

Assessment of a Visual Instructional Model for Reiri Smart HVAC Systems

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Abstract

This study evaluated the technical validity, instructional quality, and technology acceptance of a visual instructional model for the Reiri Smart HVAC system to address learning gaps in smart building control literacy within Mechanical Engineering and ETEEAP curricula. Using a quantitative evaluative research design guided by the Plan-Do-Check-Act (PDCA) cycle, data were gathered from 18 purposively selected MEP managers, HVAC consultants, and academic experts. The findings identified a Highly Significant Gap (Overall Mean = 3.56) in traditional instructional materials, driven by excessive cognitive load (Mean = 3.67) and poor visual mapping of third-party system integration. In contrast, the visual instructional model achieved an overall Highly Valid / Highly Effective rating (Overall Mean = 3.70), scoring highest in Industry Relevance (Mean = 3.83) and Technical Accuracy (Mean = 3.72). Assessment via the Technology Acceptance Model (TAM) demonstrated a Highly Effective level of acceptability (Overall Mean = 3.69), led by Perceived Usefulness (Mean = 3.76) and Behavioral Intention to Use (Mean = 3.72). Qualitative feedback highlighted the model's strength in bridging tacit field experience with academic concepts. Experts noted limitations in granular conductor specs and cybersecurity protocols, recommending strict conceptual disclaimers to prevent misuse as an installation blueprint. A proposed PDCA plan outlines curriculum integration, laboratory safety safeguards, and periodic updates aligned with ASHRAE standards.

Keywords: Smart HVAC Systems, Reiri Controller, Visual Instructional Model, Technology Acceptance Model (TAM), Cognitive Load

Introduction

Heating, ventilation, and air-conditioning systems have progressed from stand-alone electromechanical equipment to connected systems that exchange operating data, receive commands, coordinate multiple indoor units, and interact with building-management platforms. A contemporary practitioner is therefore expected to understand not only refrigeration cycles, psychometrics, heat transfer, piping, ductwork, and equipment selection but also sensors, controllers, network topology, communication protocols, input/output logic, commissioning data, alarms, and safe troubleshooting. This convergence of mechanical and digital competencies is especially visible in variable refrigerant volume systems and smart-home or

smart-building platforms.

Traditional instruction commonly presents HVAC equipment through schematic refrigeration cycles and individual wiring diagrams. These remain essential, yet they may not clearly show how a central controller, a communication adaptor, an I/O node, a router, a mobile application, and third-party devices function as one system. When the communication path is treated as an invisible layer, learners may recognize each component but still struggle to trace the complete signal path from a user command to an equipment response or from a field sensor to a control action.

The Reiri smart HVAC ecosystem is a useful instructional case because it brings together air-conditioning equipment, a central smart-home controller, communication adaptors, wired and wireless links, and external devices. A visual instructional model can externalize these relationships. Rooted in the researcher's extensive professional background in HVAC installation, commissioning, and maintenance, this study addresses persistent operational challenges, notably documentation deficits and interdisciplinary coordination gaps.

Theoretical Background

Systems theory views engineered installation as a set of interdependent components whose behavior cannot be understood adequately by examining isolated parts. Cognitive Load Theory explains that working memory is limited and that learning materials should manage intrinsic complexity while reducing unnecessary mental effort. Multimedia learning theory proposes that learners can build stronger mental models when words and relevant visuals are coherently integrated. Experiential learning explains how concrete experience, reflection, conceptualization, and active experimentation contribute to professional competence. Finally, the Technology Acceptance Model (TAM) posits that a user's behavioral intention to adopt a novel technological or educational tool is driven primarily by perceived usefulness and perceived ease of use.

Conceptual Framework

The study uses an Input-Process-Output framework. Inputs consist of the existing visual model, Reiri system components and connection logic, criteria derived from current HVAC/building-automation practice, and expert experience. The process consists of instrument validation, expert assessment, quantitative analysis, and interpretation using the Plan-Do-Check-Act cycle. Outputs consist of the assessed model, identified strengths and limitations, and an implementation and improvement plan.

Review of Related Literature

Smart buildings are designed to provide support, safety, and comfort for occupants while minimizing operational expenses and energy consumption. The integration of cyber-physical technologies and the Internet of Things (IoT) has allowed modern infrastructure to transition from rigid, centralized pneumatic controls to highly responsive, distributed digital networks. Building Management Systems (BMS) act as the central nervous system of a smart facility, and Daikin's REIRI system exemplifies the current state-of-the-art in scalable smart building solutions designed to bridge the gap between complex HVAC hardware and user accessibility.

The complexity of modern BMS necessitates a shift in how operators are trained and how interfaces are designed. Traditional text-heavy manuals, schematic wiring diagrams, and rote training methods are increasingly inadequate for managing dynamic, real-time cyber-physical systems. A Visual Instructional

Model leverages Cognitive Load Theory to reduce the extraneous cognitive burden placed on users. While mechanical engineering and computer science literature extensively covers the optimization algorithms and hardware efficiency of HVAC systems, there is a noticeable gap regarding the human-computer interaction (HCI) and workforce management aspects of these technologies.

Statement of the Problem

This study aimed to assess a visual instructional model for Reiri Smart HVAC systems and determine its suitability for Mechanical Engineering and ETEEAP learning contexts toward enhancing technical comprehension and industry-aligned training. Specifically, it sought to answer the instructional gaps in existing materials, the technical quality of the visual model, the level of acceptability based on TAM constructs, pedagogical considerations, and a proposed implementation plan.

Scope and Limitations

The study is limited to the assessment of a visual instructional model that represents the general connectivity of a Reiri Home controller, DCPA01 adaptor, DIII-Net-enabled Daikin air-conditioning equipment, a Wi-Fi router, mobile or smart-home interfaces, and WAGO I/O-connected peripheral devices. Eighteen expert respondents were purposively selected. The visual model is conceptual and must not be used as a construction, shop, as-built, or manufacturer wiring diagram.

Research Methodology

The study employed quantitative evaluative research design combining developmental validation logic with expert appraisal. The Plan-Do-Check-Act cycle organized the assessment.

Table 1: Distribution of Expert Respondents

Respondent Group	Number	Primary Contribution
Senior MEP project managers/engineers	5	Installation, integration, commissioning, and constructability
Licensed mechanical engineers and HVAC/fire protection consultants	10	Technical plausibility, safety, codes, and professional practice
Mechanical Engineering academic experts	3	Instructional design, OBE alignment, and curriculum relevance
Total	18	Combined expert assessment

An assessment questionnaire was systematically organized into respondent profile, existing instructional gaps, model assessment, and open comments. Frequency, percentage, and weighted mean were utilized for data analysis.

Presentation, Analysis, and Interpretation of Data

The first objective of the study was to identify the instructional gaps observed in existing smart HVAC learning materials across four dimensions.

Table 2: Assessment of Existing Instructional Gaps

Indicators	Weighted Mean	Interpretation	Rank
A. System Integration	3.58	Highly Significant Gap	2
1. Current materials fail to clearly map independent equipment to a centralized network.	3.61	Highly Significant Gap	2
2. Existing diagrams lack clear visual relationships between physical units and the REIRI controller.	3.55	Highly Significant Gap	3
3. Lack of integrated views showing third-party device communication.	3.72	Highly Significant Gap	1
4. Traditional diagrams impose high cognitive load.	3.44	Highly Significant Gap	4
B. Wiring Complexity	3.52	Highly Significant Gap	3
1. Materials do not differentiate high/low voltage.	3.38	Highly Significant Gap	3
2. Confusing wiring topology for novices.	3.50	Highly Significant Gap	2
3. Fails to clearly indicate terminal identities.	3.67	Highly Significant Gap	1
C. Comprehension	3.46	Highly Significant Gap	4
1. Struggle translating theory to commands.	3.33	Highly Significant Gap	3
2. Resources do not explain logical pathways.	3.45	Highly Significant Gap	2
3. Over-reliance on text descriptions.	3.61	Highly Significant Gap	1
D. Cognitive Load	3.67	Highly Significant Gap	1
1. Schematics are overly cluttered.	3.78	Highly Significant Gap	1
2. Users experience "information fatigue".	3.67	Highly Significant Gap	2
3. Lack of visual scaffolding.	3.56	Highly Significant Gap	3
OVERALL MEAN	3.56	Highly Significant Gap	

The second objective evaluated the developed Reiri Smart HVAC visual instructional model.

Table 3: Technical and Instructional Quality Evaluation

Indicators	Weighted Mean	Interpretation	Rank
A. Technical Accuracy	3.72	Highly Valid	2
1. Accurately represents Daikin DIII-Net topology.	3.83	Highly Valid	1
2. Distinguishes VRV components from modular I/O.	3.72	Highly Valid	2
3. Connection paths align with standards.	3.61	Highly Valid	3
B. Instructional Quality	3.67	Highly Effective	3
1. Visual scaffolding reduces cognitive burden.	3.78	Highly Effective	1
2. Illustrates logical sequence of exchange.	3.67	Highly Effective	2
3. Balances technical depth and visual clarity.	3.55	Highly Effective	3
C. Industry Relevance	3.83	Highly Valid	1
1. Accurately reflects modern interoperability.	3.89	Highly Valid	1
2. Prepares learners for MEP coordination.	3.78	Highly Valid	2
3. Relevant for ETEEAP and work-based learning.	3.83	Highly Valid	3
D. Troubleshooting Utility	3.58	Highly Effective	4
1. Guides systematic signal path tracing.	3.67	Highly Effective	1

2. Aids establishing logical "fault domains".	3.50	Highly Effective	3
3. Encourages evidence-based diagnostics.	3.56	Highly Effective	2
OVERALL MEAN	3.70	Highly Valid / Highly Effective	

Table 4: Technology Acceptance Model (TAM) Assessment

Indicators	Weighted Mean	Interpretation	Rank
A. Perceived Usefulness	3.76	Highly Effective	1
1. Improves understanding of smart HVAC systems.	3.83	Highly Effective	1
B. Perceived Ease of Use	3.61	Highly Effective	4
1. Easy to navigate visual pathways.	3.61	Highly Effective	2
C. Behavioral Intention to Use	3.72	Highly Effective	2
1. Intend to utilize for ME/ETEEAP sessions.	3.78	Highly Effective	1
D. Learner's Satisfaction	3.67	Highly Effective	3
1. Satisfied with overall clarity and accuracy.	3.72	Highly Effective	1
OVERALL MEAN	3.69	Highly Effective	

Summary of Findings, Conclusions, and Recommendations

The expert panel identified a "Highly Significant Gap" (Overall Mean: 3.56) in current smart HVAC learning materials. The visual instructional model was rated as "Highly Valid / Highly Effective" (Overall Mean: 3.70), confirming it accurately reflects modern interoperability requirements. Assessment via TAM demonstrated a "Highly Effective" acceptability rating (Overall Mean: 3.69). Qualitative feedback noted strengths in bridging mechanical theory with digital networking, but cited limitations regarding granular wiring specifications, requiring an absolute conceptual disclaimer to avoid misuse as a construction blueprint.

It is recommended to integrate the visual instructional model into HVAC, Industrial Controls, and Building Automation modules to scaffold student understanding before introducing complex manufacturer wiring diagrams. Workplaces should adopt the visual model as a preliminary discussion aid during onboarding. Future researchers should conduct experimental studies to quantitatively measure actual learning gains when utilizing this model.

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