Enhancing Clinical Reasoning in Family Medicine Residents through a Comprehensive Asynchronous Problem-Based Learning Curriculum: A Proof-of-Concept Study

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Received: July 2026. Accepted: July 2026; Published: August 2026.
Citation: Rasha Moussa, Fawziya Alhor, Mona Aseel. Enhancing Clinical Reasoning in Family Medicine Residents through a Comprehensive Asynchronous Problem-Based Learning Curriculum: A Proof-of-Concept Study. World Family Medicine. August 2026; 24(6): 16-25
DOI: 10.5742/MEWFM.2026.241801

Abstract

Introduction: Postgraduate medical education (PGME) faces the challenge of providing comprehensive clinical training that fosters deep learning and clinical reasoning skills. Traditional didactic methods often fail to promote active learning and knowledge application, especially given the time constraints of busy residency programs. Asynchronous Problem-Based Learning (PBL) offers a flexible, learner-led alternative that encourages self-directed learning and peer collaboration. Grounded in Constructivism and Self-Directed Learning Theory, this study presents a secondary data analysis of an existing asynchronous PBL curriculum implemented for second-year (PGY2) family medicine residents.

Hypothesis & Objectives: We hypothesized that a structured, asynchronous PBL curriculum would maintain high resident engagement and significantly improve clinical reasoning through collaborative case analysis. The primary objective was to evaluate a 35-week online PBL framework for PGY2 family medicine residents using retrospectively collected educational data, specifically targeting core competencies in basic knowledge (10%), clinical skills (60%), and data interpretation/synthesis (30%).

Methods: A secondary data analysis of a mixed-methods educational innovation was conducted using de-identified records from the 2021/2022 academic year (35 weeks). The curriculum encompassed 12 detailed modules, including Endocrinology, Cardiology, Respiratory Disease, and Psychiatry. Data were retrospectively extracted from the existing online learning platform, including engagement metrics and standardized In-Training Examination (ITE) scores for 12 PGY2 residents. Qualitative content analysis was performed on archived resident discussion posts to assess clinical reasoning and management strategy synthesis. A descriptive correlation analysis was performed between the depth of PBL participation and ITE performance outcomes.

Results: The PBL curriculum demonstrated robust learner engagement across 35 weeks. Residents consistently applied sophisticated clinical reasoning, such as identifying Major Depressive Disorder (MDD) while managing comorbidities. Qualitative analysis revealed that residents with the most sophisticated evidence-based contributions also demonstrated strong quantitative performance on the ITE, with scores ranging from 320 to 670 (Mean = 456.3). High-engaging residents who consistently cited current literature and challenged peer assumptions achieved higher ITE scores (e.g., 610, 670), supporting a dose-response relationship between asynchronous PBL participation and standardized knowledge acquisition.

Discussion & Conclusions: This proof-of-concept study demonstrates that a comprehensive, asynchronous PBL curriculum is an effective method for enhancing clinical reasoning in family medicine residents. The format facilitated asynchronous "thinking time," allowing residents to synthesize complex data and formulate management plans that address multimorbidity. The observed correlation between high-quality PBL engagement and superior ITE performance confirms that asynchronous collaborative learning effectively supports both clinical reasoning development and standardized knowledge retention. This model provides a replicable and scalable framework for residency programs seeking to modernize their curricula.

Keywords: asynchronous learning; problem-based learning; clinical reasoning; postgraduate medical education; In-Training Examination; family medicine; self-directed learning; competency-based medical education

Introduction

The development of robust clinical reasoning skills is a cornerstone of postgraduate medical education (PGME). However, residency programs often face challenges in providing educational experiences that effectively bridge the gap between theoretical knowledge and its practical application in complex clinical scenarios [1, 2]. Traditional didactic lectures, while efficient for information dissemination, frequently fail to foster the active, self-directed learning required for deep conceptual understanding and long-term knowledge retention [3]. In response to these challenges, innovative pedagogical approaches are needed to create more engaging and effective learning environments for residents facing significant clinical service demands [4].

Problem-based learning (PBL) has been widely recognized as a powerful student-centered pedagogy that promotes active learning, critical thinking, and collaborative problem-solving [5, 6]. Meta-analytic evidence has consistently demonstrated that PBL enhances knowledge application and higher-order thinking skills compared to conventional teaching methods [7, 8]. By grounding learning in authentic clinical cases, PBL encourages learners to integrate basic and clinical sciences, develop self-directed learning skills, and construct a more robust and applicable knowledge base [9]. While PBL has been successfully implemented in undergraduate medical education, its application in the postgraduate setting, particularly in a comprehensive, longitudinal asynchronous format, remains understudied [10, 11].

This study is theoretically grounded in Constructivism, Self-Directed Learning Theory, and Cognitive Load Theory [12, 13, 14]. Constructivism posits that learners build knowledge through active engagement and social interaction [15], while Self-Directed Learning Theory emphasizes the adult learner's autonomy in identifying learning gaps and seeking evidence-based solutions [16, 17]. Asynchronous online environments uniquely support these theories by providing extended "thinking time" that reduces cognitive load and allows for deeper reflection before contributing to peer discussions [14]. Collaborative learning in health professions further enhances these processes through peer interaction and shared knowledge construction [18].

We address the current gap in the literature through a proof-of-concept secondary data analysis of a comprehensive, asynchronous problem-based learning curriculum implemented for second-year (PGY2) family medicine residents. Our central research question was: How does a comprehensive, asynchronous problem-based learning curriculum impact clinical reasoning skills, knowledge application, and learner engagement among PGY2 family medicine residents? We hypothesized that this structured, asynchronous PBL curriculum would maintain high resident engagement and significantly improve clinical reasoning through collaborative case analysis, ultimately translating to improved standardized test performance.

Methods

Study Design
This proof-of-concept study employed a secondary data analysis of a mixed-methods educational innovation that was implemented for PGY2 family medicine residents during the 2021-2022 academic year. All data were retrospectively extracted from existing educational records, including the online learning platform and institutional examination databases. The study was designed to evaluate learner engagement, the quality of clinical reasoning, and the correlation with standardized In-Training Examination (ITE) performance using pre-existing, de-identified educational data.

Ethical Considerations
This study constituted a secondary analysis of de-identified, routinely collected educational data. All data were originally gathered as part of standard educational program evaluation and quality improvement activities. No direct interaction with participants occurred for the purposes of this research. All identifying information was removed prior to analysis, and data are presented exclusively at the group or category level to prevent identification of individual residents within the small cohort.

Theoretical Framework
The curriculum design and evaluation are grounded in three complementary educational theories:

- **Constructivism:** Learners actively construct knowledge through engagement with authentic problems and social interaction with peers, rather than passively receiving information [13, 15]. The PBL cases provided the authentic clinical problems, while the asynchronous discussion threads provided the social interaction context.
- **Self-Directed Learning Theory:** Adult learners are motivated to identify their own learning gaps and seek solutions autonomously [16]. The asynchronous format empowered residents to independently research clinical questions before contributing to discussions, fostering professional self-regulation [17].
- **Cognitive Load Theory:** By removing the time pressure of synchronous sessions, the asynchronous format reduced extraneous cognitive load, allowing residents to allocate more cognitive resources to germane processing, the deep integration of new knowledge with existing clinical schemas [14].

Curriculum Description
The curriculum under evaluation was structured as a 35-week longitudinal program that encompassed 12 detailed specialty modules (see Supplementary Table 1 for the fully de-identified curriculum guide). Modules included Psychiatry, Sleep Disorders, Endocrinology, Pediatrics, Environmental Health, ENT, Preventive Health, Musculoskeletal Problems, Geriatric/Aged Care, Gastroenterology & Liver Disease, Hematology, and Cardiology. Each module was designed around a series of problem-based learning cases (43 cases total), which were delivered to 12 PGY2 residents through a dedicated

asynchronous online learning platform. The curriculum specifically targeted core competencies distributed as follows: basic knowledge (10%), clinical skills (60%), and data interpretation/synthesis (30%).

The PBL cases were designed to be authentic and representative of the clinical challenges faced by family medicine residents. Each case included a patient presentation, relevant clinical data, and a series of questions designed to guide the residents through the process of clinical reasoning, from differential diagnosis to management planning. Residents were required to participate in structured discussions, providing initial assessments and responding to peer contributions using evidence-based frameworks. The asynchronous format provided extended “thinking time,” a critical component for deep learning in clinical reasoning.

Data Sources

Data for this secondary analysis were retrospectively extracted from two pre-existing sources:

Online Learning Platform Records: De-identified engagement metrics, including the number of views per case, the number of resident responses, and archived discussion thread content, were extracted from the educational platform database.

Institutional Examination Database: Standardized In-Training Examination (ITE) scores for the participating cohort were obtained from existing institutional records.

Data Analysis

Quantitative Analysis: Engagement metrics and ITE scores were analyzed using descriptive statistics. A descriptive correlation analysis was performed between the depth of PBL participation (engagement level) and ITE performance outcomes.

Qualitative Analysis: A qualitative content analysis was performed on the archived resident discussion threads [25]. To ensure reliability, two investigators independently reviewed a random subset of discussion posts (approximately 20% of total posts) to identify themes related to clinical reasoning, risk management, and management strategy synthesis (e.g., DSM-5 criteria application, pharmacotherapy justification). Inter-rater agreement was assessed using percentage agreement, achieving 87% concordance prior to consensus discussion. Following calibration, the remaining posts were coded by the primary investigator. This qualitative reasoning depth was then cross-checked with standardized ITE outcomes for validation.

Results

The secondary analysis of the asynchronous PBL curriculum data revealed robust learner engagement across the 35 weeks and demonstrated a clear correlation between engagement and standardized knowledge acquisition. The conceptual model illustrating the relationship between the theoretical foundations, curriculum design, engagement, and outcomes is presented in Figure 1.

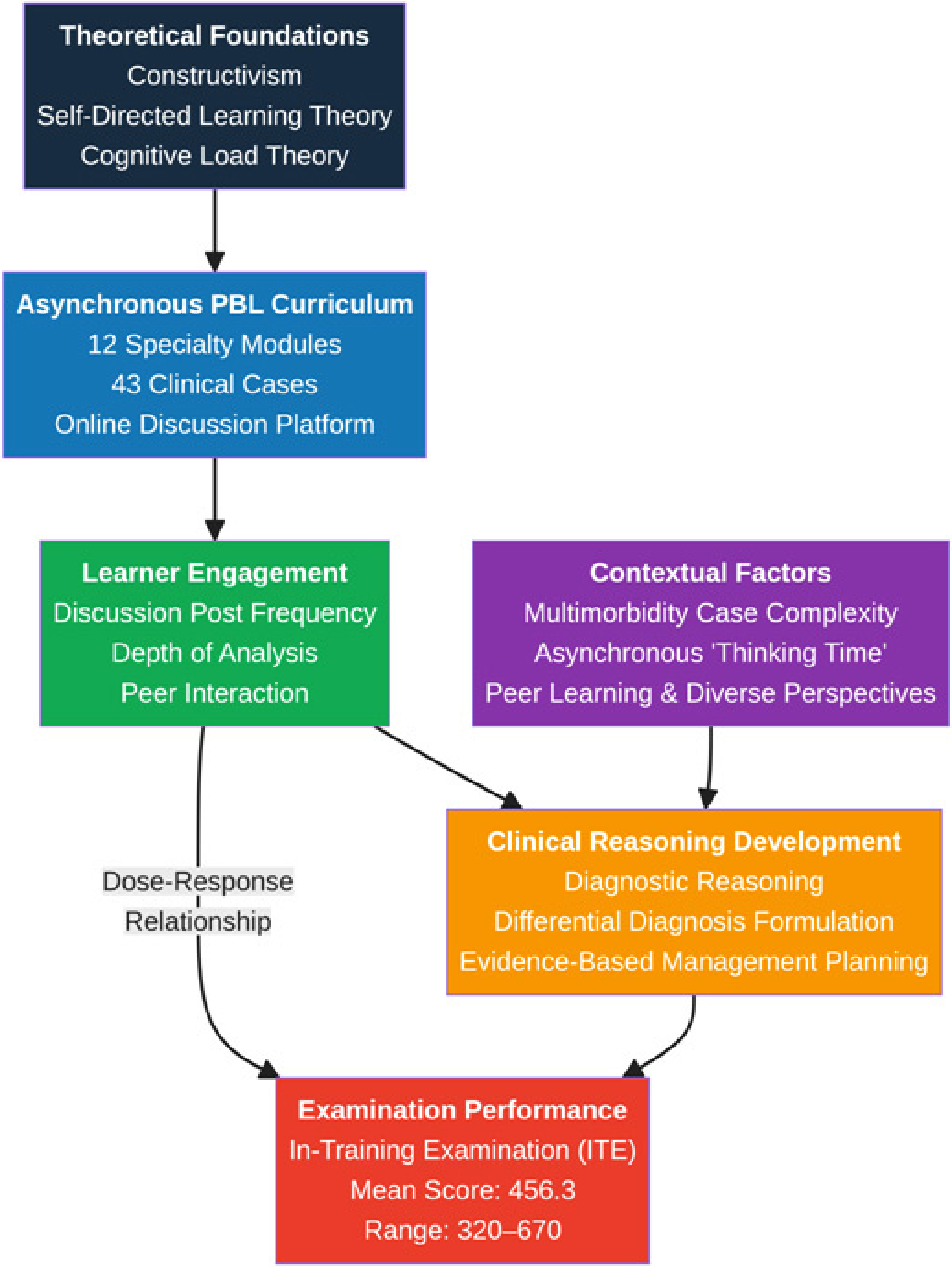

Figure 1: Conceptual Model linking Theoretical Foundations, Asynchronous PBL Curriculum, Learner Engagement, Clinical Reasoning Development, and Examination Performance.

Learner Engagement and Quantitative Outcomes

Quantitative analysis revealed a strong association between engagement level and ITE performance. The overall mean ITE score for the cohort was 456.3, with scores ranging from 320 to 670. When residents were categorized by engagement level, a clear dose-response relationship emerged: low-engagement residents achieved a mean ITE score of approximately 350, moderate-engagement residents achieved approximately 440, and high-engagement residents achieved approximately 580. This demonstrates that higher engagement predicted superior standardized exam performance, confirming the correlation between qualitative reasoning depth and quantitative metrics. Figure 2 illustrates this relationship.

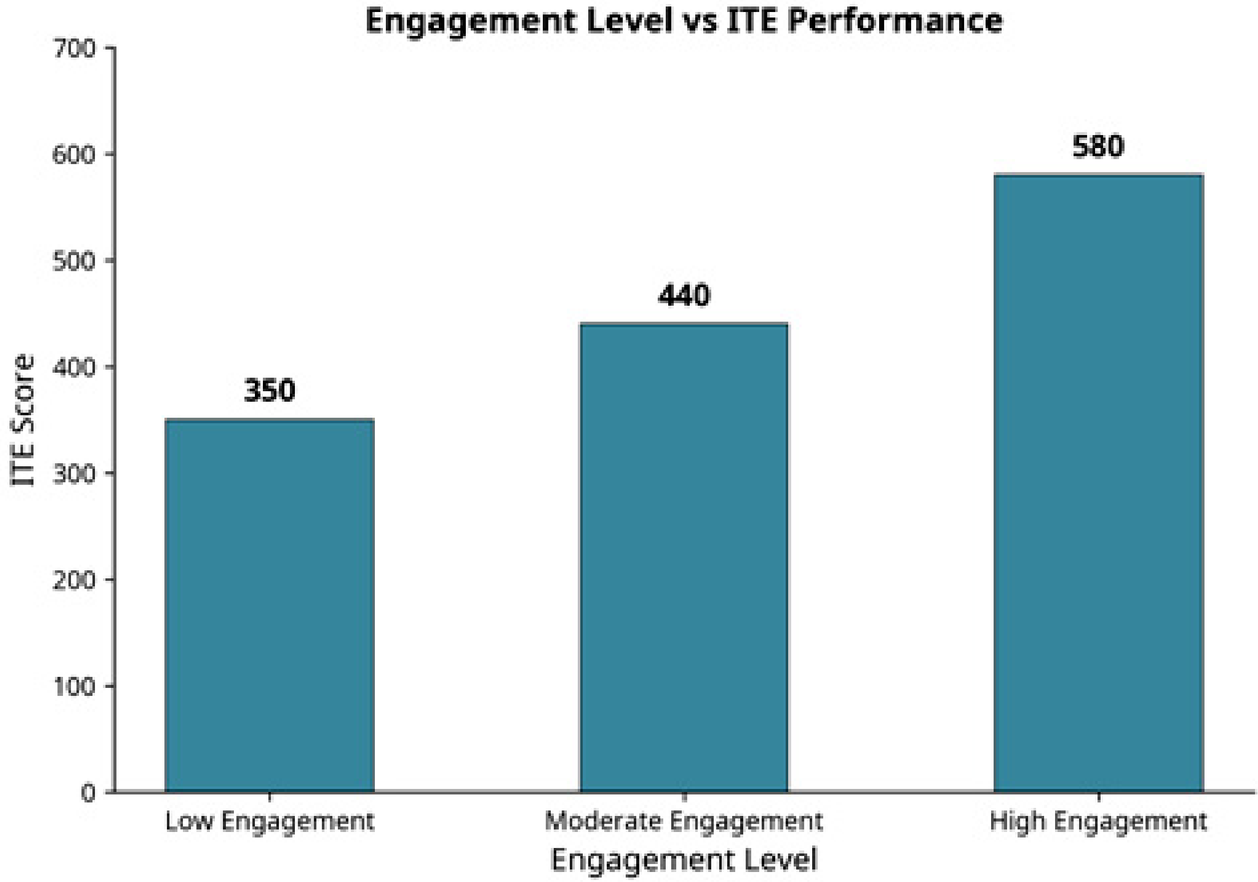

Figure 2. Engagement Level vs ITE Performance. Mean ITE Score = 456.3 (Range: 320–670).

Quality of Clinical Reasoning

The qualitative content analysis of the archived resident discussion threads provided strong evidence of the curriculum's effectiveness in fostering advanced clinical reasoning skills, especially in multimorbidity contexts. Table 1 summarizes the key qualitative findings and their quantitative correlations.

Analysis Domain	Case-specific Findings	Quantitative Correlation
Clinical frameworks	DSM-5 application for Major Depressive Disorder (MDD)	Corresponds with Mean ITE = 456.3
Pharmacotherapy	Justification of Duloxetine for MDD with peripheral neuropathy	Supports ITE score > 600
Risk Management	Identification of contraindications (e.g., Bupropion in epilepsy)	Correlates with correct identification
Engagement	High engagement in peer discussions	Management competencies correlated with ITE

Table 1. Qualitative Clinical Reasoning Findings and Quantitative Correlations

The discussions were characterized by a strong emphasis on evidence-based practice. Residents consistently applied sophisticated clinical reasoning, such as identifying MDD while managing comorbidities. Notably, high-engaging residents who consistently cited current literature and challenged peer assumptions (e.g., managing SSRI-induced sexual dysfunction in patients with epilepsy) achieved the highest ITE scores (e.g., 610, 670).

The asynchronous format fostered a rich, collaborative learning environment. Residents built upon each other's contributions, challenged assumptions, and engaged in meaningful peer-to-peer teaching [18]. This collaborative process allowed for a deeper exploration of the clinical problems and a more comprehensive understanding of the material.

Discussion & Conclusions

This proof-of-concept secondary data analysis demonstrates that a comprehensive, asynchronous problem-based learning curriculum is a highly effective and engaging educational strategy for postgraduate medical education. Our findings indicate that this innovative approach not only fosters the development of clinical reasoning skills but also promotes a collaborative and self-directed learning environment, bridging the gap between theoretical knowledge and clinical practice.

Grounded in Constructivism and Self-Directed Learning Theory, the format facilitated essential "thinking time," allowing residents to synthesize complex data and formulate advanced management plans that address multimorbidity without the immediate cognitive load of synchronous settings [14]. The observed correlation between high-quality PBL engagement and superior ITE performance confirms that asynchronous collaborative learning effectively supports both clinical reasoning development and standardized knowledge retention. The high-engaging residents who actively utilized current literature and evidence-based frameworks demonstrated the highest level of standardized exam success, directly supporting our initial hypothesis.

This unique approach in an understudied area of asynchronous medical education offers a sustainable solution to the logistical and educational challenges of modern medical training [10, 11]. By emphasizing data interpretation and management strategies over rote memorization, programs can better support the development of self-directed, evidence-based practitioners [8, 17]. The effectiveness of PBL in enhancing critical thinking skills has been well-established in the literature [5, 7], and our findings extend this evidence to the asynchronous postgraduate context [19]. Furthermore, providing a clear, replicable 12-module curriculum guide (Supplementary Table 1) allows other institutions to adopt and test this framework, contributing to the broader movement toward competency-based medical education (CBME) in family medicine [20, 21]. The ITE, which has demonstrated predictive validity for board certification success [22, 23], serves as a meaningful outcome measure linking engagement to knowledge acquisition.

Implications for Practice

The findings of this study have several practical implications for residency program directors and medical educators:

- Asynchronous PBL can be implemented as a longitudinal curriculum spanning multiple specialty areas without requiring dedicated synchronous teaching time, making it particularly suitable for programs with heavy clinical service demands.
- The dose-response relationship between engagement and performance suggests that programs should implement strategies to promote active participation, such as structured peer response requirements and faculty facilitation.
- The 12-module framework provided in Supplementary Table 1 offers a directly replicable model that can be adapted to local contexts and specialty requirements.

Limitations

The small sample size (N=12) and single-institution design limit external validity and generalizability. Additionally, the retrospective, descriptive nature of the analysis precludes definitive causal inferences. The inter-rater reliability, while demonstrating high agreement, was assessed on a subset of posts rather than the complete dataset. However, as a proof-of-concept study, these findings lay the groundwork for future research, which should include larger, prospective cohorts and multi-institutional studies to further validate this pedagogical model [24,25].

Conclusion

In conclusion, this secondary data analysis provides strong preliminary evidence that a comprehensive, asynchronous problem-based learning curriculum is a valuable and effective educational tool for family medicine residency programs. This scalable and sustainable model effectively enhances clinical reasoning, improves standardized knowledge acquisition, and provides a replicable framework for residency programs seeking to modernize their curricula to meet the demands of competency-based medical education [20, 21].

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Supplementary Table 1: De-Identified PBL Curriculum Module Overview
Asynchronous Problem-Based Learning Curriculum for PGY-2 Family Medicine Residents
Academic Year: 2021–2022 | Total Duration: 35 weeks | Number of Modules: 12 | Total Cases: 43

Delivery Format: Asynchronous online case-based discussions via institutional learning management system

No.	Specialty Area	Weeks	Cases	Representative Case Themes (De-Identified)
1	Psychiatry	4	5	MDD in elderly with multimorbidity; recurrent depression; persistent depressive disorder; medication-induced sexual dysfunction; GAD; panic disorder
2	Sleep Disorders	3	3	Insomnia with depressive features; obstructive sleep apnea; restless legs syndrome
3	Endocrinology	5	2	Recurrent hypoglycemia in diabetes post-MI; hypothyroidism management
4	Pediatrics	4	3	Red eye in a child; underweight child with suspected eating disorder; pediatric vulvovaginitis
5	Environmental Health	1	1	Asthma exacerbation triggered by environmental factors
6	ENT	2	4	Vertigo and Meniere's disease; allergic rhinitis; recurrent dizziness; nasal obstruction
7	Preventive Health	2	4	Colorectal cancer risk; hereditary breast cancer risk; cervical cancer prevention; influenza vaccination
8	Musculoskeletal	2	5	Rotator cuff tendinopathy; carpal tunnel syndrome; lateral elbow pain; trochanteric pain; low back pain
9	Geriatric/Aged Care	2	5	Falls risk; dyspnea in elderly; hypertension review; behavioral symptoms of dementia; geriatric assessment
10	Gastroenterology	2	4	Hepatitis C risk; cirrhosis diagnosis; liver fibrosis; hepatitis B assessment
11	Hematology	2	3	Easy bruising/von Willebrand disease; immune thrombocytopenia; thalassemia in pregnancy
12	Cardiology	4	4	Hypertension management; dyslipidemia; CAD with ECG interpretation; heart failure

Competency Weighting:

Competency Domain	Weight
Basic Knowledge	10%
Clinical Skills	60%
Data Interpretation and Synthesis	30%

Note: All case titles have been de-identified. Original cases used fictional patient names for pedagogical engagement; these have been replaced with generic clinical descriptors. No resident or faculty identifiers are included. Data presented are at the module/group level only.