SEMARAK ILMU
PUBLISHING
202103268166(003316878-P)

Semarak International Journal of Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/sijaset/index
ISSN: 3030-5314

Development and Validation of the IoT-FiER Instrument for Fire Emergency Response Management

Rabeah Md Zin[1,*], Adi Irfan Che Ani[2], Nur ‘Amirah Mhd Noh[3], Mohd Asrul Hassin[3], Zainuddin Mat Daud[4]

[1] Department of Architecture, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Malaysia
[2] School of Liberal Studies, CITRA, Universiti Kebangsaan Malaysia, Malaysia
[3] School of Building Surveying, College of Built Environment, Universiti Teknologi Mara, Malaysia
[4] Fire Safety Division, Malaysia Fire and Rescue Department, Malaysia

ARTICLE INFO

Article history:
Received 12 November 2024
Received in revised form 10 December 2024
Accepted 24 December 2024
Available online 31 December 2024

ABSTRACT

This study aims to develop and validate the IoT-FiER instrument to assess the acceptance and adoption of IoT technology in fire emergency response management. The focus is on ensuring the instrument's content validity for use by Malaysian Fire and Rescue Department (JBPM) firefighters. The instrument was developed using a systematic literature review (SLR) to identify critical elements and sub-constructs related to IoT adoption. A total of 102 items were created and validated through expert judgment using the Content Validity Index (CVI). Nine domain experts, including fire officers, engineering professionals, and academicians, rated the relevance of the items. The I-CVI, S-CVI/UA, and S-CVI/Ave were quantified to determine content validity. The validation process demonstrated high content validity, with I-CVI values ranging from 0.11 to 1. The scale-level content validity index (S-CVI/Ave) achieved 0.80, while the universal agreement (S-CVI/UA) was 0.78. A total of 21 items were removed due to low relevance ratings, ensuring the refined instrument aligns with domain-specific constructs. This study focuses on content validity; future research should examine reliability, face validity, and criterion validity to ensure the robustness of the IoT-FiER instrument. The IoT-FiER instrument provides a validated tool for evaluating IoT adoption readiness within fire safety management. It can assist policymakers and practitioners in improving fire emergency responses through IoT integration. This study contributes a systematically validated instrument that bridges theoretical frameworks and practical applications of IoT in fire safety, specifically for emergency management in Malaysia.

Keywords:
Internet of Things (IoT); fire emergency response; assessment instrument; Content Validity Index (CVI); emergency response and experts

1. Introduction

Rapid technological progress, particularly through the Internet of Things (IoT), has transformed various sectors by connecting physical devices to the Internet, facilitating the exchange of data and real-time communication. The Industrial Revolution 4.0 and the IoT have garnered significant

* *Corresponding author.*
E-mail address: p127581@siswa.ukm.edu.my

https://doi.org/10.37934/sijaset.4.1.112

attention in recent years. They are expected to gain both local and international popularity if they become integral parts of various governments' primary initiatives [1]. IoT is a relatively new subject that continues to grow at a rapid rate [2].

This evolution has significant implications for emergency response management, especially fire safety. IoT technology empowers organizations to collect and analyze vast amounts of real-time data regarding environmental conditions, fire incidents, and resource allocation [3]. IoT is a system that enables machines and devices to generate data and transmit it to control systems for analysis, processing, and control action via the Internet [4]. For instance, smart sensors can detect changes in temperature, smoke, or carbon monoxide levels, providing early warnings that can enhance situational awareness and enable faster, more informed decision-making by emergency responders [5]. As a result, integrating IoT into fire safety management presents valuable opportunities to improve operational efficiency, increase safety for responders and civilians and optimize resource utilization during fire emergencies [6].

Despite the potential benefits, the adoption of IoT within the Malaysian Fire and Rescue Department (JBPM) is still at a nascent stage. Several factors contribute to this slow integration, including financial constraints, lack of technical expertise, and limited understanding of the technology's benefits and applications among firefighters [7]. Additionally, the complexity of IoT systems and concerns regarding data privacy and security pose significant hurdles that need to be addressed to foster a more widespread adoption [8]. Consequently, it becomes imperative to understand the current state of IoT implementation in fire safety management and to identify the barriers that hinder its adoption in Malaysia.

The provision of fire safety systems in buildings, including both active and passive systems, is crucial for minimizing the spread of fire throughout the building [9].To address these challenges, this study aims to develop and validate a comprehensive instrument that measures the adoption of IoT technologies in fire safety emergency response management among Malaysian firefighters. The significance of a measurement instrument lies in its ability to capture dimensions related to technology readiness, perceived usefulness, and barriers to implementation, which can provide invaluable insights for policymakers and fire safety practitioners [10]. Readiness for change involves recognizing the importance of the problem and having confidence in one's ability to make the change. Understanding these dimensions can facilitate strategic planning and resource allocation, leading to more effective and efficient fire response efforts [11].

A critical aspect of developing any measurement instrument is ensuring its content validity. Content validity ensures that the items included in the instrument accurately represent the measured construct, which, in this case, is the adoption of IoT in fire safety emergency response management [12]. Evaluating content validity is essential to ascertain that the instrument effectively captures the perspectives and experiences of firefighters regarding IoT technology and its applications. This evaluation typically involves systematic reviews and expert assessments to ensure the items are relevant, comprehensive, and culturally appropriate for the target population [13]. Application based on IoT devices are getting more attenstion because of their capabilities to cover one system [14]. This study outlines an expert-guided instrument's content validity evaluation process to assess IoT adoption in fire safety emergency response management. Before their intended applications, the instrument must undergo testing for validity and reliability [15]. A quantitative survey methodology was employed to develop and validate the instrument to achieve a robust and credible instrument. Nine experts including officers from the Malaysian Fire and Rescue Department, engineering professionals from various disciplines, Building Facility Managers and academicians in the field were selected through judgmental sampling to participate in the content validity evaluation. By incorporating the insights of these experts, this research endeavors to create a reliable tool that can assist in gauging IoT readiness within Malaysian fire services, ultimately contributing to enhanced fire safety management practices and better emergency response outcomes in the region.

The adoption of Internet of Things (IoT) technology in various fields has revolutionized operational management, particularly in emergency response services like fire safety [16]. Malaysian firefighters, under the Malaysian Fire and Rescue Department (JBPM), stand to benefit significantly from the integration of IoT, which allows for real-time data collection and communication. This technological advancement enhances situational awareness, leading to faster and more informed decision-making during fire incidents [17].

To develop a comprehensive assessment tool for evaluating the adoption of IoT in fire safety emergency response management, this study adopts a systematic literature review (SLR) approach to identify the critical elements associated with IoT technology adoption [18]. This process resulted in the selection of four relevant theories: the Technology Acceptance Model (TAM) by Davis [19], the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh *et al.,* [20], the Technology-Organization-Environment (TOE) Framework by Tornatzky and Fleischer,1990; Baker, 2012, and the Theory of Planned Behaviour (TPB) by Ajzen (1991) [21]. Each theoretical framework provides valuable insights into user acceptance and the complexities surrounding adopting new technologies, making them appropriate for creating the IoT-FiER instrument as shown in Figure 1.

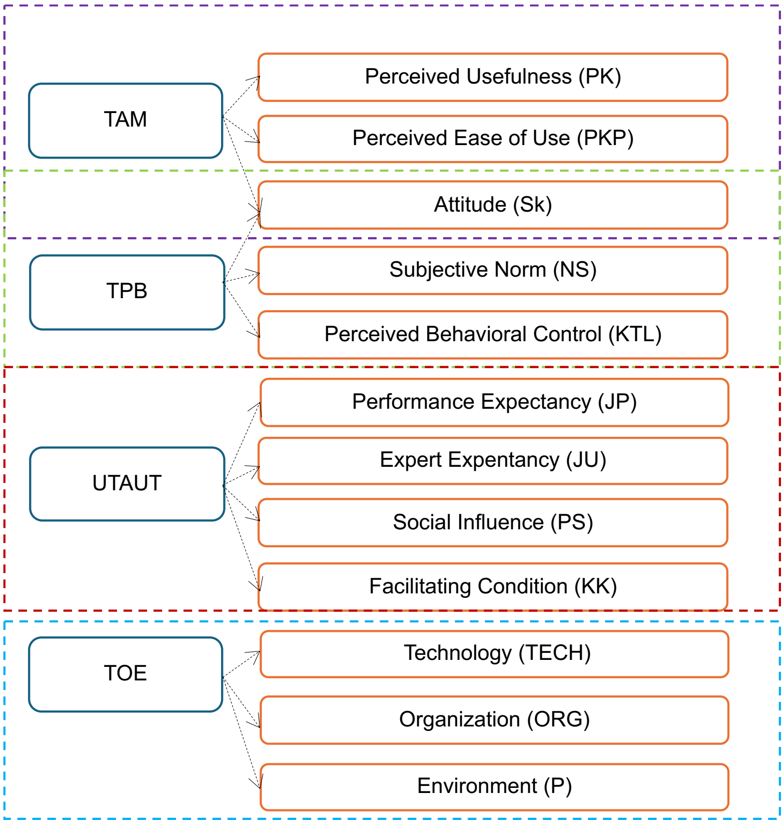


Fig. 1 Conceptual Framework of the Study Source: Modified from various references

2. Content Validation Procedure

An essential aspect of developing the IoT-FiER instrument is ensuring content validity, which can be achieved through various methods, including literature reviews, expert interviews, and panel assessments [22]. Among these approaches is the quantitative method, utilizing metrics such as the content validity index (CVI), a decision-making tool for evaluating individual items in the instrument [23]. The CVI is favored for its simplicity, effectiveness in providing clarity on item status, and ability to compute the scale-level CVI (S-CVI), facilitating a more comprehensive validation process. Each item's evaluation informs whether it should be accepted, revised, or discarded from the instrument [24]. It is worth noting that validating the content of instruments via subjective judgments of researchers (based on the literature review or informal consultations with experts) may produce biased outcomes [15].

2.1 Stage 1: Development of an instrument

Despite the significance of content validation in instrument development, there is a noticeable lack of literature addressing the formal calculation of content validity in similar contexts [25]. Thus, this study aims to detail the systematic steps in calculating content validity for the IoT-FiER instrument as part of its development phase. The method involved in content validity is shown in Figure 2.

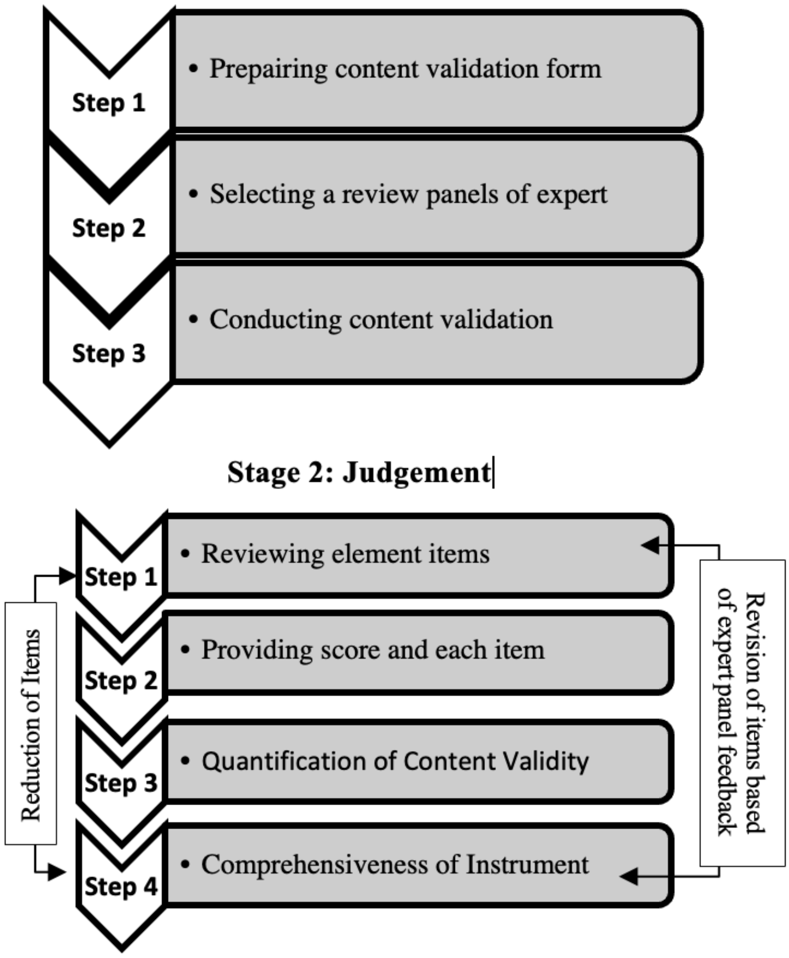


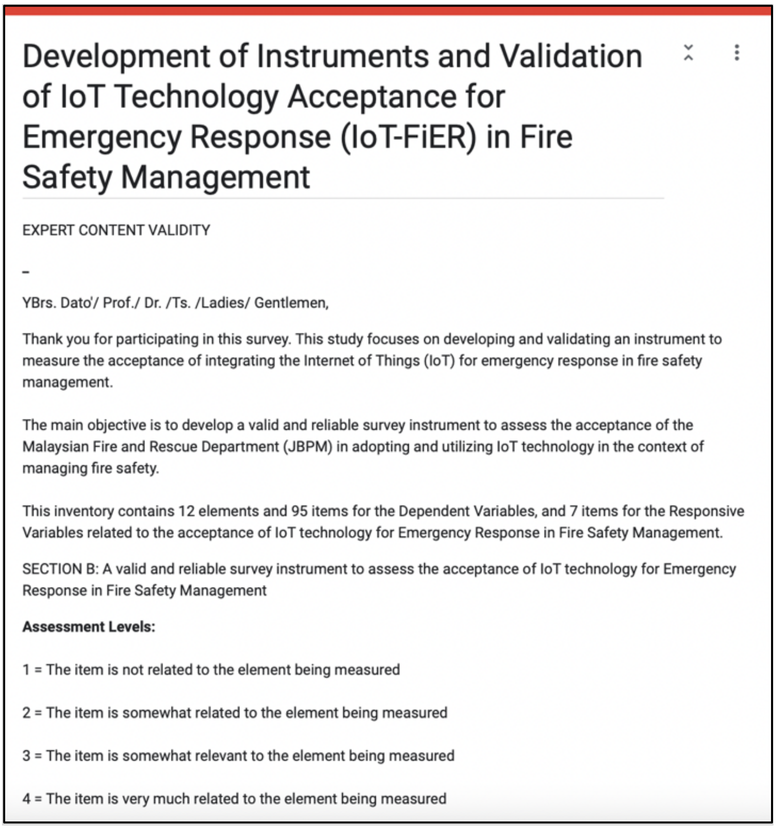
Fig. 2 Method involved in content validity Source: Modified from various references

The development of an instrument itself initiates the process of addressing content validity. This involves a two-phase process of instrument development and judgement, ensuring that content validity is determined and measured throughout the instrumentation process. The validity of the content of the items produced was assessed with the cooperation of 9 experts.

3. Phase 1: Development of Instrument

3.1 Step 1: Development of an instrument

The first step of content validation is to prepare an online content verification form (Google Forms) to ensure the expert review panel has clear expectations and an understanding of the task. Examples of instructions and the rating scale are provided in Figure 3. A recommended relevance rating scale (1–4) was used for individual item scoring [26].


Development of Instruments and Validation of IoT Technology Acceptance for Emergency Response (IoT-FiER) in Fire Safety Management

EXPERT CONTENT VALIDITY

-

YBrs. Dato'/ Prof./ Dr. /Ts. /Ladies/ Gentlemen,

Thank you for participating in this survey. This study focuses on developing and validating an instrument to measure the acceptance of integrating the Internet of Things (IoT) for emergency response in fire safety management.

The main objective is to develop a valid and reliable survey instrument to assess the acceptance of the Malaysian Fire and Rescue Department (JBPM) in adopting and utilizing IoT technology in the context of managing fire safety.

This inventory contains 12 elements and 95 items for the Dependent Variables, and 7 items for the Responsive Variables related to the acceptance of IoT technology for Emergency Response in Fire Safety Management.

SECTION B: A valid and reliable survey instrument to assess the acceptance of IoT technology for Emergency Response in Fire Safety Management

Assessment Levels:

1 = The item is not related to the element being measured

2 = The item is somewhat related to the element being measured

3 = The item is somewhat relevant to the element being measured

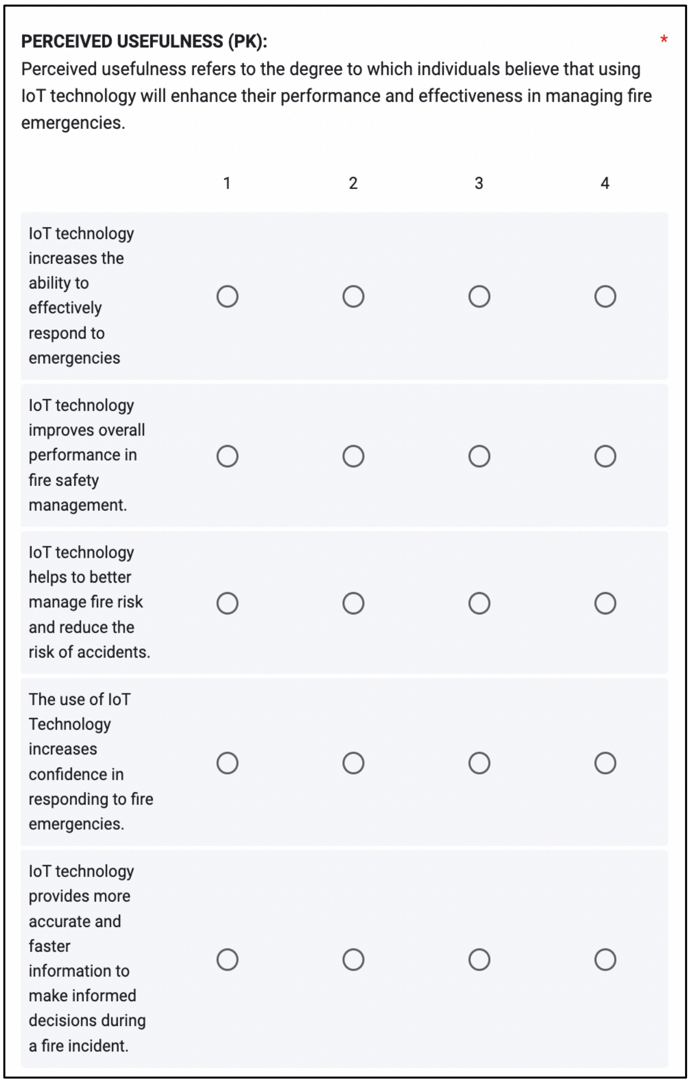
4 = The item is very much related to the element being measured

Fig. 3 IoT-FiER content validation form to the experts

The current study aimed to develop the IoT-FiER instrument to assess the extent of acceptance of IoT technology among firefighters in Malaysia's Fire and Rescue Department (JBPM) for emergency actions in fire safety management. This comprehensive instrument consists of 12 key elements: Perception of Usefulness (PK), Perception of Ease of Use (PKP), Attitude (Sk), Subjective Norms (NS), Behavioural Control (KTL), Performance Expectations (JP), Effort Expectations (JU), Social Influence (PS), Facilitating Conditions (KK), Technology (TECH), Environment (P), and Organization (ORG), encompassing a total of 95 items for the dependent variable sub-constructs. Additionally, 7 items focus on the response variable related to adopting IoT technology for emergency actions. Initially designed with 102 items distributed across these components, the instrument underwent a robust content validation process, involving systematic steps to evaluate and refine each item by calculating the CVI.

This study details the methodology for calculating content validity and addresses the limited literature on comprehensive content validation in instrument development, emphasizing the importance of these steps in enhancing the reliability and relevance of the IoT-FiER instrument for fire safety management.

The validation of the IoT-FiER instrument content reported in this study is a pivotal component of the instrument's development phase, comprising three distinct stages. The constructs and subconstructs IoT-FiER instrument were developed, through an SLR, which provided a comprehensive basis for identifying relevant subconstructs. The Iot-FiER instrument is shown in Figure 4.



PERCEIVED USEFULNESS (PK): *
Perceived usefulness refers to the degree to which individuals believe that using IoT technology will enhance their performance and effectiveness in managing fire emergencies.

	1	2	3	4
IoT technology increases the ability to effectively respond to emergencies	○	○	○	○
IoT technology improves overall performance in fire safety management.	○	○	○	○
IoT technology helps to better manage fire risk and reduce the risk of accidents.	○	○	○	○
The use of IoT Technology increases confidence in responding to fire emergencies.	○	○	○	○
IoT technology provides more accurate and faster information to make informed decisions during a fire incident.	○	○	○	○

Fig. 4 Example of IoT-FiER instrument to the experts

3.2 Step 2: Selecting a Review Panel of Expert

This study outlines an expert-guided instrument's content validity evaluation process to assess IoT adoption in fire safety emergency response. A quantitative survey methodology was employed to develop and validate the instrument to achieve a robust and credible instrument. Nine experts including officers from the Malaysian Fire and Rescue Department, engineering professionals from various disciplines, Building Facility Managers and academicians in the field were selected through judgmental sampling to participate in the content validity evaluation. By incorporating the insights of these experts, this research endeavors to create a reliable tool that can assist in gauging IoT readiness within Malaysian fire services, ultimately contributing to enhanced fire safety management practices and better emergency response outcomes in the region.

The adoption of IoT technology in various fields has revolutionized operational management, particularly in emergency response services like fire safety. Malaysian firefighters under JBPM stand to benefit significantly from the integration of IoT, which allows for real-time data collection and communication [27]. This technological advancement enhances situational awareness, leading to faster and more informed decision-making during fire incidents [28]. Table 1 summarizes the recommended number of experts and their implications for the acceptable cut-off score of CVI.

Table 1
The number of experts and its implication on the acceptable cut-off score of CVI

Number of Expert	Acceptable CVI Values	Source
2 experts	0.8	Davis [30]
3-5 experts	1	Polit and Beck [32], Polit *et al.,* [31]
6 experts	0.83	
6-8 experts	0.83	Lynn [29]
9 experts	0.78	

3.3 Step 3: Conducting Content Validation

The approach in this study is carried out online the confirmation form is sent by email to the specialist and clear instructions are provided in Figure 3. Based on the writer's experience, this non-face-to-face approach is very efficient and systematic because follow-up actions are made to improve the response rate and time.

4. Stage 2: Judgement

4.1 Step 1: Reviewing alignment and item

In the content verification form, definition elements and items that represent elements are provided to experts as shown in Figure 4. The experts were asked to review the elements critically and the items before assigning a score to each item. The researcher requested experts to prepare oral comments or written comments to increase item relevance with targeted elements. All comments are considered to refine elements and items.

4.2 Step 2: Providing a score for each item

After finishing checking the elements and items, experts were asked to score each item independently on the relevant scale (Table 2). The definition and formula in Table 2 were based on the recommendations by Lynn [29], Davis *et al.,* [30], Polit *et al.,* [31]. Experts are required to submit answers to the researcher when they have finished rating all the items.

To determine the content elements of IoT technology adoption, an extensive literature review was conducted. The literature review helps researchers identify various research gaps in the foundation of the construct.

Table 2
The definition and formula of I-CVI, S-CVI/Ave and S-CVI/UA

The CVI Indicates	Definition	Formula
I-CVI (item-level content validity index)	The proportion of content experts giving item a relevance rating of 3 or 4	I-CVI = (agreed item)/ (number of expert)
S-CVI/Ave (scale-level content validity index based on the average method)	The average of the I-CVI scores for all items on the scale or the average of proportion relevance judged by all experts. The proportion relevant is the average of relevance rating by individual expert.	S-CVI/Ave = (sum of I-CVI scores)/(number of item)
S-CVI/UA (scale-level content validity index based on the universal agreement method)	The proportion of items on the scale that achieve a relevance scale of 3 or 4 by all experts. Universal agreement (UA) score is given as 1 when the item achieved 100% experts in agreement, otherwise the UA score is given as 0.	S-CVI/UA = (sum of UA scores)/(number of item)

4.3 Step 3: Quantification of Content Validity Index
4.3.1 Content Validity Index – CVI

To evaluate items created for the adoption of IoT technology in JBPM's fire emergency actions, researchers request feedback from a panel of experts. The CVI was calculated for individual items (I-CVI) and the entire scale (S-CVI). To ascertain the CVI, experts rated each item based on its relevance to the underlying construct using a 4 point scale, designed to avoid a neutral midpoint. The scale ratings were: 1 = not relevant, 2 = somewhat relevant, 3 = somewhat relevant, and 4 = very relevant.

The I-CVI for each item was determined as the ratio of experts giving a rating of 3 or 4 to the total number of experts. For instance, if four out of five experts rated an item as 3 or 4, the I-CVI would be 0.80 [32]. It is recommended that I-CVI should reach 1.00 when there are five or fewer judges and should not be less than 0.78 with six or more judges [33].

To ensure the overall scale's content validity, the S-CVI was calculated and is conceptualized in two methods: S-CVI Universal Agreement (UA) and S-CVI (Average). The S-CVI UA denotes the fraction of items that all experts rated as 3 or 4. Conversely, the S-CVI (Average) offers a broader view by averaging the I-CVI values, focusing on average item quality rather than consensus among experts. A minimum S-CVI of 0.8 is advised to ensure content validity, as noted by Lynn [29], Polit and Beck [31] and Rubio *et al.,* [34].

Table 3
The relevance ratings on the item scale by nine experts for IoT-FiER

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	No. in agreement	I-CVI	UA	Categories
PK1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PK2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PK3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PK4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PK5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PKP1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PKP2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PKP3	0	0	0	0	1	0	0	0	0	1	0.111	0	Eliminated
PKP4	0	0	0	0	0	0	1	0	0	1	0.111	0	Eliminated
PKP5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PKP6	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PKP7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PKP8	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PKP9	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
Sk1	1	1	0	0	0	0	0	0	0	2	0.222	0	Eliminated
Sk2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
Sk3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
Sk4	0	0	1	1	0	1	1	1	1	6	0.667	0	Eliminated
Sk5	1	1	0	0	0	0	0	0	0	2	0.222	0	Eliminated
Sk6	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
Sk7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
Sk8	0	0	0	1	0	0	0	0	0	1	0.111	0	Eliminated
Sk9	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
NS1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
NS2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
NS3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
NS4	1	1	1	1	0	1	1	1	1	8	0.889	0	Appropriate
NS5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
NS6	1	1	0	0	0	0	0	0	0	2	0.222	0	Eliminated
NS7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
NS8	0	0	1	1	0	1	1	1	1	6	0.667	0	Eliminated
KTL1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
KTL2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
KTL3	1	1	0	0	0	0	0	0	0	2	0.222	0	Eliminated
KTL4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
KTL5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
KTL6	0	0	0	0	0	0	1	1	1	3	0.333	0	Eliminated
KTL7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
KTL8	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
KTL9	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JP1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JP2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JP3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JP4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JP5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JP6	1	1	0	1	0	0	1	0	1	5	0.556	0	Eliminated
JP7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU6	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
JU8	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS6	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
PS8	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
KK1	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
KK2	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
KK3	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
KK4	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
KK5	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
KK6	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
KK7	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
KK8	0	0	0	1	1	1	1	1	1	6	0.667	0	Eliminated
TECH1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
TECH2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
TECH3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
TECH4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
TECH5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
TECH6	0	0	1	0	0	0	0	0	1	2	0.222	0	Eliminated
TECH7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
TECH8	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P6	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
P8	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
ORG1	0	0	0	0	0	0	1	0	0	1	0.111	0	Eliminated

ORG2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
ORG3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
ORG4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
ORG5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
ORG6	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
ORG7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
ORG8	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
DV1	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
DV2	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
DV3	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
DV4	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
DV5	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
DV6	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
DV7	1	1	1	1	1	1	1	1	1	9	1.000	1	Appropriate
Relevance Ratio	0.84	0.84	0.82	0.91	0.87	0.89	0.93	0.90	0.92	TOTAL	90.000	80	
Average item for 9 experts						0.882							
										S-CVI/Ave:	**0.880**	**Accepted**	
										S-CVI/UA:	**0.78**	**Accepted**	

4.4 Content Validity Index – CVI

I-CVI for all items for 12 elements is between 0.11 to 1. S-CVI (Average) for dimensions Perception of Usefulness (PK), Perception of Ease of Use (PKP), Attitude (Sk), Subjective Norms (NS), Behavioral Control (KTL), Performance Expectations (JP), Effort Expectations (JU), Social Influence (PS), Facilitating Conditions (KK), Technology (TECH), Environment (P), and Organization (ORG) and additionally, 7 items focus on the response variable related to adopting IoT technology for emergency actions. The overall I-CVI and S-CVI for the 102 items scale were 0.80 and 0.78, respectively, indicating high item content validity of the IoT technology acceptance construct. 21 items need to be removed from the question instrument for the next stage refer to Table 3. Based on the above calculation, we can conclude that I-CVI, S-CVI/Ave and S-CVI/UA meet satisfactory levels, and thus the scale of the questionnaire has achieved a satisfactory level of content validity.

5. Conclusion

The measurement process in social science research involves linking abstract concepts with empirical indicators. This field often requires the formulation of highly abstract concepts, which are challenging to measure. Content validity plays a crucial role in this context by ensuring that a construct's operationalization is anchored in items derived from content-specific domains relevant to the specific measurement situation. To evaluate the content validity of an assessment instrument, nine experts were selected through judgmental sampling. These experts included officers from the Malaysian Fire and Rescue Department, engineering professionals from various disciplines, and Building Facility Managers. During the instrument development phase, 102 items were identified through a systematic literature review (SLR) to pinpoint critical elements related to IoT technology adoption. At the judgment stage, these nine domain experts rated the items based on their relevance and necessity. The quantification of content validity using the Content Validity Index (CVI, including I-CVI and S-CVI) demonstrated high content validity for the items. Calculating content validity for a construct aid in bridging the gap between academic and industry perspectives on topics such as employee engagement, as identifying content domains is crucial for developing instruments with agreed-upon definitions. Content validity is essential for ensuring the overall validity of an assessment; therefore, a systematic approach to content validation, based on evidence and best practices, should be employed. This paper outlines a systematic, evidence-based approach to conducting thorough content validation. Consequently, future studies should also ensure that instruments are evaluated for reliability and other validity forms, such as face, construct, and criterion validity, to enhance the applicability of the assessment instrument.

Acknowledgement
The author would like to express their gratitude and appreciation to Kementerian Pendidikan Tinggi (KPT), Universiti Kebangsaan Malaysia (UKM) especially for their financial support under grant FRGS/1/2021/TK01/UKM/02/1 and to all those who have been involved in this study.

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