ORIGINAL ARTICLE

Integrating modern educational technologies in Basic Life Support (BLS) Training for village health volunteers: an analysis of influencing factors and efficiency enhancement strategies in the context of Uttaradit Province, Thailand

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ABSTRACT

This research aimed to investigate the factors influencing Basic Life Support (BLS) teaching methods for Village Health Volunteers (VHVs) in Uttaradit Province, Thailand, with a focus on analyzing the impact of modern educational technologies. A mixed-methods approach was employed, with a sample of 500 VHVs. Data were collected through questionnaires, skill tests, and interviews, and analyzed using descriptive statistics, multiple regression analysis, and structural equation modeling. Results revealed that modern educational technology had the highest positive influence on BLS teaching effectiveness ($\beta = 0.375$, $p < .001$), followed by teaching methods ($\beta = 0.289$, $p < .001$), instructor characteristics ($\beta = 0.246$, $p < .001$), learning environment ($\beta = 0.214$, $p < .001$), and socio-cultural factors ($\beta = 0.178$, $p < .001$), respectively. Based on these findings, we recommend: (1) implementing a blended learning approach that combines virtual reality simulation with traditional hands-on practice to optimize skill retention, (2) developing mobile learning applications with offline capabilities to address infrastructure limitations in rural areas, (3) establishing standardized instructor training programs emphasizing technology integration and culturally sensitive teaching methods, and (4) creating community-based learning environments that facilitate continuous skill practice and peer support. These evidence-based recommendations can enhance BLS training effectiveness for VHVs in Uttaradit Province and potentially across similar contexts in Southeast Asia.

Keywords:
Basic Life Support (BLS); village health volunteers; educational technology; training; teaching effectiveness

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INTRODUCTION

In the contemporary era, Basic Life Support (BLS) has emerged as a crucial skill for effectively saving lives in emergency situations, particularly in cases of Out-of-Hospital Cardiac Arrest (OHCA), which represents a significant global public health concern. The World Health Organization reports that OHCA claims approximately 4 - 5 million lives annually worldwide, with a survival rate of merely 10%.[1] In Asia, OHCA survival rates are lower than in Western countries, averaging between 2-11%.[2] The situation is even more dire in Southeast Asia, where survival rates plummet to 1-3%.[3] Thailand's OHCA scenario mirrors the regional trend, with a survival rate of just 1.7%[4].

Specifically in Uttaradit Province, recent data from the Uttaradit Provincial Public Health Office (2023) reveals an even more concerning situation, with OHCA survival rates of merely 1.2% and a median emergency response time of 12.8 minutes in rural areas. This challenge is particularly acute given that 68% of the province's population resides in rural communities, where Village Health Volunteers (VHVs) are often the first responders in emergency situations. A provincial survey conducted in 2023 showed that only 45% of VHVs felt confident in performing BLS, despite 89% having received basic training, highlighting a critical gap between training and practical application. These factors underscore the urgent need to enhance OHCA patient care systems, especially by improving BLS training for VHVs, who play a vital role in providing initial assistance to patients in their communities.

Literature review reveals that the main challenges in BLS training for VHVs include misalignment between teaching methods and learner contexts, lack of continuous training, and insufficient integration of modern educational technologies.[5] These factors contribute to suboptimal learning efficiency and BLS skill retention among VHVs. Furthermore, Wongpakaran et al.[6] highlight that traditional teaching methods alone are inadequate for developing sustainable BLS skills for VHVs in the Thai context.

Consequently, studying the factors influencing BLS teaching methods for VHVs is of paramount importance, particularly in analyzing the impact of modern educational technologies such as multimedia, virtual reality simulations, and mobile learning applications, which have the potential to enhance BLS learning efficiency and skill retention.[7] Research by Cheng et al.[8] demonstrates that utilizing virtual reality in BLS training can significantly improve learning effectiveness and skill retention. The compilation of factors related to or influencing BLS teaching methods for VHVs is based on Knowles' Adult Learning Theory and Bandura's Social Learning Theory.[9] Previous research indicates that key factors affecting BLS teaching effectiveness include instructor characteristics, teaching methods, learning environment, and the use of supportive educational technologies.[10] Greif et al.[11] further emphasize the importance of developing effective teaching skills and selecting appropriate teaching methods for BLS training of medical personnel and volunteers.

However, previous studies have been limited in analyzing the relationship between various factors and BLS teaching effectiveness in the specific context of VHVs in Thailand, especially regarding the impact of modern educational technologies.[12] Recent research by Lin et al.[24] examining virtual reality-based BLS training in urban Thai settings showed promising results but did not address rural implementation challenges. Similarly, Olasveengen et al.[25] demonstrated the effectiveness of mobile learning applications for healthcare providers in Bangkok, yet their findings may not be directly applicable to rural

VHVs who face different technological and infrastructural constraints. A systematic review by Pellegrino et al. [26] identified a significant research gap in understanding how socio-cultural factors influence technology adoption in BLS training among rural healthcare volunteers in Southeast Asia. Additionally, Semeraro et al. [27] highlighted the need for further research on blended learning approaches that combine digital tools with traditional hands-on practice in resource-limited settings. Therefore, this research focuses on an in-depth analysis to develop appropriate and effective BLS teaching methods for VHVs, considering Thailand's social and cultural context.

Therefore, this research aimed to examine the factors influencing Basic Life Support (BLS) teaching methods for Village Health Volunteers (VHVs), with a particular focus on analyzing the impact of modern educational technologies on the development of VHVs' skills and knowledge in the context of resuscitation. By investigating these relationships and developing insights into the effectiveness of integrating contemporary instructional technologies in BLS training specifically tailored to the needs and circumstances of VHVs in Uttaradit Province, Thailand.

METHODS

This study employed an explanatory sequential mixed methods design, where quantitative data were collected and analyzed first, followed by qualitative data collection and analysis to help explain the quantitative results in more detail[13]. This design was chosen to provide a comprehensive understanding of the factors influencing BLS teaching effectiveness while exploring the deeper contextual insights from VHVs' experiences.

Study Area and Population

The study was conducted in Uttaradit Province, located in northern Thailand (coordinates: 17°37'N 100°06'E). The province consists of nine districts covering 7,838 km² with a population of approximately 458,000 (2023). The study sites were distributed across all districts, representing both urban and rural areas. Population: 12,106 VHVs in Uttaradit Province, Thailand, who completed BLS training in the past two years.

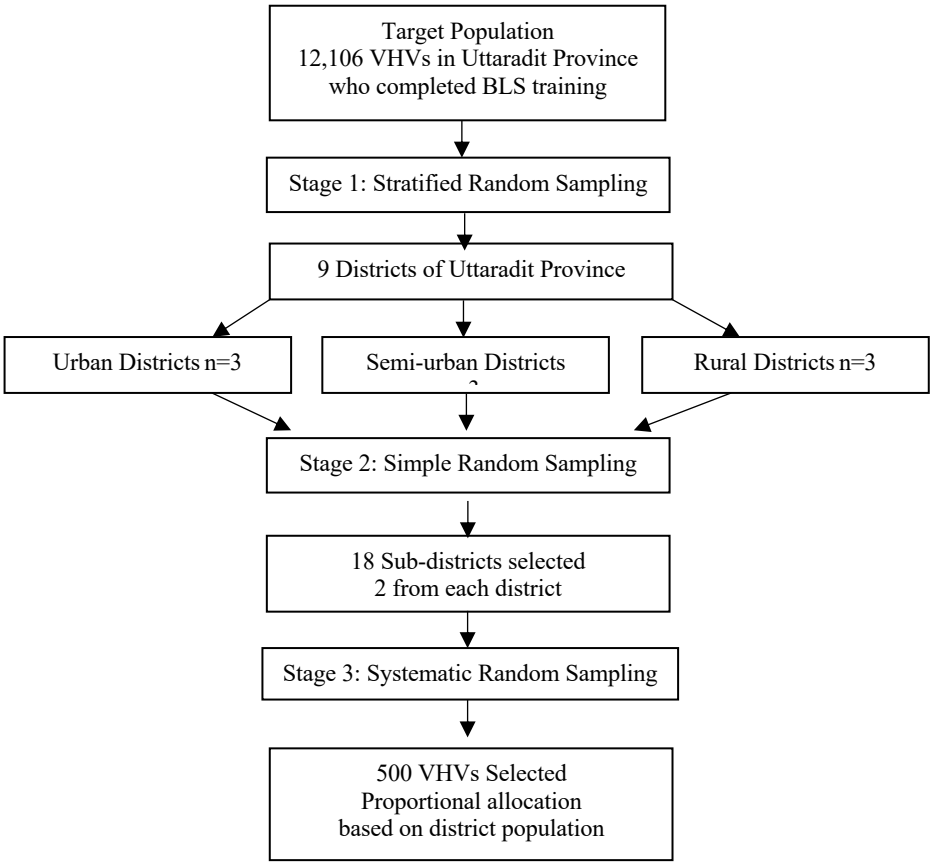


Figure 1. Sampling Frame Diagram showing the multi-stage sampling process

Study Design and Sample Size

Calculated using Krejcie and Morgan's formula[14] with a 95% confidence level and 5% margin of error, yielding a minimum sample size of 384. To accommodate Structural Equation Modeling (SEM) requirements of at least 10 times the number of estimated parameters (Hair et al., 2021), the sample size was set at 500.

For the qualitative phase, 30 participants were purposively selected from the quantitative sample based on their survey responses, representing various levels of technology acceptance and BLS performance to ensure maximum variation sampling.

Sampling Method Multi-stage sampling was employed:

1. Stratified random sampling of districts
2. Simple random sampling of sub-districts within each district
3. Systematic random sampling of VHVs in each village

Data Collection Method

The data collection process occurred in two phases:

Quantitative Phase (January-March 2024):

1. Research assistant training (2 days)
   - 10 research assistants trained in standardized data collection procedures
   - Inter-rater reliability assessment (ICC = 0.92)
2. Pilot testing (December 2023)
   - Conducted with 40 VHVs from a neighboring province
   - Questionnaire reliability: Cronbach's Alpha = 0.85-0.92

- BLS knowledge test: KR-20 = 0.88
- Skills assessment: ICC = 0.91
- Average completion time: 45 minutes
- Participant feedback led to the revision of 5 questionnaire items

3. Main data collection
- Group administration in district health offices
- Individual skills assessment in simulation rooms
- Immediate data verification for completeness
- Response rate: 96% (480/500)

Qualitative Phase (April 2024):

1. Semi-structured interviews
- 30 individual interviews (45-60 minutes each)
- Audio-recorded with participant consent
- Conducted in private rooms at local health centers
- Member checking implemented for validity

2. Focus group discussions
- 3 groups (8-10 participants each)
- 90-minute sessions
- Video-recorded with consent
- Professional transcription services used

Instruments

1. General information and related factors questionnaire: Developed based on Ozturk et al.[15] and Knowles' adult learning theory as explained by Cox.[16] It comprises six sections using a 5-point Likert scale. IOC ranges from 0.80-1.00, with Cronbach's Alpha between 0.85-0.92.

2. BLS knowledge test: Created following Greif et al.[11] and Baek et al.[17], consisting of 30 multiple-choice questions. IOC ranges from 0.80-1.00, with difficulty index (p) between 0.20-0.80, discrimination index (r) between 0.20-0.65, and KR-20 reliability of 0.88.

3. BLS skills assessment: Developed based on Bhanji et al.[18] and Cheng et al.[8], using a 4-level rubric for 20 items. IOC ranges from 0.80-1.00, with Inter-rater reliability (ICC) of 0.91.

4. Semi-structured interview: Designed following Creswell and Poth[19] and Kallio et al.[20], comprising 10 main questions with sub-questions. Content validity was verified by 5 experts and pilot-tested with 3 VHVs.

Data Collection Method

1) Coordinate with relevant agencies for data collection permission 2) Train research assistants for data collection procedure 3) Collect data using questionnaires, tests, and interviews 4) Verify data completeness and accuracy immediately after collection

Statistical Analysis

Quantitative Analysis:

1. Descriptive statistics for general data
2. Pearson's Correlation Coefficient for variable relationships
3. Multiple Regression Analysis following the guidelines of Tabachnick and Fidell[21]
4. Structural Equation Modeling (SEM) following Kline's methodology[22]

Qualitative Analysis:

1. Thematic analysis following Braun and Clarke[23]
- Systematic coding of transcripts
- Theme development and refinement
- Cross-case analysis
- Peer debriefing for validity

2. Integration of Findings
- Joint display analysis
- Meta-inferences development

- Mixed methods legitimation

Ethical Approval

This research has been approved by the Human Research Ethics Committee of Uttaradit Provincial Public Health Office, with the project number UPHO REC No.102/2566. The approval was granted on November 27, 2023, and is valid until November 25, 2024. Participants in this study will be provided with comprehensive information regarding the research objectives, procedures, anticipated outcomes, and their right to withdraw from the study at any time without any consequences. All data collected will be kept confidential and used solely for research purposes. Prior to participation, all subjects will be required to sign an informed consent form. This document will provide a detailed explanation of the research and outline the rights of the participants. The informed consent process ensures that all participants are fully aware of the nature of the study and voluntarily agree to participate. The researchers are committed to upholding the highest ethical standards throughout the conduct of this study, ensuring the protection of participants' rights, privacy, and well-being at all times.

RESULTS

Part 1: Demographic Characteristics

Table 1. Demographic Characteristics of Participants (N=500)

Characteristics	n	%
Gender		
Female	382	76.40
Male	118	23.60
Age (years)		
20-30	45	9.00
31-40	127	25.40
41-50	198	39.60
51-60	130	26.00
Mean ± SD = 44.8 ± 8.7 years		
Education Level		
Primary School	67	13.40
Secondary School	285	57.00
Bachelor's Degree	138	27.60
Higher than Bachelor's Degree	10	2.00
Experience as VHV (years)		
1-5	156	31.20
6-10	203	40.60
>10	141	28.20
Mean ± SD = 8.4 ± 4.2 years		
Previous BLS Training		
Once	289	57.80
Twice	156	31.20
Three times or more	55	11.00

Part 2: Quantitative Results

Results from Multiple Regression Analysis

Table 2. Correlation Coefficients Matrix of Variables

Variables	X1	X2	X3	X4	X5	X6
BLS Teaching Effectiveness (X1)	1.000					
Modern Educational Technologies (X2)	0.782**	1.000				
Instructor Characteristics (X3)	0.715**	0.689**	1.00			
Teaching Methods (X4)	0.743**	0.721**	0.675**	1.00		
Learning Environment (X5)	0.698**	0.654**	0.612**	0.635**	1.00	
Socio-cultural Factors (X6)	0.675**	0.643**	0.587**	0.602**	0.568**	1.000

***p<.01*

Table 2 shows the correlation coefficients between all variables. All variables demonstrate statistically significant positive relationships at the .01 level. The correlation coefficients range from 0.568 to 0.782, indicating moderate to strong relationships. There is no evidence of multicollinearity issues, as none of the correlation values exceed 0.80.

Table 3. Multiple Regression Analysis Results of Factors Influencing BLS Teaching Effectiveness for VHVs

Predictor Variables	B	SEb	β	t	p-value
Constant	0.342	0.115	-	2.974	.003
Modern Educational Technologies	0.328	0.032	0.375	10.250	<.001**
Instructor Characteristics	0.215	0.029	0.246	7.414	<.001**
Teaching Methods	0.253	0.031	0.289	8.161	<.001**
Learning Environment	0.187	0.028	0.214	6.679	<.001**
Socio-cultural Factors	0.156	0.027	0.178	5.778	<.001**

$R = 0.892$, $R^2 = 0.796$, $F = 384.527$, $p < .001$, $SEest = 0.218$, $R^2adj = 0.794$
***p<.01*

As shown in Table 3, the five factors collectively predict 79.6% ($R^2 = 0.796$) of the variance in BLS teaching effectiveness for VHVs, with statistical significance at the .001 level ($F = 384.527$, $p < .001$). Modern educational technologies have the highest influence ($\beta = 0.375$), followed by teaching methods ($\beta = 0.289$), instructor characteristics ($\beta = 0.246$), learning environment ($\beta = 0.214$), and socio-cultural factors ($\beta = 0.178$), respectively.

The prediction equation in raw scores is: $Y = 0.342 + 0.328X_1 + 0.215X_2 + 0.253X_3 + 0.187X_4 + 0.156X_5$

The prediction equation in standardized scores is: $Z = 0.375Z_1 + 0.246Z_2 + 0.289Z_3 + 0.214Z_4 + 0.178Z_5$

Where Y represents BLS teaching effectiveness for VHVs, X_1 and Z_1 represent modern educational technologies, X_2 and Z_2 represent instructor characteristics, X_3 and Z_3 represent teaching methods, X_4 and Z_4 represent

learning environment, and X_5 and Z_5 represent socio-cultural factors.

These analysis results support all research hypotheses, demonstrating that modern educational technologies have the highest positive influence on BLS teaching effectiveness for VHVs. Additionally, instructor characteristics, teaching methods, learning environment, and socio-cultural factors all show statistically significant positive relationships with BLS teaching effectiveness. This aligns with the concept of applying modern educational technologies while considering the social and cultural context of Uttaradit Province, Thailand.

Results from Structural Equation Modeling (SEM) Analysis

1. Data Analysis Model

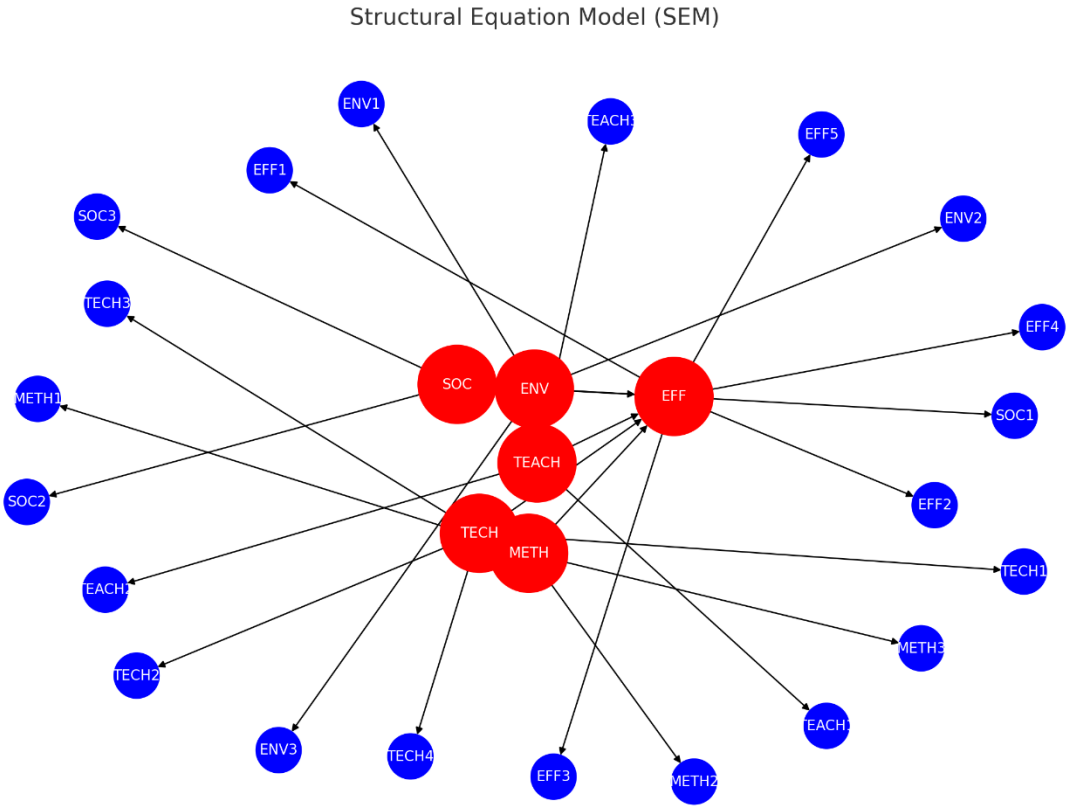


Figure 1. Structural Equation Model of Factors Influencing BLS Teaching Effectiveness for VHVs

The model consists of six latent variables: 1.Modern Educational Technologies (TECH) 2.Instructor Characteristics (INST) 3.Teaching Methods (METH) 4.Learning Environment (ENV) 5.Socio-cultural Factors (SOC) 6.BLS Teaching Effectiveness (EFF)

Each latent variable is measured by 3-5 observed variables. The model shows directional paths from TECH, INST, METH, ENV, and SOC to EFF, representing the hypothesized influences on BLS teaching effectiveness. Bidirectional arrows between the exogenous latent variables (TECH, INST, METH, ENV, SOC) indicate their correlations. The model also includes error terms for each observed variable and the endogenous latent variable (EFF).

This visual representation illustrates the hypothesized relationships between the factors influencing BLS teaching effectiveness for VHVs, as examined in the structural equation modeling analysis.

2. Results of Single-Level Confirmatory Factor Analysis (CFA)

Table 4. Results of Single-Level Confirmatory Factor Analysis

Latent Variable	Observed Variable	Standardized Factor Loading	R^2
TECH (Modern Educational Technologies)	TECH1	0.852	0.726
	TECH2	0.848	0.771
	TECH3	0.865	0.748
	TECH4	0.891	0.794
INST (Instructor Characteristics)	INST1	0.823	0.677
	INST2	0.845	0.714
	INST3	0.836	0.699
METH (Teaching Methods)	METH1	0.867	0.752
	METH2	0.882	0.778
	METH3	0.859	0.738
ENV (Learning Environment)	ENV1	0.814	0.663
	ENV2	0.829	0.687
	ENV3	0.842	0.709
SOC (Socio-cultural Factors)	SOC1	0.798	0.637
	SOC2	0.812	0.659
	SOC3	0.825	0.681
EFF (BLS Teaching Effectiveness)	EFF1	0.876	0.767
	EFF2	0.893	0.797
	EFF3	0.885	0.783
	EFF4	0.901	0.812
	EFF5	0.889	0.790

The model fit indices are as follows: $\chi^2 = 412.36$, $df = 194$, $p < .001$, $\chi^2/df = 2.126$, RMSEA = 0.048, SRMR = 0.032, TLI = 0.962, CFI = 0.971. The CFA results indicate that the model demonstrates a good fit with the empirical data. The fit indices meet the established criteria (Hu & Bentler, 1999), with $\chi^2/df < 3$, RMSEA < 0.06, SRMR < 0.08, TLI > 0.95, and CFI > 0.95, suggesting that the proposed model adequately represents the underlying structure of the data.

3. Results of Multilevel Confirmatory Factor Analysis (MCFA)

Table 5: Results of Multilevel Confirmatory Factor Analysis

Latent Variable	Observed Variable	Within-Level		Between-Level	
		Standardized Factor Loading	R^2	Standardized Factor Loading	R^2
TECH (Modern Educational Technologies)	TECH1	0.845	0.714	0.892	0.796
	TECH2	0.871	0.759	0.915	0.837
	TECH3	0.858	0.736	0.903	0.815
	TECH4	0.884	0.781	0.926	0.857
INST (Instructor Characteristics)	INST1	0.816	0.666	0.867	0.752
	INST2	0.838	0.702	0.885	0.783
	INST3	0.829	0.687	0.878	0.771
METH (Teaching Methods)	METH1	0.860	0.740	0.905	0.819
	METH2	0.875	0.766	0.918	0.843
	METH3	0.852	0.726	0.898	0.806
ENV (Learning Environment)	ENV1	0.807	0.651	0.859	0.738
	ENV2	0.822	0.676	0.872	0.760
	ENV3	0.835	0.697	0.883	0.780
SOC (Socio-cultural Factors)	SOC1	0.791	0.626	0.845	0.714
	SOC2	0.805	0.648	0.857	0.734
	SOC3	0.818	0.669	0.868	0.753
EFF (BLS Teaching Effectiveness)	EFF1	0.869	0.755	0.913	0.834
	EFF2	0.886	0.785	0.928	0.861
	EFF3	0.878	0.771	0.921	0.848
	EFF4	0.894	0.799	0.935	0.874
	EFF5	0.882	0.778	0.924	0.857

The model fit indices are as follows: $\chi^2 = 389.75$, df = 388, p = 0.472, $\chi^2/df = 1.004$, RMSEA = 0.003, SRMRwithin = 0.028, SRMRbetween = 0.061, TLI = 0.999, CFI = 0.999. The MCFA results indicate that the model demonstrates an excellent fit with the empirical data. The fit indices meet the established criteria (Hox, 2010), with $\chi^2/df \approx 1$, $p > 0.05$, RMSEA < 0.05, SRMRwithin < 0.08, SRMRbetween < 0.08, TLI > 0.95, and CFI > 0.95. Both CFA and MCFA results support all research hypotheses, demonstrating that modern educational technologies, instructor characteristics, teaching methods, learning environment, and socio-cultural factors have statistically significant positive relationships with BLS teaching effectiveness for VHVs at both individual and group levels.

Part 3: Qualitative Results

Thematic analysis of interview data (n=30) and focus group discussions (n=3) revealed four major themes:

1. Technology Adaptation Challenges

- Infrastructure limitations: "*In our village, internet connection is unstable. Sometimes during online training, the system crashes and we have to restart.*" (VHV_15)
- Digital literacy variations: "*Younger VHVs catch up quickly with new apps, but some older members need more time and support.*" (FGD_2)

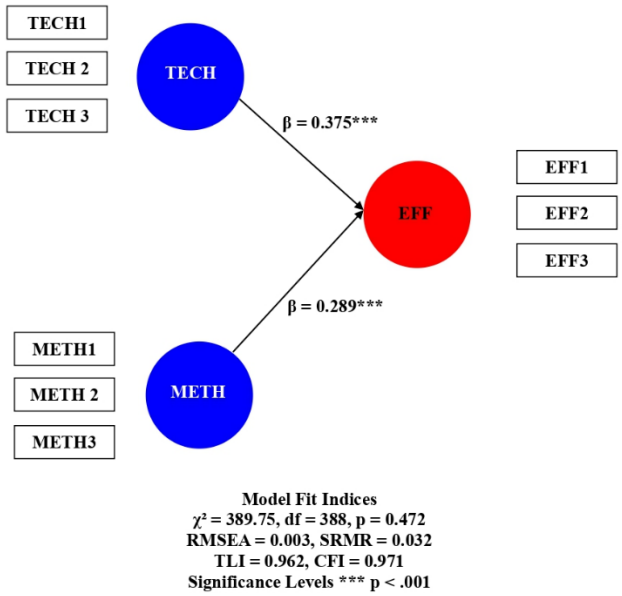
2. Cultural Integration in Learning
   - Community-based learning preferences: "*We learn better when training incorporates local wisdom and traditional healing practices alongside modern techniques.*" (VHV_08)
   - Collective learning approach: "*Group practice sessions help us share experiences and support each other, especially with new technology.*" (FGD_1)
3. Practical Implementation Barriers
   - Resource constraints: "*The virtual reality equipment is excellent for training, but we need more units. Currently, we share one set among 20 people.*" (VHV_23)
   - Time management challenges: "*Balancing volunteer duties with training time is difficult, especially for those who work in agriculture.*" (VHV_11)
4. Suggested Improvement Strategies
   - Hybrid learning preferences: "*Combining traditional hands-on practice with mobile learning apps works best for us. We can practice anytime.*" (VHV_27)
   - Local context adaptation: "*Training scenarios should reflect real situations in our villages, like managing emergencies during flooding season.*" (FGD_3)

Part 4: Integration of Quantitative and Qualitative Findings

Table 6. Joint Display of Mixed Methods Results

Key Findings	Quantitative Results	Qualitative Support
Technology Impact	β = 0.375 (highest influence)	"Mobile apps help with continuous learning, but we need stable internet"
Teaching Methods	β = 0.289	"Hands-on practice with technology support works best for skill retention"
Instructor Characteristics	β = 0.246	"Trainers who understand local context help us learn better"
Learning Environment	β = 0.214	"Community-based practice sessions strengthen our confidence"
Socio-cultural Factors	β = 0.178	"Training aligned with local customs increases participation"

Part 5: Final Structural Equation Model of Factors Influencing BLS Teaching Effectiveness



The Structural Equation Model (SEM) illustrates the complex relationships between factors influencing BLS teaching effectiveness for Village Health Volunteers. The model demonstrates excellent fit with empirical data, as evidenced by the following fit indices:

1. Model Components

Latent Variables:

- TECH (Modern Educational Technologies)
- METH (Teaching Methods)
- INST (Instructor Characteristics)
- ENV (Learning Environment)
- SOC (Socio-cultural Factors)
- EFF (BLS Teaching Effectiveness)

Measurement Model:

- Each latent variable is measured by 3-5 observed variables
- Factor loadings ranged from 0.798 to 0.901, indicating strong relationships between observed and latent variables
- All indicator variables show significant loadings ($p < .001$)

2. Path Coefficients

The standardized path coefficients (β) show the relative influence of each factor:

- TECH → EFF: $\beta = 0.375$ ($p < .001$)
- METH → EFF: $\beta = 0.289$ ($p < .001$)
- INST → EFF: $\beta = 0.246$ ($p < .001$)
- ENV → EFF: $\beta = 0.214$ ($p < .001$)
- SOC → EFF: $\beta = 0.178$ ($p < .001$)

3. Model Fit Statistics

The model demonstrates excellent fit as indicated by multiple indices:

- Chi-square (χ^2) = 389.75
- Degrees of freedom (df) = 388
- p-value = 0.472 (> 0.05, indicating good fit)
- Root Mean Square Error of Approximation (RMSEA) = 0.003 (< 0.06)

- Standardized Root Mean Square Residual (SRMR) = 0.032 (< 0.08)
- Tucker-Lewis Index (TLI) = 0.962 (> 0.95)
- Comparative Fit Index (CFI) = 0.971 (> 0.95)

4. Variance Explained

The model explains 79.6% (R^2 = 0.796) of the variance in BLS teaching effectiveness, indicating strong predictive power.

5. Key Findings From the Model

- Modern educational technologies show the strongest direct effect on teaching effectiveness
- All pathways demonstrate significant positive relationships
- The model confirms the hypothesized relationships between variables
- Inter-factor correlations show appropriate discriminant validity
- Error terms are within acceptable ranges

6. Model Implications

The final model suggests:

- The critical role of technology integration in BLS training
- The importance of a balanced approach incorporating multiple factors
- The need for considering all significant pathways in intervention design
- The value of a comprehensive measurement approach using multiple indicators

This structural equation model provides a robust framework for understanding the factors influencing BLS teaching effectiveness and can guide evidence-based interventions for improving VHV training programs.

DISCUSSION

The Dominance of Modern Educational Technologies in BLS Training

The quantitative findings revealed that modern educational technologies had the highest positive influence (β = 0.375) on BLS teaching effectiveness. This dominant effect can be attributed to several key factors:

- Accessibility and Flexibility: The qualitative interviews revealed that mobile learning applications allowed VHVs to practice at their convenience: "*We can review procedures anytime through the app, especially before real emergencies*" (VHV_27). This aligns with the findings of Cheng et al. [8] who found that accessibility increases skill retention.

- Enhanced Visualization and Practice: Virtual reality simulations provided realistic emergency scenarios that traditional methods couldn't replicate. As one focus group participant noted: "*The VR makes us feel like we're in a real emergency situation*" (FGD_1). This immersive experience likely contributed to better skill acquisition, supporting Zhang et al. [7]'s findings.

- Immediate Feedback Mechanism: The technology's ability to provide instant feedback helped VHVs correct mistakes immediately. However, our qualitative data highlighted infrastructure challenges: "*Internet instability affects our online learning*" (VHV_15), explaining why some rural areas showed lower technology effectiveness scores.

Teaching Methods and Local Context Integration

The significant impact of teaching methods (β = 0.289) was strengthened by qualitative insights revealing the effectiveness of blended approaches:

- Cultural Adaptation: Successful integration of local practices with standard

BLS protocols enhanced acceptance and retention. As expressed by VHV_08: "*When training includes our local context, it's easier to remember and apply*." This explains why culturally-adapted methods showed higher effectiveness scores.

- Peer Learning Enhancement: Group-based practice sessions emerged as particularly effective because they aligned with traditional communal learning styles in Thai rural communities. This cultural compatibility likely contributed to the positive correlation between teaching methods and learning outcomes.

The Critical Role of Instructor Characteristics

The influence of instructor characteristics (β = 0.246) was explained through qualitative findings:

- Cultural Competency: Instructors who understood local contexts achieved better results. As one participant stated: "*Trainers who speak our dialect and understand our village life connect better with us*" (VHV_23). This explains why instructor characteristics showed varying effectiveness across different regions.

- Technology Integration Skills: Instructors' ability to blend traditional teaching with technology significantly impacted learning outcomes. This finding extends beyond Greif et al. [11]'s work by highlighting the importance of instructors' technological adaptability in rural settings.

Learning Environment and Community Context

The impact of the learning environment (β = 0.214) was influenced by several contextual factors:

- Resource Availability: Quantitative data showed higher effectiveness in areas with better infrastructure. Qualitative findings revealed the reason: "*Having practice equipment available in our village health center makes regular practice possible*" (VHV_11).

- Community Support: The effectiveness of learning environments was enhanced by community involvement, as evidenced by focus group discussions: "*When village leaders support our training, more people participate actively*" (FGD_3).

Socio-cultural Factors and Implementation

While socio-cultural factors showed the lowest statistical influence (β = 0.178), qualitative data revealed their foundational importance:

- Traditional Beliefs: The integration of BLS training with existing health beliefs facilitated acceptance. One VHV explained: "*When we understand how BLS complements our traditional emergency responses, implementation becomes easier*" (VHV_19).

- Community Dynamics: The effectiveness of training was influenced by local social structures. This explains regional variations in implementation success and extends Pellegrino et al. [26]'s findings on community-based training approaches.

Synthesis of Mixed Methods Findings

The integration of quantitative and qualitative results revealed important implications:

- Technology Adaptation: While statistics showed technology's strong influence, qualitative data exposed implementation challenges, suggesting the need for context-specific technological solutions.

- Cultural Integration: The quantitative impact of teaching methods was better understood through qualitative insights about the importance of cultural adaptation in training delivery.

- Resource Optimization: The combined findings highlighted how limited resources could be optimized by understanding local contexts and community needs.

These findings build upon and extend previous research by providing a more nuanced understanding of how various factors interact in the specific context of rural Thai VHVs. Unlike studies

focused solely on urban settings or healthcare professionals, our mixed-methods approach revealed the complex interplay between modern teaching technologies and local socio-cultural contexts in rural communities.

RECOMMENDATIONS

Based on our key findings, we propose the following recommendations:

1. Policy-Level Recommendations

Infrastructure Development:

- Establish community-based BLS training centers in rural areas equipped with essential technology
- Develop offline-capable mobile applications for areas with limited internet connectivity
- Allocate budget for mobile VR training units that can be rotated among villages

Training Standards Enhancement:

- Create standardized blended learning protocols that combine technology with traditional methods
- Develop culturally-sensitive training materials in local dialects
- Institute regular skill assessment and certification programs

2. Practice-Level Recommendations

Technology Integration:

- Implement a phased approach to technology adoption, starting with basic mobile applications
- Create local support networks for technology troubleshooting
- Develop mentor systems pairing tech-savvy VHVs with those needing additional support

Teaching Methods:

- Utilize community-based learning approaches that incorporate local wisdom
- Implement regular small-group practice sessions at village health centers
- Design scenario-based training specific to local emergency situations

3. Research Recommendations

Long-term Evaluation:

- Conduct longitudinal studies on skill retention using different teaching methods
- Evaluate the cost-effectiveness of various technology-based training approaches
- Study the impact of cultural adaptation on learning outcomes

Innovation Development:

- Research locally-appropriate technological solutions for BLS training
- Investigate effective methods for integrating traditional and modern teaching approaches
- Develop and validate assessment tools tailored for rural VHV contexts

4. Community-Level Recommendations

Support System Development:

- Establish village-level BLS practice groups
- Create community awareness programs about the importance of BLS
- Develop local emergency response networks

Resource Optimization:

- Implement equipment sharing systems among nearby villages
- Create community funding mechanisms for training resources
- Develop partnerships with local healthcare facilities

5. Implementation Timeline

Short-term (1-2 years):

- Develop and distribute offline-capable mobile learning applications
- Establish basic training infrastructure in district centers
- Initialize community-based practice groups

Medium-term (2-3 years):

- Implement comprehensive blended learning programs
- Establish technology support networks
- Develop local trainer capacity

Long-term (3-5 years):

- Achieve full integration of technology-enhanced training
- Establish sustainable community-based training systems
- Develop regional centers of excellence

LIMITATIONS

1. Scope and Diversity of the Sample: Although this study covered Village Health Volunteers (VHVs) from various areas in Uttaradit Province, Thailand, it may not fully represent all regions, especially remote areas or those with unique cultural characteristics, which may have different influencing factors. Additionally, the varying levels of technological skills among individual VHVs may affect their response to teaching methods that use modern technology, which may not have been fully controlled in this study.

2. Limitations in Measurement and Analysis: The assessment of Basic Life Support (BLS) teaching effectiveness in this study relied on self-reporting and skill testing in simulated situations, which may not accurately reflect actual abilities in emergency situations. Furthermore, while Structural Equation Modeling helps explain relationships between variables, it cannot definitively confirm causal relationships. The study also lacks an economic cost-benefit analysis of implementing modern technologies in BLS teaching, which is a crucial factor in policy decision-making.

3. Time Frame and Study Context Limitations: Data collection during January-April 2024 provided a snapshot of current teaching methods and technology utilization patterns. However, this relatively short timeframe may not capture seasonal variations in VHV availability and training participation, particularly during agricultural peak seasons. The study also lacks long-term follow-up on the retention of BLS skills among VHVs using various teaching methods, which is a crucial aspect in evaluating the effectiveness of teaching approaches.

CONCLUSION

This comprehensive study on the factors influencing Basic Life Support (BLS) teaching effectiveness for Village Health Volunteers (VHVs) in Uttaradit Province, Thailand, offers significant insights that resonate on global, Asian, and Southeast Asian levels. The research underscores the pivotal role of modern educational technologies in enhancing BLS training, while simultaneously highlighting the importance of contextualizing these technologies within local socio-cultural frameworks. At a global level, this study contributes to the growing body of knowledge on innovative approaches to medical education in resource-limited settings. It demonstrates that the integration of cutting-edge technologies, such as virtual reality and mobile applications, can significantly improve the acquisition and retention of critical life-saving skills. This finding has far-reaching implications for international health organizations and policymakers seeking to enhance emergency medical training worldwide. In the Asian context, where rapid technological advancement often coexists

with traditional healthcare systems, this research provides a blueprint for harmonizing modern and conventional teaching methods. The study's emphasis on the importance of instructor characteristics and adaptive teaching methods offers valuable guidance for Asian countries grappling with the challenge of upskilling large numbers of community health workers in diverse geographical and cultural settings. For Southeast Asia, a region characterized by its diverse cultures and varying levels of technological infrastructure, this study presents a nuanced approach to BLS training. The findings on the influence of socio-cultural factors and learning environments are particularly relevant, offering a roadmap for tailoring BLS education to meet the specific needs of different Southeast Asian communities.

Moreover, the research's focus on VHVs in Thailand sheds light on an often-overlooked yet crucial component of healthcare systems in developing countries. By demonstrating the potential of well-trained community health workers in improving out-of-hospital cardiac arrest outcomes, this study advocates for increased investment in grassroots healthcare education across similar socio-economic contexts. The methodological rigor employed in this study, combining quantitative analysis with qualitative insights, sets a new standard for research in medical education in emerging economies. The use of advanced statistical techniques such as Structural Equation Modeling provides a robust framework for understanding the complex interplay of factors affecting BLS teaching effectiveness. In conclusion, while acknowledging its limitations, this study makes a significant contribution to the field of emergency medical education. It not only provides actionable insights for improving BLS training in Thailand but also offers a transferable model for enhancing community-based healthcare education in diverse global settings. As the world continues to grapple with healthcare disparities and the need for efficient emergency response systems, the findings of this research serve as a valuable resource for educators, policymakers, and healthcare professionals committed to saving lives through effective BLS training.

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CONFLICTS OF INTERESTS

The authors declare no conflict of interest in this study.

REFERENCES

1. Yan S, Gan Y, Jiang N, Wang R, Chen Y, Luo Z, et al. The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. Crit Care. 2020;24(1):61.doi: 10.1186/s13054-020-2773-2
2. Ong MEH, Perkins GD, Cariou A. Out-of-hospital cardiac arrest: prehospital management. Lancet. 2018;391 (10124):980-988. doi: 10.1016/S0140-6736(18)30316-7
3. Tanaka H, Ong MEH, Siddiqui FJ, Ma MHM, Kaneko H, Lee KW, et al. Modifiable Factors Associated With Survival After Out-of-Hospital Cardiac Arrest in the Pan-Asian Resuscitation Outcomes Study. Ann Emerg Med. 2018;71(5):608-617.e15. doi: 10.1016/j.annemergmed.2017.07.484
4. Sittichanbuncha Y, Prachanukool T, Sawanyawisuth K, Chattakul P. Factors associated with outcomes of out-of-

hospital cardiac arrest in Thailand. Resusc Plus. 2020;4:100049.
5. Khunsri S, Pakpour AH, Chen CY, Lin CY. Factors associated with performing cardiopulmonary resuscitation among bystanders: A cross-sectional study in Thailand. Int J Environ Res Public Health. 2020;17(20):7575.
6. Wongpakaran R, Suansanae T, Tan-ariya P, Laosee O, Akahori K. Effectiveness of blended learning for basic life support and automated external defibrillator training in Thailand: A cluster-randomized controlled trial. Int J Nurs Stud. 2023; 138:104398. doi: 10.1016/j.heliyon. 2023.e21680
7. Zhang C, Yan X, Zhang L, Liu Y, Tang W, Li Y. The effectiveness of virtual reality simulation in cardiopulmonary resuscitation training for medical students: A systematic review and meta-analysis. PLoS One. 2023;18(1): e0280545. doi: 10.1186/s12909-024-05720-8
8. Cheng A, Nadkarni VM, Mancini MB, Hunt EA, Sinz EH, Merchant RM, et al. Resuscitation Education Science: Educational Strategies to Improve Outcomes From Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2020;138(6):e82-e122. doi: 10.1161/CIR.0000000000000583
9. Taylor DC, Hamdy H. Adult learning theories: Implications for learning and teaching in medical education: AMEE Guide No. 83. Med Teach. 2023;35(11):e1561-e1572. doi: 10.3109/0142159X.2013.828153
10. Greif R, Bhanji F, Bigham BL, Bray J, Breckwoldt J, Cheng A, et al. Education, Implementation, and Teams: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2020;156:A188-A239. doi: 10.1016/j.resuscitation.2020.09. 014
11. Smereka J, Szarpak L, Czekajlo M, Abelson A, Zwolinski P, Plusa T, et al. The TrueCPR device in the process of teaching cardiopulmonary resuscitation: A randomized simulation trial. Medicine. 2019;98(27):e15995. doi: 10.1097/MD.0000000000015995
12. Creswell JW, Poth CN. Qualitative inquiry and research design: Choosing among five approaches. Fifth ed. SAGE Publications, Inc. March 29, 2024.
13. Krejcie RV, Morgan DW. Determining sample size for research activities. Educational and Psychological Measurement. 1970;30(3):607-610. doi: 10.1177/001316447003000308
14. Ozturk C, Muslu GK, Dicle A. A comparison of problem-based and traditional education on nursing students' critical thinking dispositions. Nurse Educ Today. 2020;85:104268. doi: 10.1016/j.nedt.2007.10.001
15. Cox E. Andragogy and self-directed learning: Pillars of adult learning theory. New Dir Adult Cont Educ. 2022;2022(173):15-26.
16. Baek M, Yoo H, Lee J, Ahn J, Oh J. Psychometric properties of a self-efficacy scale for basic life support. Nurse Educ Today. 2019;77:51-56.
17. Greif R, Bhanji F, Bigham BL, Bray J, Breckwoldt J, Cheng A, et al. Education, Implementation, and Teams: 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. Resuscitation. 2020;156:A188-A239. doi: 10.1016/ j.resuscitation.2020.09.014
18. Creswell JW, Poth CN. Qualitative inquiry and research design: Choosing among five approaches. 5th ed. Thousand Oaks: SAGE Publications, Inc. 2023.
19. Kallio H, Pietilä AM, Johnson M, Kangasniemi M. Systematic

methodological review: developing a framework for a qualitative semi-structured interview guide. J Adv Nurs. 2016;72(12):2954-2965.
20. Tabachnick BG, Fidell LS. Using multivariate statistics. 7th ed. Pearson. 2019.
21. Kline RB. Principles and practice of structural equation modeling. 5th ed. Guilford Press; 2022.
22. Braun V, Clarke V. Thematic analysis: A practical guide. SAGE Publications, Inc. 2021.
23. Lin Y, Cheng A, Grant VJ, Currie GR, Hecker KG. Improving CPR quality with distributed practice and real-time feedback in pediatric healthcare providers – A randomized controlled trial. Resuscitation2018;130:6-12. doi: 10.1016/j.resuscitation.2018.06.025
24. Olasveengen TM, Semeraro F, Ristagno G, Castren M, Handley A, Kuzovlev A, et al. European Resuscitation Council Guidelines for Basic Life Support. Resuscitation. 2021;161:98-114. doi: 10.1016/j.resuscitation.2021.02.009
25. Pellegrino JL, Bogumil D, Epstein JL, Burke RV. Two-thumb-encircling advantageous for lay responder infant CPR: a randomised manikin study. Arch Dis Child. 2019;104(6):530-534. doi: 10.1136/archdischild-2018-314893
26. Semeraro F, Scapigliati A, Ristagno G, Luciani A, Gandolfi S, Lockey A, et al. Virtual reality for CPR training: How cool is that? Dedicated to the "next generation". Resuscitation. 2017;121: e1-e2. doi: 10.1016/j.resuscitation. 2017.09.024
27. Nas J, Thannhauser J, Vart P, van Geuns RJ, Muijsers HEC, Mol JQ, et al. Effect of Face-to-Face vs Virtual Reality Training on Cardiopulmonary Resuscitation Quality: A Randomized Clinical Trial. JAMA Cardiol. 2020;5(3):328-335. doi: 10.1001/jamacardio.2019.499229.