient is a reliable index for examining alignment of opinions in group decision-making processes and indicated the final reliability of the approved indicators within the proposed model.

3. Findings and Results

The qualitative data analysis from 15 semi-structured interviews with curriculum planning experts was conducted using MAXQDA 2022 software and based on the thematic analysis approach. In this phase, the data were coded line-by-line, categorized into similar semantic categories, and the final themes associated with each component of the project-based curriculum model were extracted. This analysis not only led to the identification of key elements for each component but also provided the groundwork for validating and refining the model's structure. The combined results of expert suggestions in the first round of the fuzzy Delphi process for each of the ten core components are presented in the table below.

Table 1

Summary of Expert Suggestions Analysis in Round One of Delphi for the Components of the Project-Based Curriculum Model

Component	Type of Change Applied	Number of Indicators Changed	Explanation
Objectives	1 added, 1 revised	2	New indicator "Data Literacy Development" added; Aesthetic Literacy revised conceptually.
Content	1 removed	1	"Gamification" removed due to being part of lesson planning.
Lesson Planning	1 added	1	"Cognitive Load Management" added to control learning complexity.
Learning Activities	1 added, 1 overlap review	2	"Research-Based Activity" added; overlap between two indicators rejected.
Teacher Role	1 merged, 1 removed	2	"Experience Design" and "Process Management" merged; "Co-Learning" removed.
Student Role	1 merged, 1 revised	2	"Documentation" merged into F5; F5 rewritten.
Learning Resources	No change	0	Full consensus on adequacy of indicators.
Grouping	1 suggestion rejected	0	Suggested indicator "Conflict Management" implicitly included in others.
Learning Environment	1 removed, 1 suggestion rejected	1	"Space as Innovation System" removed; "Safety" suggestion rejected due to non-philosophical nature.
Assessment	1 revised, 1 separation suggestion rejected	1	"Quality of Thinking" revised; self-assessment and peer-assessment remained merged.

Based on the analysis of the first round of the fuzzy Delphi process, out of the initial 68 indicators, 5 were removed. These included: "Gamification" (B7), "Teacher's Learning Experience Design" (E2), "Co-Learning" (E5), "Documentation as a Student Role" (F6), and "Space as a Metaphor for Innovation" (I1). In contrast, three new indicators were added to the model: "Data Literacy Development" (A9), "Cognitive Load Management" (C7), and "Research-Based Activities" (D7). Additionally, three indicators were conceptually revised: A7 became "Visual and Aesthetic Literacy," J2 became "Assessment of Metacognitive Processes," and F5 became "Functional Roles in the Learning Community (including Documentation)." Ultimately, the refined version of the model consisted of 10 components and 66 indicators, which formed the basis for the fuzzy questionnaire in the second Delphi round. This process demonstrates that deep qualitative analysis of expert insights can lead to the design of a more precise, comprehensive model aligned with both local and global demands of project-based education.

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Table 2

Fuzzy Analysis Results and Screening of Indicators in Round Two of Delphi

Indicator Code	Indicator Title	Fuzzy Mean	Defuzzified Score	Final Decision
A6	Environmental Responsibility Development	(0.507, 0.700, 0.847)	0.684	Referred to Round 3
A7	Visual and Aesthetic Literacy Development	(0.347, 0.527, 0.760)	0.545	Referred to Round 3
B3	Content as Sensory and Phenomenological Exploration	(0.240, 0.420, 0.620)	0.427	Referred to Round 3
B6	Foresight-Oriented and Speculative Approach	(0.493, 0.680, 0.833)	0.669	Referred to Round 3
B8	Integration of Economic Literacy in Projects	(0.160, 0.320, 0.513)	0.331	Referred to Round 3
D6	Game- and Simulation-Based Activities	(0.507, 0.700, 0.847)	0.684	Referred to Round 3
F4	Student as Ecological and Future-Oriented Steward	(0.507, 0.700, 0.847)	0.684	Referred to Round 3
H2	Emergent and Self-Organized Grouping	(0.493, 0.680, 0.833)	0.669	Referred to Round 3
J6	Community and External Experts as Evaluators	(0.520, 0.707, 0.853)	0.693	Referred to Round 3

The fuzzy analysis findings from the second round showed that out of the 66 indicators evaluated, 57 indicators achieved a defuzzified score equal to or higher than the threshold of 0.7 and were thus validated by the expert panel. However, 9 indicators failed to reach the required consensus and were referred to the third round for reevaluation and final decision-making. Indicators such as "Visual and Aesthetic Literacy Development" (A7), "Content as Sensory and Phenomenological Exploration" (B3), and "Integration of Economic Literacy in Projects" (B8) received the lowest scores, indicating conceptual challenges or lack of sufficient agreement on their importance and place in the model. In contrast, indicators like "Student as Ecological Steward" (F4) and "Game- and Simulation-Based Activities" (D6), despite borderline scores, retained the potential for revision or defense in the third round. These results demonstrate the high effectiveness of the fuzzy Delphi process in filtering and distinguishing core components from peripheral elements and represent a critical step toward finalizing the validated model.

Table 3

Fuzzy Analysis and Final Decision for Indicators Referred to Round Three of Delphi

Indicator Code	Indicator Title	Round Two Score	Fuzzy Mean Round Three	Round Three Score	Final Decision
A6	Environmental Responsibility Development	0.684	(0.587, 0.780, 0.913)	0.760	Approved
A7	Visual and Aesthetic Literacy Development	0.545	(0.347, 0.527, 0.760)	0.545	Removed
B3	Content as Sensory Exploration	0.427	(0.280, 0.460, 0.660)	0.467	Removed
B6	Foresight-Oriented and Speculative Approach	0.669	(0.540, 0.727, 0.867)	0.711	Approved
B8	Integration of Economic Literacy in Projects	0.331	(0.140, 0.300, 0.500)	0.313	Removed
D6	Game- and Simulation-Based Activities	0.684	(0.540, 0.727, 0.867)	0.711	Approved
F4	Student as Ecological and Future-Oriented Steward	0.684	(0.560, 0.753, 0.887)	0.733	Approved
H2	Emergent and Self-Organized Grouping	0.669	(0.513, 0.700, 0.847)	0.687	Removed
J6	Community and External Experts as Evaluators	0.693	(0.560, 0.753, 0.887)	0.733	Approved

The results of the fuzzy analysis in the third round of Delphi revealed that out of the 9 indicators referred for re-evaluation, 5 indicators achieved a defuzzified score above the threshold of 0.7 and were finally approved by the experts. These indicators include: Environmental Responsibility Development (A6), Foresight-Oriented Approach (B6), Game-Based Activities (D6), Ecological Stewardship (F4), and Assessment by External Experts (J6). In contrast, 4 indicators—Visual Literacy Development (A7), Sensory Exploration (B3), Economic Literacy (B8), and Emergent Grouping (H2)—were removed due to repeated low scores in this round. This final stage of the fuzzy Delphi process resulted in the stabilization and consensus on 62 validated indicators, constituting the final structure of the project-based curriculum model.

Table 4

Complete Structure of the Final Project-Based Curriculum Model with Indicator Importance Scores

Component Code	Core Component	Indicator Code	Full Description of Final Indicator	Importance Score
1	Objectives	A1	Promoting Systems and Holistic Thinking	0.940
		A2	Developing Self-Directed and Metacognitive Learners	0.947
		A3	Enhancing Executive Brain Functions	0.798
		A4	Fostering Social and Moral Agency	0.940
		A5	Developing Interpersonal Competencies	0.889
		A6	Environmental Responsibility Development	0.760
		A8	Developing Critical Digital Literacy	0.896
		A9	Enhancing Data and Information Literacy	0.889
2	Content	B1	Content as Process and Methodology	0.871
		B2	Content as Social Interaction and Challenge	0.791
		B4	Critical-Social Approach to Content Selection	0.700
		B5	Contextual and Localized Approach	0.927
		B6	Foresight-Oriented and Speculative Approach	0.711
3	Lesson Planning	C1	Process-Oriented Models	0.940
		C2	Humanistic Models	0.791
		C3	Intelligent Scaffolding Strategy	0.967
		C4	Formative and Forward-Looking Feedback	0.927
		C5	Personalized Learning Pathways	0.871
		C6	Teacher Thought Modeling	0.851
		C7	Cognitive Load Management	0.918
4	Learning Activities	D1	Analytical and Engineering Projects	0.880
		D2	Social and Activist Projects	0.902
		D3	Creative and Expressive Projects	0.722
		D4	Reflective and Metacognitive Activities	0.940
		D5	Construction and Production-Based Activities	0.933
		D6	Game- and Simulation-Based Activities	0.711
		D7	Research- and Inquiry-Based Activities	0.947
5	Teacher Role	E1	Designer and Orchestrator of Learning Experiences	0.967
		E3	Curator and Networker of Resources	0.858
		E4	Metacognitive Feedback Coach	0.902
		E6	Shaper of Classroom Culture	0.918
6	Student Role	F1	Project Manager and Systems Engineer	0.887
		F2	Learning and Metacognitive Architect	0.940
		F3	Critical-Social Citizen	0.831
		F4	Ecological and Future-Oriented Steward	0.733
		F5	Performing Functional Roles in the Learning Community	0.896
7	Learning Resources	G1	High-Quality Specialized Materials and Tools	0.918
		G2	Inspiring Information Resources	0.896
		G3	Thinking, Organization, and Reflection Tools	0.918
		G4	Human Networks and Local Community	0.913
		G5	Intangible Resources (Time and Psychological Safety)	0.933
8	Grouping	H1	Strategic and Goal-Oriented Grouping	0.896
		H3	Allocation of Functional and Social Roles	0.896
		H4	Organization Based on Collaboration Protocols	0.918
		H5	Digital Tools for Team Collaboration	0.722
9	Learning Environment	I2	Space as a Communication Base	0.871
		I3	Flexibility and Modularity of Space	0.967
		I4	Zoning Space for Diverse Activities	0.896
		I5	Expanding Space to Community and Nature	0.933
10	Assessment	J1	Assessment of Process, Growth, and Impact	0.967
		J2	Assessment of Metacognition and Critical Thinking	0.940
		J3	Assessment of Authentic Documentation	0.896
		J4	Assessment of Authentic and Public Performance	0.902
		J5	Self-Assessment and Peer Assessment	0.776
		J6	Assessment by Community and Experts	0.733

The above table presents the complete and validated structure of the project-based curriculum model for the sixth-grade "Work and Technology" course, in full detail. This model comprises 10 core components and 62 approved indicators, all developed, refined, and finalized through a three-stage fuzzy Delphi process with the participation of 15 experts. In this model, components such as "Lesson Planning" and "Assessment" received the highest importance scores, especially for indicators such as Intelligent Scaffolding (C3), Learning Experience Design by the Teacher (E1), and Growth Process Assessment (J1). Conversely, indicators related to environmental orientation, foresight, and external evaluation were retained in the model due to their scores near the approval threshold. By integrating conceptual, skill-based, social, and technological perspectives, this model offers a comprehensive and localized framework for project-based education in elementary school, aligned with 21st-century demands and the specific requirements of Iran's education system.

Figure 1

Final Research Model

4. Discussion and Conclusion

The results of the present study indicated that it is possible to design and validate a comprehensive, structured, and localized project-based curriculum model for the sixth-grade "Work and Technology" course. The final output of this process was a model consisting of 10 core components and 62 indicators, identified, refined, and validated through three rounds of fuzzy Delphi involving 15 experts in curriculum planning and education. The fuzzy analysis of the data revealed strong expert consensus on the significance of components such as "lesson planning," "assessment," "teacher role," and "learning activities" in structuring project-based learning for this subject. Moreover, indicators such as "intelligent scaffolding," "process and growth assessment," "cognitive load management," and "research-based projects" received the highest importance scores among all indicators.

These findings are consistent with numerous studies on the design and effective implementation of PBL. For instance, the study by (Sun, 2023) found that the success of project-based learning depends on designing real-world learning scenarios, an active teacher role as facilitator, and process-oriented assessment. Similarly, (Hou et al., 2023), in a study focusing on sustainable architecture education using virtual reality, emphasized the importance of components such as teacher's thought modeling and formative feedback in the effectiveness of PBL. The findings of this research likewise demonstrated that indicators like "forward-focused formative feedback strategies" and "thinking modeling strategies" were among the most impactful components of the proposed model.

One noteworthy finding was the validation of components such as "data literacy," "environmental responsibility," "extending learning space to community and nature," and "student's citizenship role," reflecting a paradigm shift in curriculum approaches—from static knowledge transmission to the development of biological, social, and future-oriented competencies. This aligns with the emphasis in (Veraksa et al., 2023) on the role of pretend and project-based play in children's social development, as well as with the findings of (Zhang & Ma, 2023) in a meta-analysis of PBL's effects on students' cognitive, social, and identity competencies.

On the other hand, indicators such as "visual literacy development," "economic literacy," and "self-organized grouping," despite their importance in international literature, did not achieve high validity scores in this study and were eliminated. Qualitative analysis of expert opinions indicated that conceptual ambiguity, weak evaluability, and overlap with other indicators were the primary reasons for their removal. This highlights the necessity of balancing theoretical richness with practical applicability in the design of localized models. In this context, (Pantiwati et al., 2023) warns that the integration of international models into local education must pay careful attention to cultural context, age levels, and available educational resources.

Another important result was the broad validation of indicators emphasizing design thinking, scaffolding, and continuous feedback. In particular, the "intelligent scaffolding" indicator received the highest importance score among all indicators. This underscores the need for tools that enable teachers to guide learners step by step through complex projects. The study by (Bouhaï, 2025) also stresses the key role of designing learning experiences based on

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design thinking and the need for logically structured projects in ensuring the success of learning.

Regarding the teacher's role, the findings showed that teachers' multiple roles—as designers of learning experiences, metacognitive feedback coaches, and classroom culture shapers—were considered vital. These results are consistent with the studies by (Zenkov, 2023) and (Shekh-Abed, 2024), which demonstrated that fulfilling these roles contributes to the formation of professional identity, positive interaction with students, and the enhancement of cognitive skills.

In terms of the student dimension, the validation of indicators such as "project manager," "learning architect," and "ecological steward" indicates a tendency toward fostering student agency, self-regulation, and social responsibility in teaching models. The study by (Haider et al., 2023) also noted that successful projects are often characterized by active team participation, reflectivity, and meaningful role-playing, which, at the student level, can be realized through the assumption of various roles in the learning process.

Within the assessment component, the emphasis on indicators such as "growth assessment," "critical thinking," "documentation," and "community-based assessment" signifies a multifaceted and participatory approach to evaluating learning. The findings of the present study align with the results of (Jame Bozorg et al., 2023), who found that the use of portfolios, public presentations, and peer assessment contributes significantly to enhancing students' creativity and cognitive engagement.

Ultimately, the final structure of the model developed in this study—with its emphasis on ten curriculum components and integration of both conceptual and practical indicators—represents an effort to create a comprehensive, flexible, and context-sensitive framework. By combining theoretical and empirical perspectives, the model offers a practical tool for the design, implementation, and evaluation of project-based learning at the elementary level, particularly for the "Work and Technology" course. Rather than providing a one-size-fits-all solution, this model seeks—through a precise, systematic, and expert-driven approach—to take a meaningful step toward curriculum reform and innovation within Iran's educational system.

One of the main limitations of this study was its focus on the specific course "Work and Technology" in the sixth grade, which may limit the generalizability of the findings to other subjects or educational levels. Additionally, the sample was composed solely of academic experts and instructional supervisors, and the perspectives of practicing teachers and students were not directly included. Another limitation was the study's reliance on the fuzzy Delphi method which, although highly effective for identifying and validating indicators, remains subject to the subjective judgments of experts and potential bias in evaluations.

It is recommended that future research experimentally implement the designed model in classroom settings to assess its impact on student learning, motivation, and engagement using quasi-experimental methods. Furthermore, comparative studies could be conducted to analyze the differential impact of implementing this model across various geographic regions or between public and private schools. Including the perspectives of teachers, parents, and students in the process of designing or revising the model could also enrich its depth and applicability.

The final model developed can serve as a guiding framework for developing instructional content, designing learning units, and even creating teacher training programs. Educational policymakers can use this model to revise the "Work and Technology" curriculum and extend it as a prototype for skill-based curriculum development in other subjects. Additionally, the components and indicators of this model can provide a foundation for designing evaluation tools to assess the quality of PBL implementation in schools and support the continuous improvement of the teaching–learning process.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in studies involving human participants were under the ethical standards of the institutional and, or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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