

FACTORS AFFECTING THE EFFECTIVENESS OF ENGLISH – MEDIUM INSTRUCTION PROGRAM IN MATHEMATICS EDUCATION: AN EFA–CFA STUDY

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Abstract: This study aims to identify the underlying factors influencing the effectiveness of English-medium instruction (EMI) at mathematics programs among pre-service mathematics teachers and to assess the reliability and validity of these factors for future research applications. A five-point Likert-scale survey was developed based on a synthesis of existing literature. Data were collected from 372 students enrolled in EMI mathematics courses and were randomly divided into two equal subsets: one for Exploratory Factor Analysis (EFA) and the other for Confirmatory Factor Analysis (CFA), each comprising 186 participants. The EFA revealed a four-factor structure that accounted for 61.134% of the total variance. Subsequent CFA confirmed the model, with fit indices indicating strong reliability and acceptable convergent validity. The four latent factors identified were: (1) Learners' personal competence and psychological attributes, (2) Lecturers' teaching competence in English-mediated instruction, (3) Institutional support, and (4) Perceived learning effectiveness. These findings provide a robust empirical foundation for the refinement and enhancement of EMI-based mathematics education in teacher training programs.

Keywords: CFA, EFA. English-medium mathematics instruction, learning effectiveness, pre-service mathematics teachers

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In the context of deepening international integration, the incorporation of English as a medium of instruction (EMI) for specialized subjects at the tertiary level—particularly within teacher training institutions—has emerged as an inevitable and strategic trend in the world. The EMI programs have been exploited from different perspectives, from the policy to the implementation in the classroom (Bolton et al., 2024). This shift aims to enhance national competitiveness and cultivate a high-quality human resource base. Within the domain of Mathematics Education, the delivery of subject-specific courses in English is perceived not only as a means to improve students' academic language proficiency but also as a vehicle for accessing advanced scientific knowledge, utilizing international academic resources, and equipping graduates to operate effectively in bilingual or international teaching environments. As noted by Chung et al. (2020), the preparation of future bilingual mathematics educators has been recognized as a key strategic orientation in response to the imperatives of educational globalization.

In Vietnam, the implementation of EMI programs has been established as a priority task for higher education, as directed by the Prime Minister in 2017 (Ministry of Education and Training

(MOET), 2017). Over the past decade, several universities have launched high-quality academic programs using English as the primary medium of instruction. However, recent studies indicate that the operation and organization of EMI programs continue to face significant challenges and limitations (Lê, 2021; Le & Nguyen, 2023; Tran & Nguyen, 2018).

In recent years, several leading teacher training universities in Vietnam have proactively implemented undergraduate programs in Mathematics Education (Chung et al., 2020). This development represents a significant step toward equipping future school teachers with the skills necessary to meet the growing demands of bilingual education. Nevertheless, the effectiveness of student learning within these programs is shaped by a complex interplay of factors, including students' English language proficiency, academic competence, instructional methodologies, the quality of educational materials, as well as psychological variables and learner motivation (Chung, 2017; Chung et al., 2020; Lê, 2021; Le & Nguyen, 2023; Nga, 2024).

Some prior studies have focused on identifying the challenges associated with teaching science subjects in English. For instance, Goodman (2014) found that implementing EMI in academic fields such as mathematics often encounters significant language barriers and a lack of appropriate instructional materials. In addition, Ellili-Cherif and Alkhateeb (2015) emphasized that students' positive attitudes toward EMI have a substantial impact on their academic performance. Similarly, Nga (2024) reported that students often struggle with understanding subject-specific terminology, which directly affects their ability to comprehend and retain course content. Arizmendi et al. (2021) highlighted the importance of academic language support in improving mathematics learning outcomes in EMI settings. Furthermore, Hoang (2008) categorized the factors influencing the quality of English-medium instruction into personal, instructional, curricular, environmental, and institutional components—many of which are relevant to the context of teacher education for EMI.

While considerable research has been conducted internationally and domestically on EMI in STEM education, there remains a lack of in-depth studies that systematically analyze the factors affecting mathematics education students' learning outcomes in English-medium courses—particularly for those preparing to teach mathematics in English at the secondary level in the near future. A significant gap in the existing literature is the absence of comprehensive quantitative studies employing robust statistical techniques such as Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) to identify and validate reliable models of influencing factors. This study aims to fill that gap by proposing and validating a factor model of variables that affect the learning effectiveness of mathematics education students in EMI courses. The model is grounded in theoretical synthesis and empirical survey data, thereby providing insights that may guide improvements in curriculum design, instructional methods, and institutional support policies for training teachers in EMI mathematics programs within the broader context of educational integration. To this end, the study sought to answer the following research questions:

1. What are the latent factors influencing the learning effectiveness of mathematics education students in English-medium instruction?
2. Are these factors reliable and valid for use in future research?

LITERATURE REVIEW

In recent years, the integration of English-medium instruction (EMI) in teacher education—particularly for mathematics and science teachers—has become a growing trend in many countries, including Vietnam. In the era of globalization, future teachers need not only strong disciplinary knowledge but also sufficient language competence to teach effectively in bilingual or internationalized settings.

While EMI in mathematics teacher education offers various potential benefits, its implementation remains challenging, especially in ensuring students' learning effectiveness (Chung et al., 2020; Le, 2021; Le & Nguyen, 2023; Tran & Nguyen, 2018). Therefore, reviewing previous studies to identify key factors affecting EMI-based mathematics learning is essential for establishing a theoretical foundation and developing a valid factor model for this study.

Key Concepts

There are various definitions of English as a Medium of Instruction (EMI). According to Dearden (2015), EMI refers to the use of English to teach academic subjects in countries or institutions where English is not the primary language. Similarly, Macaro and Dearden (2018, p.456) describe it as “a term used to refer to the teaching of academic subjects in English.” Vu and Burns (2014) note the difficulty in establishing a precise definition, but this study adopts Dearden's (2015, p.3) interpretation, where EMI is defined as “the use of the English language to teach academic subjects in countries or jurisdictions where the first language of the majority of the population is not English.” Dale and Tanner (2012) outlined key distinctions between EMI and CLIL (Content and Language Integrated Learning) programs. First, CLIL emphasizes language acquisition with content embedded, whereas EMI focuses primarily on delivering subject content through English. Second, CLIL is often implemented by language teachers, while EMI is delivered by subject-matter specialists. Third, CLIL assesses both language and content learning, while EMI evaluates only content knowledge.

To assess learning effectiveness, Nguyen and Nguyen (2023) argue that evaluation should consider learners' learning goals and the extent to which they achieve intended learning outcomes. In this study, the term “learning effectiveness” is understood comprehensively, encompassing content mastery, development of language skills, learners' confidence and motivation, and their perceived opportunities for future employment.

Previous Studies

A synthesis of both domestic and international EMI-related studies identified five main categories of factors as potentially influencing the effectiveness of English-medium instruction (EMI) in mathematics education for pre-service teachers. More details are provided as follows:

Regarding learners' competence and psychological attributes, previous studies emphasize that learners' English proficiency and psychological readiness are critical to EMI success. While several scholars have highlighted EMI's benefits for content knowledge, language development, and career opportunities (Coleman, 2006; Talzt, 2011; Xiao & Zou, 2020; Yang, 2019), other empirical studies present inconsistent findings (Macaro, 2024; Lei & Hu, 2014). Language limitations, particularly in listening and understanding mathematical terminology, have been

shown to hinder comprehension (Nga, 2024; Phuong & Nguyen, 2019). Learner anxiety, low confidence, and fear of being judged negatively reduce class participation and knowledge acquisition (Ellili-Cherif & Alkhateeb, 2015; Ozturk & Gurbuz, 2014). Conversely, students with clear long-term goals and positive attitudes toward EMI are more proactive and motivated (Costa, 2023). These findings support the inclusion of a latent factor: learners' competence and awareness, including proficiency, confidence, attitude, and motivation.

In terms of teachers' EMI teaching competence, research indicates that lecturers' ability to teach effectively in English, including their pedagogical strategies and language use, is a major determinant of EMI success (DelliCarpini & Alonso, 2014; Chen, 2017). Challenges arise in delivering complex content in English, especially for mixed-level learners. Some lecturers resort to using the native language as a workaround (Chen et al., 2020), though concerns remain about long-term effectiveness (Macaro, 2020). Classroom studies in China reveal a significant gap between perceived and actual English use (Tong & Tang, 2017). Moreover, incorporating CLIL techniques such as checking comprehension, visual aids, and language support has shown promise (Akbarov et al., 2018; Bashir & Batool, 2017). Nonetheless, teacher-centered delivery continues to limit learner engagement (Sun et al., 2023). In Vietnam, even English-trained lecturers report a lack of confidence in EMI settings (Le, 2016; Nguyen et al., 2016). This underscores the second latent factor: teachers' EMI competence.

In relation to learning materials, the complexity, accessibility, and contextual relevance of English-language resources play a critical role in determining the effectiveness of English-medium instruction (EMI). Empirical evidence suggests that materials lacking bilingual support or simplified language can significantly impede student comprehension, particularly for learners with limited English proficiency (Chiang, 2010; Le, 2021; Lasagabaster, 2022; Zumor & Qasem, 2019). Additionally, research indicates that students frequently resort to digital translation tools, which may hinder learning efficiency and reduce productivity (Phuong & Nguyen, 2019). To mitigate these challenges, scholars have advocated for the integration of digital learning resources and provided pre-lesson vocabulary lists to enhance student preparedness and understanding (Dearden & Beaumont, 2024). Furthermore, curriculum design, course scheduling, and content selection are also acknowledged as influential factors in EMI outcomes (Chung et al., 2020). Consequently, learning materials are recognized as the third latent factor affecting EMI implementation.

With regard to institutional support, although relatively limited, existing research underscores the significance of institutional support in shaping the outcomes of English-medium instruction (EMI). Support mechanisms—such as international partnerships, faculty incentive programs, English-language academic support centers, and customized advising systems—have been shown to facilitate EMI implementation; however, such structures are frequently underdeveloped or inconsistently applied (Li & Wu, 2017). These insights contribute to identifying institutional support as the fourth latent factor influencing the effectiveness of EMI initiatives.

In addition to external factors, this study incorporates learners' perceived outcomes in EMI courses, encompassing satisfaction with content learning, English language development, and anticipated career advancement. Previous research emphasizes the need for more holistic evaluations of EMI program effectiveness from the student perspective (Bolton et al., 2024;

Sahan et al., 2021; Tran & Nguyen, 2018). Accordingly, perceived learning effectiveness is identified as the fifth latent factor in this study.

In summary, these five constructs—learners' competence and psychology, teachers' EMI competence, learning materials, institutional support, and perceived learning effectiveness—form the theoretical foundation for this study. They will be empirically tested through EFA and CFA, contributing to a validated measurement model for improving EMI practices in mathematics teacher education.

METHOD

Research Design

This study employed a quantitative approach to identify and validate the factors influencing the effectiveness of EMI-based mathematics learning among pre-service mathematics teachers. Two techniques were combined: EFA and CFA. EFA was used to uncover the underlying structure of the survey data, reduce the number of observed variables, and form representative latent constructs (Hair et al., 2009). Subsequently, the factor structure established through EFA was validated using CFA to assess the model's fit with actual data. The dataset was randomly split into two independent groups: one for EFA and the other for CFA. This two-stage design enhances objectivity and ensures reliable results by avoiding the validation of a model on the same dataset used for exploration.

Sampling and Data Collection

Participants were pre-service mathematics teachers enrolled in EMI courses at several major universities in Vietnam. Data were collected via a structured questionnaire administered both in-person and online (Google Forms). Before the main data collection, the questionnaire was refined based on feedback from two experts in mathematics education and bilingual instruction to ensure content and language validity. A total of 393 responses were received. After removing 21 invalid responses (incomplete or careless answers), 372 valid responses remained (94.6%). These were randomly divided into two groups: 186 for EFA and 186 for CFA.

Figure 1 presents the demographic characteristics of the sample, including students' institutions and academic years. Figure 1(a) shows the geographical distribution of participants, mapped across Vietnam. The sample included a wide range of institutions, with the highest representation from Thai Nguyen University (61%), followed by Vinh University (26%), Dong Thap University (6%), Ho Chi Minh City University of Education (5%), and Hanoi National University of Education (2%). This indicates a diverse and representative sample across regions. Figure 1(b) shows the academic year distribution, with first-year students making up the largest proportion (47%), followed by second-year (25%), third-year (15%), and fourth-year students (13%).

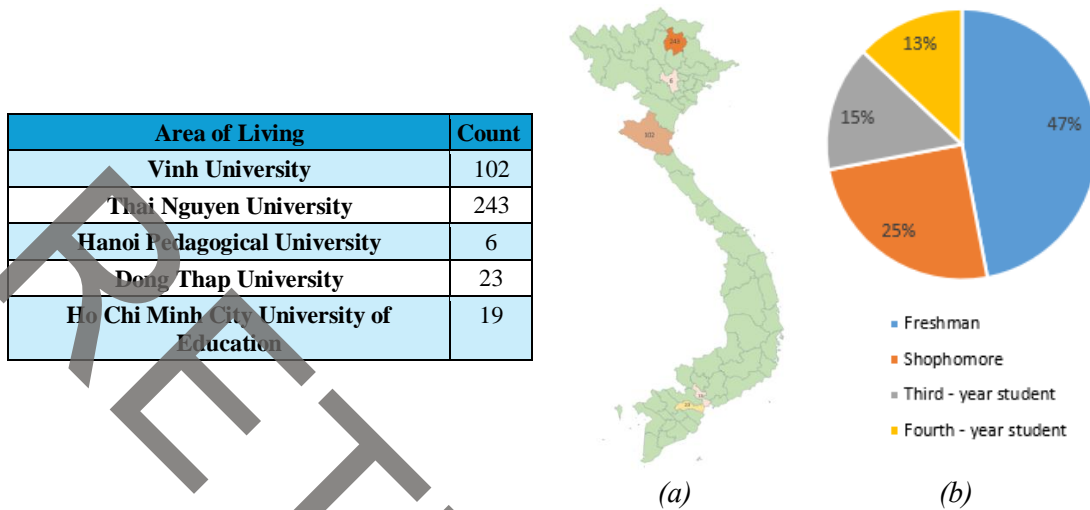


Figure 1. Geographic Distribution and Academic Year of the Surveyed Students

Instrument

The survey instrument (Table 1) comprised 22 items reflecting five latent factors: (1) learners' competence and psychological attributes, (2) teachers' EMI teaching competence, (3) learning materials, (4) institutional support, and (5) perceived learning effectiveness. Each factor included five observed variables measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The items were developed based on a synthesis of previous research, focusing on factors commonly associated with learning effectiveness in EMI and related instructional contexts. Although some of the cited studies did not directly examine EMI in mathematics education, they offered relevant insights from broader EMI, CLIL, problem-solving, and project-based learning contexts (synthesized in the “Literature review” section). These foundations were instrumental in constructing a valid and relevant set of survey items for this study.

Table 1. Survey Questionnaire Items

Expected Factors	Items	Variables
<i>Learners' Competence and psychological attributes</i>	I feel confident when studying mathematics in English.	Q1
	I can understand mathematical terminology in English.	Q2
	I actively ask questions in EMI mathematics classes.	Q3
	I believe that learning mathematics in English is beneficial for my future career.	Q4

Expected Factors	Items	Variables
	I can understand mathematical content delivered in English.	Q5
<i>Teachers' EMI teaching competence</i>	The lecturer communicates fluently in English during class.	Q6
	The lecturer uses the mother tongue effectively in EMI classes.	Q7
	The lecturer provides constructive feedback to learners.	Q8
	The lecturer is aware of students' learning characteristics.	Q9
	The lecturer uses a variety of teaching methods to support student	Q10
<i>Learning Materials</i>	English-language learning materials are sufficiently provided.	Q11
	The materials are clearly presented and easy to understand in English.	Q12
	I can easily access mathematics materials in English.	Q13
	Bilingual materials are adequately available.	Q14
<i>Institutional Support</i>	The class size in EMI courses is appropriate.	Q15
	Facilities meet the requirements for EMI teaching and learning.	Q16
	Practice environments are adequately and promptly provided.	Q17
	The university offers financial support policies for EMI students.	Q18
<i>Perceived Learning Effectiveness</i>	I am satisfied with the development of my subject knowledge in EMI classes.	Q19
	I am satisfied with the development of my language skills in EMI classes.	Q20
	I have more job opportunities after participating in EMI classes.	Q21
	I feel confident introducing the EMI program to others.	Q22

To ensure the content validity, prior to conducting the survey, the initial questionnaire comprising 22 items was evaluated by three experts in EMI and Mathematics Education for clarity, relevance, and linguistic appropriateness. More specifically, adverbs were incorporated into certain statements (e.g., “actively” in Q3 and “adequately” in Q14) to improve clarity and precision. In addition, the factor “*use of mother tongue*” replaced the initial factor concerning

terminology explanation, as one expert noted that this construct has been widely examined in previous studies (see Literature Review section). The expert-validated version was subsequently employed in the main survey.

Data Analysis

EFA was employed in the initial phase of the study to uncover the underlying structure of the survey data. This method is particularly effective for reducing the number of observed variables and identifying latent constructs that represent abstract theoretical concepts. Without EFA, examining all pairwise correlations among the 22 items would require processing 231 correlation coefficients, making the task complex and time-consuming. Thus, EFA not only reduces dimensionality but also offers a comprehensive view of factor structure, serving as a foundation for subsequent multivariate analyses such as CFA.

The EFA phase used 186 observations across 22 items, yielding a subject-to-variable ratio of 8.45:1. According to Hair et al. (2009), a ratio of 5:1 is acceptable, 10:1 is average, and 20:1 is ideal. Therefore, the sample size for EFA in this study is within the acceptable range to ensure factor reliability. However, due to the limited number of pre-service mathematics teachers currently enrolled in EMI courses in Vietnam, data collection posed several challenges. With 372 valid responses, the study optimized sampling under realistic conditions, ensuring reasonable reliability while demonstrating the study's feasibility in the Vietnamese teacher education context.

Data were analyzed using IBM SPSS version 25.0. Principal Component Analysis (PCA) with Varimax rotation was applied to extract and interpret the factor structure. The selection of the PCA method in combination with Varimax rotation in this study was grounded in both statistical and theoretical considerations as follows: (i) The objective of the EFA stage is to extract and identify the underlying structure of the initial dataset by reducing dimensionality and grouping highly correlated variables into common factors; therefore, PCA is an appropriate method for exploring data structure. (ii) The Varimax rotation technique, an orthogonal rotation method, facilitates a simple structure by clarifying the relationships between observed variables and factors while assuming minimal inter-factor correlations—consistent with identifying distinct groups of influencing factors. (iii) The combination of PCA and Varimax has been widely recommended in numerous studies on factor analysis in the social sciences (Hair et al., 2009; Byrne, 2013) as it enhances interpretability and ensures the stability of the factor model.

Before conducting factor analysis, the research team examined data distribution through descriptive statistics, including mean, standard deviation, skewness, and kurtosis. These metrics help determine the data's suitability for EFA and CFA. Following Byrne (2013) and Kline (2023), skewness and kurtosis values within ± 2 are acceptable for assuming normality, especially for medium-sized measurement models (West et al., 1995). Additionally, item means should range between 2.5 and 4.0 on a 5-point Likert scale to ensure adequate spread, while standard deviations between 0.5 and 1.2 indicate meaningful variability. Descriptive indicators falling within these recommended thresholds enhance the reliability of EFA and CFA, enabling accurate modeling under the assumption of normality.

Following descriptive analysis, the internal consistency of the scale was assessed using Cronbach's alpha for each factor-based item group. Any group with alpha below the acceptable threshold (0.70), or with items that reduce overall reliability, was revised or excluded before EFA. Data suitability for EFA was evaluated using the KMO statistic (> 0.7) and Bartlett's Test of Sphericity ($p < 0.05$). Factors were retained based on eigenvalues > 1 , scree plot analysis, total variance explained ($\geq 50\%$), and factor loadings ≥ 0.5 (Hair et al., 2009).

The number of factors was not predetermined but derived through a flexible approach informed by statistical criteria, ensuring an accurate reflection of the data's latent structure. With 22 items, each factor was expected to contain at least two, preferably three or more, items to ensure model stability and interpretability (Hair et al., 2009).

After identifying the latent factors from the EFA results, the research team proceeded to assess the internal consistency of these newly formed variable groups using Cronbach's Alpha. The calculation of Cronbach's Alpha following EFA serves to ensure that the new scales derived from empirical data maintain the necessary internal reliability for subsequent analytical procedures. Conducting reliability testing at both stages—before and after EFA—is essential in the context of this study, as it integrates both theoretical and data-driven approaches. This process not only facilitates the early elimination of weak items from the initial theoretical framework but also reaffirms the reliability of the discovered factor structure, thereby enhancing the rigor and objectivity of the measurement model.

Following EFA, CFA was conducted using AMOS 24.0 to validate the measurement model. Model fit was evaluated using the following indices: Chi-square/df < 3 , CFI and TLI ≥ 0.9 , RMSEA < 0.08 , and PCLOSE ≥ 0.05 . Composite reliability (CR > 0.7) and average variance extracted (AVE > 0.5) were also computed to assess reliability and convergent validity (Hair et al., 2009; Hu & Bentler, 1999).

FINDINGS AND DISCUSSION

Findings

Descriptive Statistics

Table 2 reports the descriptive statistics for the observed variables, including mean, standard deviation, skewness, and kurtosis.

Table 2. Means, Standard Deviations, Skewness, and Kurtosis of the Observed Variables

Variable	Mean	Std. Deviation	Kurtosis	Skewness
Q1	3.1935	0.96151	-0.029	0.008
Q2	3.3602	0.89704	-0.106	-0.186
Q3	2.8978	1.05282	-0.451	-0.075
Q4	4.1505	1.00212	1.135	-1.219
Q5	3.4462	1.0292	-0.042	-0.44

Variable	Mean	Std. Deviation	Kurtosis	Skewness
Q6	3.7366	1.06566	-0.133	-0.621
Q7	3.8172	0.95234	-0.127	-0.499
Q8	4.0484	0.88399	0.403	-0.759
Q9	3.8333	0.95247	-0.9	-0.305
Q10	3.957	1.00715	0.162	-0.812
Q11	4.1075	0.92954	-0.401	-0.747
Q12	4.0323	0.85046	0.394	-0.648
Q13	3.7957	0.92484	-0.422	-0.286
Q14	3.7742	1.02011	-0.729	-0.368
Q15	3.8925	1.02364	-0.538	-0.577
Q16	3.9301	0.99211	-0.142	-0.665
Q17	3.828	0.98775	-0.74	-0.396
Q18	3.5161	1.11125	-0.53	-0.364
Q19	3.7903	0.87864	-0.019	-0.398
Q20	3.7634	0.85611	-0.684	-0.151
Q21	3.9409	0.89548	0.044	-0.568
Q22	3.7688	0.92724	-0.569	-0.504

The descriptive statistics for the 22 observed variables show that the means range from 2.89 to 4.15, with most values falling within the central range of the 5-point Likert scale (2.5–4.0), indicating a reasonable level of agreement. Standard deviations mostly range from 0.85 to 1.11, suggesting moderate dispersion in responses. Skewness and kurtosis values for all variables lie within the acceptable range of ± 2 , meeting the criteria for approximate normality as recommended by Kline (2023). These results confirm that the dataset meets the essential assumptions for conducting EFA.

Before performing EFA, the reliability of the scales was assessed using Cronbach’s alpha for the five theoretical factor groups. As shown in Table 3, all scales achieved Cronbach’s alpha values greater than 0.7, which is the recommended threshold for internal consistency reliability (Hair et al., 2009).

Table 3. Cronbach’s Alpha for the Proposed Factors

No	Proposed Factor	Number of Items	Cronbach's Alpha
1	Learners’ Competence and Awareness	5	.755
2	Teachers’ EMI Competence	5	.829
3	Learning Materials	4	.838
4	Institutional Support	4	.775
5	Perceived Learning Effectiveness	4	.866

These five factors form the core structure of the measurement model. The first four represent key conditions influencing EMI mathematics learning: learners' competence and psychological attributes, teachers' EMI teaching competence, learning materials, and institutional support. The fifth—perceived learning effectiveness—captures students' reflections on outcomes such as satisfaction, academic and language development, and career expectations. Together, these factors provide a comprehensive and balanced framework for evaluating EMI effectiveness.

Following the reliability assessment, all measurement scales demonstrated satisfactory internal consistency, with Cronbach's Alpha coefficients exceeding 0.7. The dataset was then subjected to EFA using all 22 observed variables. The EFA results indicated that five items (Q11, Q12, Q13, Q19, and Q20) did not meet the retention criteria, as they exhibited factor loadings below 0.50 or cross-loadings of 0.30 or higher on two or more factors, as well as communalities below 0.40. Consequently, these items were removed to ensure the unidimensionality and construct purity of the extracted factors in the model.

The KMO and Bartlett's test results for the remaining 17 items indicated a satisfactory sampling adequacy, with a KMO value of 0.883 (Table 4), confirming the suitability of the data for factor analysis. Moreover, Bartlett's test of sphericity was statistically significant, $\chi^2(136) = 1244.075$, $p < 0.000$, suggesting that the variables were sufficiently correlated to justify the use of EFA.

Table 4. KMO and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.883
Bartlett's Test of Sphericity	Approx. Chi-Square	1244.076
	Df	136
	Sig.	.000

Exploratory Factor Analysis

Table 5 presents the extracted components along with their eigenvalues, explained variance, and cumulative variance. Following Kaiser's criterion, only components with eigenvalues greater than 1 were retained. Results from the 17 retained items revealed four underlying factors influencing EMI effectiveness, one fewer than originally hypothesized.

Table 5. Extracted Factors and Explained Variance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.323	37.192	37.192	6.323	37.192	37.192
2	1.791	10.537	47.729	1.791	10.537	47.729
3	1.212	7.130	54.859	1.212	7.130	54.859
4	1.067	6.276	61.134	1.067	6.276	61.134
5	.821	4.831	65.965			

The total variance explained by the four retained factors is 61.134%, indicating a substantial representation of the data from 186 student responses. While there is no fixed threshold, social science research typically accepts 60% or more as satisfactory (Aktas & Tabak, 2018). The unexplained variance may stem from external factors not captured by the model. As shown in Table 5, the four extracted components contribute 37.192% (Factor 1), 10.537% (Factor 2), 7.130% (Factor 3), and 6.276% (Factor 4) to the total variance, respectively. Factor 1 contributes the most, suggesting its dominant role in the model.

Figure 2 displays the scree plot with a noticeable inflection point at the fourth component, indicating a sharp drop in eigenvalues. According to Kaiser’s criterion, only components with eigenvalues greater than 1.0 are retained. The plot confirms that only the first four components satisfy this criterion, with subsequent components falling below the threshold line (represented by the red dashed line).

Thus, retaining four components is statistically sound and visually consistent with the scree plot.

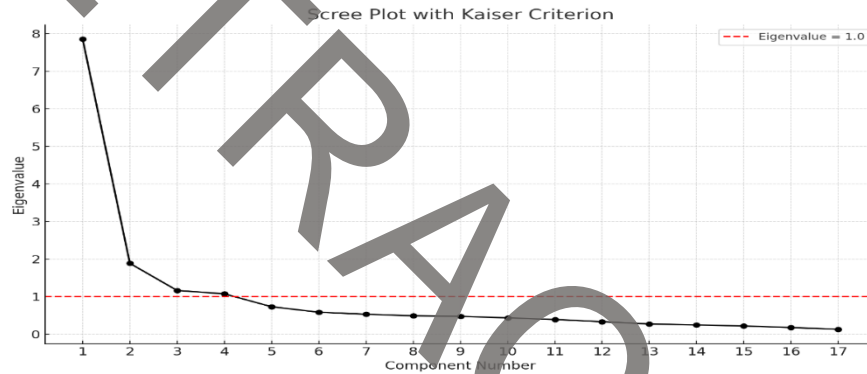


Figure 2. Scree Plot

Table 6 presents the rotated component matrix with factor loadings ranging from 0.577 to 0.805, indicating strong associations between observed items and latent constructs. According to Hair et al. (2009), factor loadings above 0.45 are statistically significant for samples over 150. Therefore, all observed items were retained. Moreover, each factor comprises at least three items with loadings exceeding 0.45, ensuring structural stability and interpretive reliability of the extracted factors.

Table 6. Rotated Component Matrix (Varimax Rotation)

Rotated Component Matrix				
	Component			
	1	2	3	4
Q8	.805			
Q9	.739			
Q7	.681			
Q10	.660			

Rotated Component Matrix				
	Component			
	1	2	3	4
Q6	.577			
Q17		.715		
Q14		.690		
Q18		.664		
Q15		.664		
Q16		.645		
Q2			.787	
Q3			.747	
Q1			.725	
Q5			.696	
Q21				.768
Q22				.701
Q4				.591

Table 7 presents the final EFA results with revised factor names and corresponding items. Based on the EFA results, the research team renamed the factors to better reflect the conceptual content of the observed variables. All four extracted factors show clear theoretical coherence and align with the original model.

Table 7. Final Factor Structure Based on EFA Results

<i>Variable Factors</i>		
<i>Factor 1: Teachers' EMI teaching Competence</i>		
Q8	Teacher provides constructive feedback.	.805
Q9	The lecturer is aware of students' learning characteristics.	.739
Q7	Teacher uses L1 strategically in EMI.	.681
Q10	Teacher uses diverse teaching strategies.	.660
Q6	Teacher communicates fluently in English.	.577
<i>Factor 2: Institutional Support</i>		
Q17	Practice environment is adequately provided.	.715
Q14	Bilingual learning materials are available.	.690
Q18	The university offers financial support policies for EMI students.	.664
Q15	School offers EMI financial support policies.	.664
Q16	Facilities support EMI teaching and learning.	.645
<i>Factor 3: Learners' Competence and Psychological attributes</i>		
Q2	I understand mathematical terms in English.	.787
Q3	I actively ask questions in EMI math class.	.747
Q1	I feel confident learning math in English.	.725
Q5	I understand math content delivered in English.	.696

Factor 4: Perceived Learning Effectiveness		
Q21	EMI improves my job opportunities.	.768
Q22	I feel confident promoting the EMI program.	.701
Q4	Learning math in English benefits my career.	.591

(Details of all 17 items retained after the EFA are presented in Appendix A).

Confirmatory Factor Analysis

Figure 3 illustrates the CFA model with four latent constructs: (1) Institutional Support, (2) Teachers’ EMI Competence, (3) Learners’ Competence and Awareness, and (4) Perceived Learning Effectiveness. Each construct is measured by corresponding observed variables through linear relationships.

Standardized regression weights between latent factors and their indicators range from 0.56 to 0.88, indicating strong associations and confirming construct validity. Inter-factor correlations range from 0.39 to 0.75, supporting the theoretical expectation that constructs are related but conceptually distinct. The model also includes measurement errors (e1–e17) for each indicator, ensuring that residual variances are independently represented apart from the latent structure.

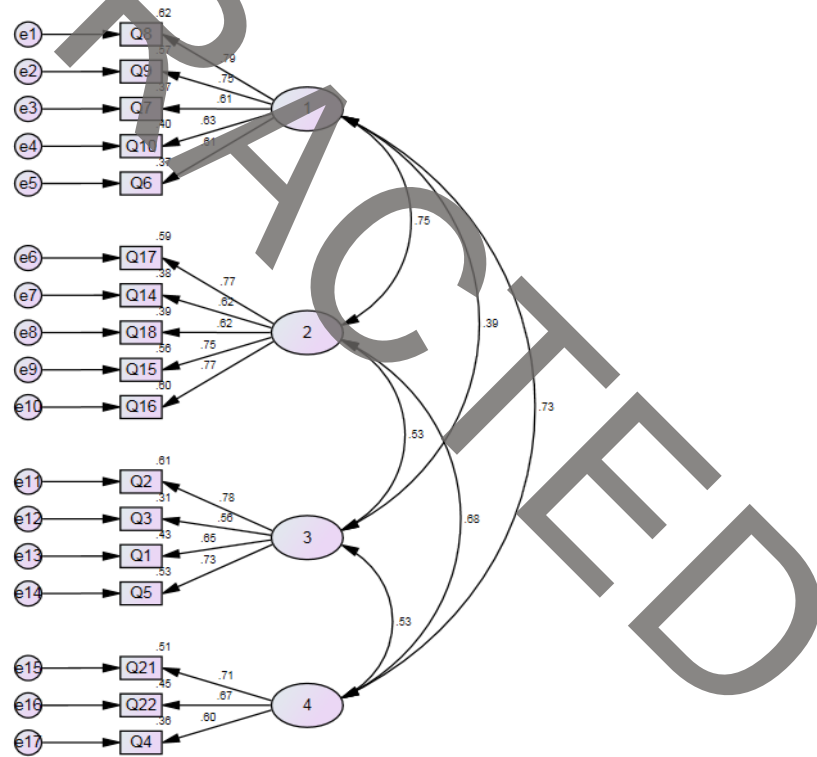


Figure 3. The Four-Factor Model of EMI Learning Effectiveness

Note: The four latent factors are numbered from 1 to 4, corresponding to the observed variable groups presented in Table 7.

Table 8 presents the model fit indices for the CFA, indicating that the four-factor model fits the data well. The Chi-square/df ratio is 1.599, which is below the commonly accepted threshold of 3, suggesting an excellent fit. Both the Goodness-of-Fit Index (GFI = 0.900) and Adjusted GFI (AGFI = 0.865) meet the recommended minimums, indicating acceptable model adequacy (Hair et al., 2009). The Normed Fit Index (NFI = 0.860) is acceptable, while the Comparative Fit Index (CFI = 0.941) approaches an excellent level. Additionally, the Root Mean Square Error of Approximation (RMSEA = 0.057) is well below 0.08, and the PCLOSE value of 0.225 exceeds the 0.05 threshold, indicating that the model is reliable and parsimonious. Taken together, these results confirm that the CFA model provides a robust and valid representation of the latent structure identified in the EFA phase.

Table 8. Model Fit Indices for the CFA Model

No	Measure	Estimate	Threshold	Interpretation
1	CMIN/D	1.599	< 3	Excellent
2	GFI	0.900	≥.90	Acceptable
3	AGFI	0.865	≥.85	Acceptable
4	NFI	0.860	≥.80	Acceptable
5	CFI	0.941	≥.90	Good
6	RMSEA	0.057	≤.08	Good
7	PCLOSE	0.225	≥.05	Excellent

Table 9 reports the Composite Reliability (CR) and Average Variance Extracted (AVE) for the four factors in the CFA model. All CR values meet or exceed the recommended threshold of 0.70, indicating good internal consistency. Two factors show AVE ≥ 0.50, demonstrating acceptable convergent validity. Although the remaining two factors have AVE values below 0.50, they still fall above 0.40. According to Fornell and Larcker (1981), such factors may be retained if CR ≥ 0.70 and model fit is satisfactory. Overall, the measurement model demonstrates acceptable reliability and convergent validity, supporting its use in further analysis.

Table 9. Composite Reliability and Average Variance Extracted of the Four Factors

No	Factor	CR	AVE
1	Teachers' EMI teaching Competence	0.849	0.532
2	Institutional Support	0.828	0.494
3	Learners' Competence and psychological attributes	0.777	0.469
4	Perceived Learning Effectiveness	0.772	0.531

The CFA results indicate that the measurement model demonstrates good fit with the survey data, as evidenced by the following indices: CMIN/df = 1.599, GFI = 0.900, CFI = 0.941, RMSEA = 0.057, and PCLOSE = 0.225. All values fall within recommended thresholds, suggesting that the model fits the empirical data well and is suitable for further analysis.

Regarding reliability and convergent validity, all factors exhibit composite reliability (CR) values of 0.77 or higher, meeting the threshold recommended by Hair et al. (2009). The AVE values range from 0.464 to 0.532, with two factors reaching the 0.5 benchmark and the

remaining two still acceptable due to adequate CR levels. This indicates that the scales demonstrate reasonable reliability and convergent validity, and are suitable for validating the proposed theoretical model.

Overall, the CFA model satisfies key measurement criteria and can be used to confirm the factor structure identified in the exploratory phase.

Discussion

The results confirm that the measurement model, comprising four latent factors - (1) Learners' personal capacity and psychological attributes, (2) Lecturers' English teaching competence, (3) Institutional support, and (4) Perceived learning effectiveness - exhibits a satisfactory fit with the observed data. The model fit indices (CMIN/DF = 1.599, GFI = 0.900, CFI = 0.941, RMSEA = 0.057) fall within commonly accepted thresholds, indicating an overall good model fit. Furthermore, all standardized factor loadings in the Confirmatory Factor Analysis (CFA) model exceed 0.56, suggesting that the observed variables effectively represent their respective latent constructs. These findings offer robust empirical support for the construct validity of the factor structure identified through Exploratory Factor Analysis (EFA).

The structural reliability (CR) of all four factors exceeds 0.77, suggesting high internal consistency among observed variables within each construct (Hair et al., 2009). Although two constructs have AVE values below 0.50, the high CR compensates for this limitation, consistent with the criteria proposed by Fornell and Larcker (1981). This implies that, despite minor shortcomings, the model remains reliable and suitable for further empirical testing and practical application.

From a theoretical perspective, the four latent factors confirmed in the CFA model are well-aligned with previous literature. "Institutional Support" corresponds to organizational and contextual elements highlighted in studies by Li and Wu (2017). "Teachers' EMI Competence" reflects pedagogical and linguistic competencies, consistent with DelliCarpini and Alonso (2014) and Chen (2017). "Learners' Competence and Awareness" echoes findings from Ellili-Cherif and Alkhateeb (2015) and Nga (2024), who emphasized the influence of English proficiency, student psychology, and learning motivation. Finally, "Perceived Learning Effectiveness" focuses on student-centered outcomes, consistent with Bolton et al. (2024) and Tran and Nguyen (2018), who explored learner perspectives on EMI program impacts.

This study places particular emphasis on the reduction of the original "learning materials" dimension to a single, bilingual-availability indicator (Q14) — and its subsequent association with the Institutional Support factor — can be interpreted both statistically and contextually. Statistically, several material-related items (Q11–Q13) failed to meet EFA retention criteria and were therefore removed to preserve factor purity; only the bilingual-availability item showed sufficient common variance to survive the extraction. Contextually, the prominence of bilingual availability reflects a pragmatic reality in the Vietnamese EMI context: learners with limited disciplinary English often require L1-supported materials as a salient, institutionally mediated scaffolding mechanism (Chiang, 2010; Hanh, 2021; Phuong & Nguyen, 2019). This interpretation is consistent with evidence that, in similar regional settings, material adequacy is frequently enacted and experienced through institutional structures rather than through ad-hoc

instructor practices alone (Lasagabaster, 2022; Dearden & Beaumont, 2024). We therefore recommend that future instrument development consider more nuanced, multi-item measures of materials (e.g., bilingual format, accessibility, alignment with course outcomes, and digital vs. print availability) and that qualitative follow-up work investigate how students and staff construe the institutional versus pedagogical dimensions of learning materials in EMI contexts.

In addition, the four-factor structure identified in this study aligns closely with constructs commonly reported in EMI-in-STEM research across the region. Regional studies frequently highlight teacher pedagogical/linguistic competence, learner language proficiency and affective factors, and institutional or policy-level supports as major determinants of EMI success (e.g., Chung et al., 2020; Tong & Tang, 2017). Where some regional models treat instructional materials as an independent domain, our model more closely resembles frameworks that foreground institutional capacity and teacher mediation as primary enablers of student learning in EMI classrooms (Li & Wu, 2017; Dearden & Beaumont, 2024).

One of the key findings of this study indicates that among the surveyed factors, Factor 1 – Learners' Personal Competence and Psychological attributes – was perceived as the most significant role in determining EMI program effectiveness. As reviewed in the literature (see Literature Review section), students enrolled in EMI programs currently face various challenges, including limited vocabulary, insufficient language proficiency, difficulties in classroom interaction, and psychological barriers such as anxiety. Therefore, to enhance the effectiveness of EMI programs, curriculum designers should incorporate discipline-specific English support courses, while EMI instructors are encouraged to implement interactive pedagogical strategies that promote classroom engagement and address learners' psychological needs.

Although previous studies have emphasized the complexity of EMI learning materials as a barrier to academic achievement (Hanh, 2021; Lasagabaster, 2022; Chiang, 2010; Zumor & Qasem, 2019), this study found that students only highlighted the availability of bilingual materials as a relevant concern. Other aspects of this variable—such as content accessibility or clarity—were not perceived as significantly influential in shaping learning outcomes. While this finding requires further empirical validation, it nonetheless offers valuable implications for future research and the development of EMI learning materials.

Another noteworthy finding of this study is the exclusion of the item “I am satisfied with my language development in the EMI course” from the final factor structure, labeled Perceived Effectiveness. This outcome is consistent with prior research, which has highlighted either uncertainty or limited improvement in English language proficiency among students participating in EMI programs (Lei & Hu, 2014). The result suggests that learners opting for EMI courses may place less emphasis on language development and instead prioritize subject mastery and career advancement. Accordingly, it is strongly recommended that institutions implementing EMI programs align their curricula with students' future employment trajectories. This could involve establishing strategic partnerships with relevant industries and organizations, as well as enhancing the visibility and reputation of EMI initiatives to increase the employability of graduates—particularly in mathematics education.

Overall, the findings of this study not only reinforce established theoretical assumptions but also offer practical implications for the design, enhancement, and evaluation of EMI-based mathematics education programs for pre-service teachers.

CONCLUSION

This study aimed to identify latent factors influencing the effectiveness of learning mathematics through English among pre-service mathematics teachers. The analysis was based on survey data collected from 372 students enrolled in EMI mathematics courses at teacher training universities. The dataset comprised 22 items, with half of the responses ($n = 186$) utilized for Exploratory Factor Analysis (EFA) and the remaining half ($n = 186$) reserved for Confirmatory Factor Analysis (CFA). The EFA results revealed a four-factor structure, accounting for 61.134% of the total variance. These factors were identified as: (1) Learners' personal capacity and psychological attributes, (2) Lecturers' English teaching competence, (3) Institutional support, and (4) Perceived learning effectiveness. The subsequent CFA confirmed the construct validity and reliability of this model, with all fit indices meeting or exceeding established thresholds. These findings not only support existing literature but also offer novel empirical insights into the key components that contribute to the successful implementation of EMI-based mathematics instruction within teacher education programs.

This study employed a quantitative design based on self-reported data, which may be subject to response biases related to participants' subjective perceptions. While the majority of CFA fit indices met the recommended criteria, the Average Variance Extracted (AVE) for two constructs fell below the 0.50 threshold, indicating limited convergent validity. Furthermore, discriminant validity between certain factor pairs was insufficient, suggesting the need for further refinement of the measurement instrument. It is recommended that Structural Equation Modeling (SEM) be employed to investigate the causal relationships among the validated latent factors. SEM would enable a more comprehensive evaluation of the individual and collective impact of these factors on EMI mathematics learning effectiveness, and provide an overall test of the theoretical model within the context of teacher education. Additionally, SEM could be used to explore mediating or moderating effects and to examine structural differences across distinct learner subgroups.

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