“Evaluate Health and Safety Improvement through BIM Adoption in Building Construction Projects”

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Outline

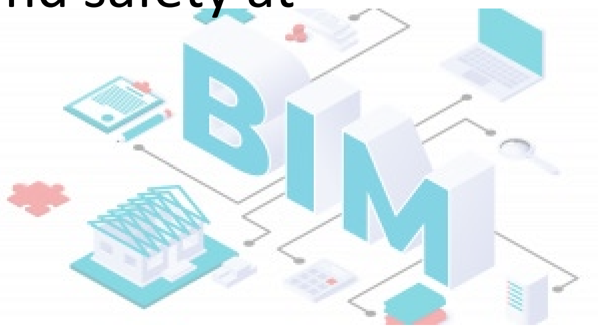
INTRODUCTION

INTRODUCTION

Background of Study

- In Malaysia, **13 fatal accidents**, **126 major accidents**, **3799 minor injuries**, and **8 cases of dangerous occurrences** in the construction industry in year 2021.
- Falls from height, slips, being struck by heavy equipment, lifting operations, and getting entangled in or between objects are the common accidents on construction sites.
- Health and safety (H&S) at sites is important consideration throughout the design and construction stage.
- Traditional safety planning are **inefficient process** and **poor information exchange quality**.
- Lack of responsive tools or technologies to assist and improve health and safety at construction sites.

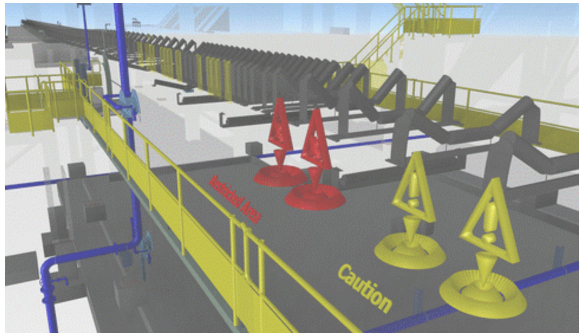
Building Information Modeling (BIM)



INTRODUCTION

Building Information Modeling (BIM)

- BIM functions to **simulate the construction project in a virtual environment** and a building information model can be constructed digitally with BIM technology.
- BIM **integrates structured, multi-disciplinary data** to produce a digital representation of an asset across its lifecycle, from planning and design to construction and operation.



- BIM **enables collaboration between all professionals** working on a project.
- A **safer workplace** can be created with **improvement of safety communication and safety planning** in the construction industry in Malaysia through BIM.

INTRODUCTION

Problem Statement

- Higher rate of accidents occurrence in construction projects in Malaysia.
- Effects of construction accidents
  - ❑ Project delays
  - ❑ Budget overruns
  - ❑ Waste of time
  - ❑ Loss of economic resources
  - ❑ Loss of human life

- Traditional safety planning which relies on manual observation and use of traditional communication system are resulting in low efficiency of process.

INTRODUCTION

Objectives

- **To assess the health and safety issues in the construction industry.**
- **To evaluate the adoption of BIM technology in improving safety in the construction industry.**
- **To develop a framework for enhancing the application of BIM for the improvement of health and safety.**

INTRODUCTION

Scope of Study

- **Researching the effects and impacts of implementation of traditional health and safety management in construction projects in Malaysia.**
- **Studying the BIM concept and theory related to health and safety in construction projects.**
- **Conducting research on the health and safety in building construction projects with the adoption of the BIM application in Malaysia.**

LITERATURE REVIEW

LITERATURE REVIEW

Traditional Safety Planning

FACTORS	REFERENCE
The construction sector has a **higher number of work injuries and fatal accidents**.	(Pham et al., 2020; Riaz et al., 2014)
Traditional safety planning is **labor-intensive** and **highly time-consuming**	(Lu et al., 2021; Ruikar, 2016; Zhang et al., 2013)
Safety knowledge is difficult to share and transfer by safety regulations alone.	(Zhang et al., 2013)
Contractors are frequently **responsible solely** for construction site safety.	(Malekitabar et al., 2016; Zhang et al., 2013)
Construction site size, work system, and **project delivery method** are factors that influence occupational safety.	(Arewa & Farrell, 2012; Pham et al., 2020)
The **unique nature of the industry, human behavior, difficult site conditions**, and poor safety management are causes of the accident.	(Akram et al., 2019; Marefat et al., 2018; Riaz et al., 2014)
Availability of skilled labor and resources, limited experience, poor safety attitudes, project size, time, and **budget** are factors that influence safety.	(Gopang et al., 2017; Kheni et al., 2010; Pham et al., 2020)
Time and economic resources are lost with the accident's occurrence.	(Zhang et al., 2013)

LITERATURE REVIEW

BIM Related Safety Application: 1) Safety Rule Checking and Design Validation

FACTORS	REFERENCE
BIM help **detects and determines physical spatial clashes** on construction site.	(Lu et al., 2021; Zou et al., 2017)
Construction models and schedules are **automatically checked** for safety through BIM.	(Rodrigues et al., 2022; Zhang et al., 2013)
BIM **visualizes, analyzes, and prevent project hazards** throughout the life cycle of the construction project.	(Hartmann et al., 2012; Rodrigues et al., 2022)
BIM is **rule-checking software** to detect safety concerns and mitigate and optimize the design.	(Zou et al., 2017)
BIM is a **semantic-based and object-oriented technique** that enables complex information system management.	(Fargnoli & Lombardi, 2020; Rodrigues et al., 2022)
Comprehend the consequences of design decisions through BIM by automatically recognizing possible safety risks.	(Kamardeen, 2010; Mihić et al., 2019)
BIM can manage the connection between design and safety on-site and control the ideal time.	(Kamardeen, 2010; Marefat et al., 2018)
BIM offers a clear simulation of all stages to provide a safe working environment.	(Ruikar, 2016)

LITERATURE REVIEW

BIM Related Safety Application: 1) Safety Rule Checking and Design Validation

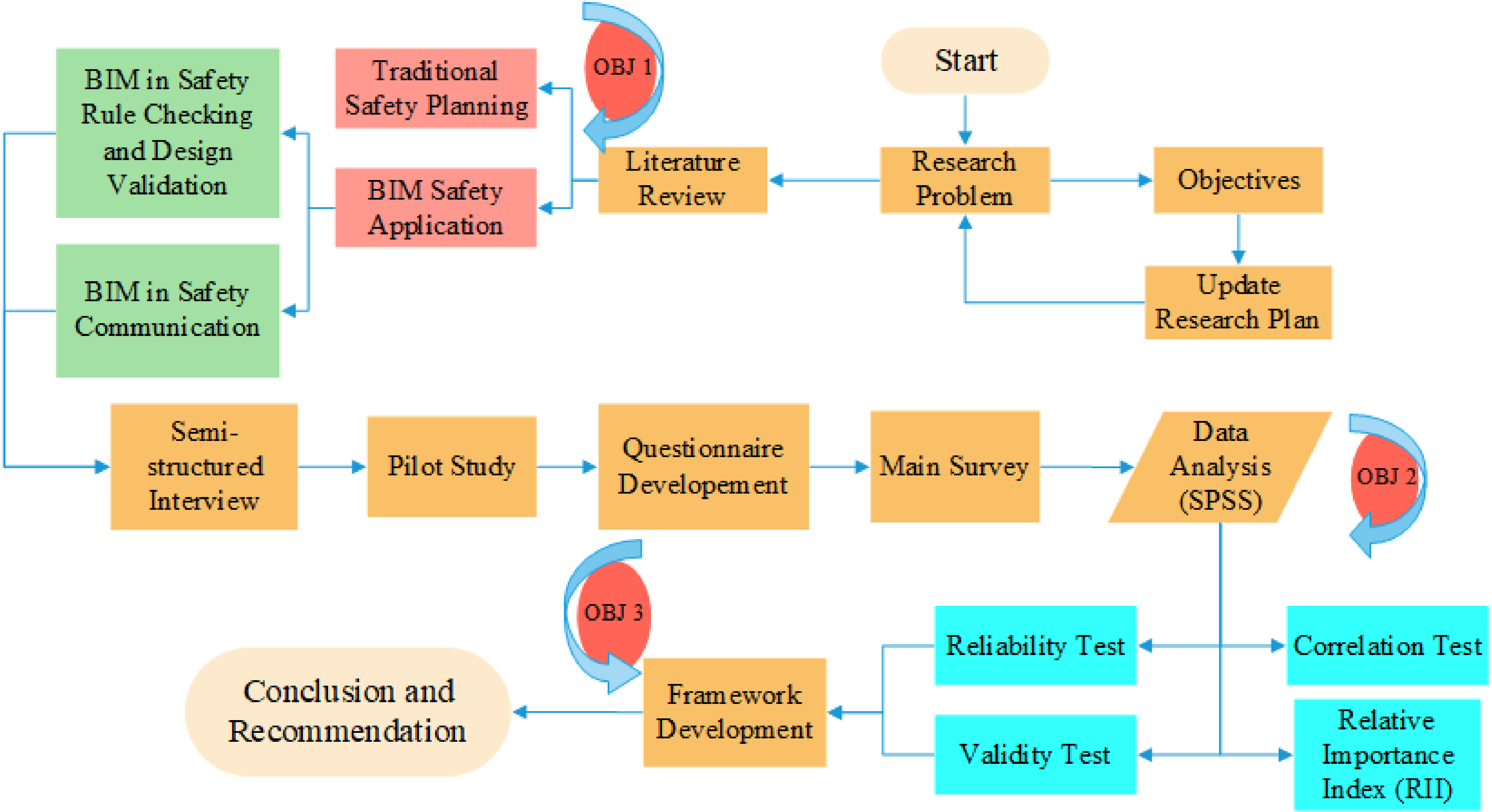
FACTORS	REFERENCE
Monitoring of confined spaces can be improved on construction sites.	(Mihić et al., 2019)
BIM **visual and predict hazard adjusts design options** and incorporates the safety process in the model.	(Rodrigues et al., 2022; Wetzel & Thabet, 2015)
Generate necessary temporary structures automatically and **assess the safety risks**.	(Kim & Cho, 2015; Mihić et al., 2019)
Congestion hazards are identified by modeling the occupancy of the construction sites.	(Mihić et al., 2019; Zhang et al., 2013)
The BIM approach enables construction simulation, integrating work planning with the 3D model, and generating a 4D model.	(Cortés-Pérez et al., 2020; Martínez-Aires et al., 2018)
Temperature and oxygen values in the confined space are monitored.	(Mihić et al., 2019; Riaz et al., 2014)
Traditional risk management is converted into visual data to increase efficiency in dynamic risk management.	(Shim et al., 2012; Zou et al., 2017)
Fall and cave-in hazards can be identified.	(Mihić et al., 2019; Zhang, Sulankivi, et al., 2015)

BIM Related Safety Application: 2) Safety Communication

FACTORS	REFERENCE
Communication is **critical at all stages of the project** for clear understanding and safety measures.	(Ganah & John, 2015; Rodrigues et al. , 2017)
Construction safety is improved by **establishing a strong relationship between safety issues and construction planning**, **providing site layout and safety plans** to aid safety communication.	(Akram et al., 2019; Azhar, 2017)
BIM increases the communication between each other, resulting in **more efficient project data and information sharing**.	(Ruikar, 2016)
BIM **provides a lot of parametric data** and **enables collaborative projects**.	(Cortés-Pérez et al., 2020; Goedert & Meadati, 2008)

METHODOLOGY

METHODOLOGY



RESULTS & FINDINGS

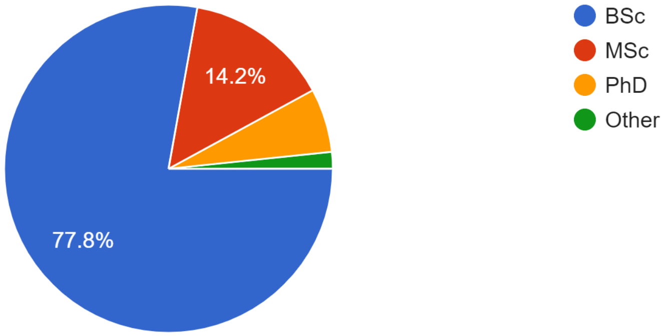
RESULTS AND FINDINGS

Total of 302 responses were received from professionals in the construction industry in Malaysia.

Respondents' General Information

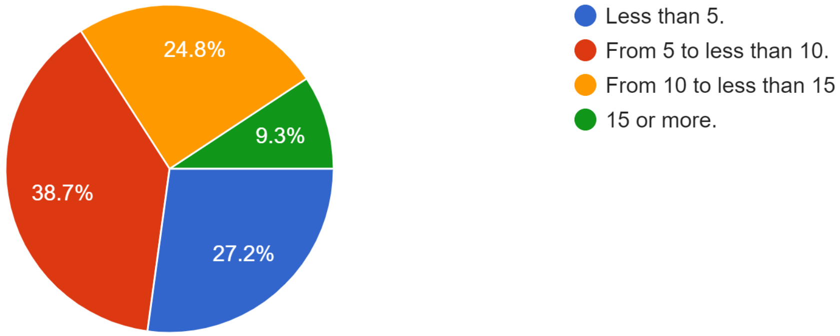
1. Your education levels.

302 responses



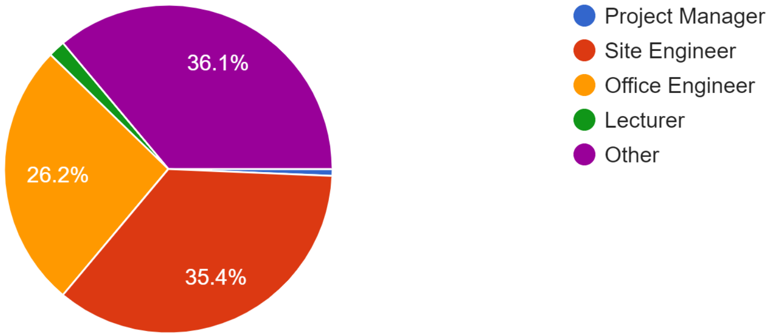
3. Your experience in construction work (Years).

302 responses



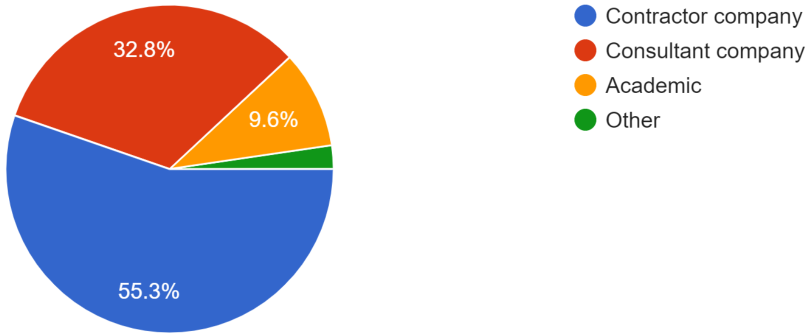
2. Your position.

302 responses



4. Your institution types.

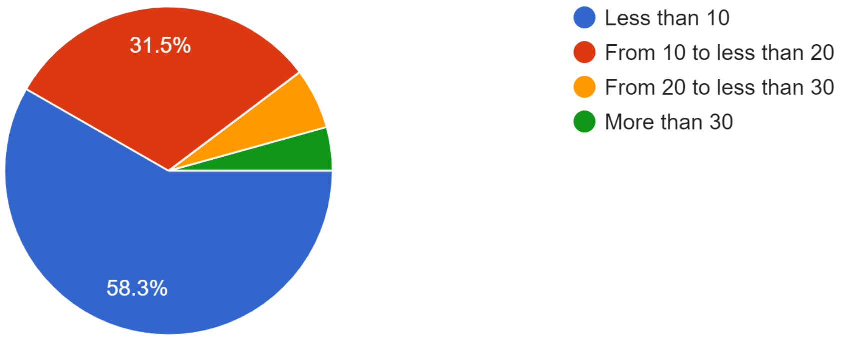
302 responses



Respondents’ General Information

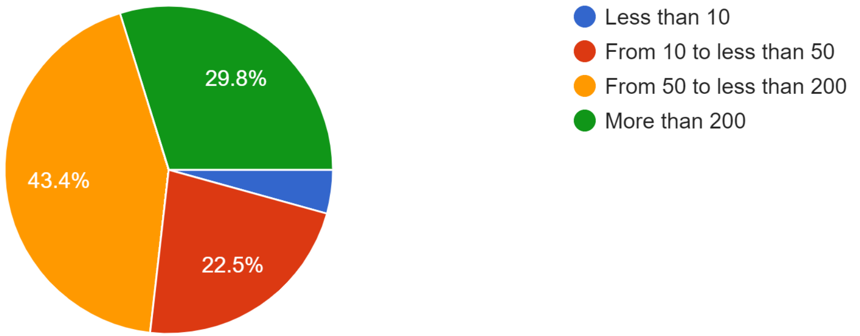
5. Your institution's experience in the construction industry (Years).

302 responses



6. Your institution size (number of employees).

302 responses



- **Reliability Test**

Case Processing Summary			
		N	%
Cases	Valid	302	100
	Excluded	0	0
	Total	302	100
Cronbach's Alpha		**0.915**	
N of items		48	

The conducted test value scored is **0.915**, with **N = 48**, which illustrates **good reliability**.

RESULTS AND FINDINGS

- **Validity Test**

Factors	Correlation Coefficient	P-Value
Construction is notorious for its health and safety record compared to other industries.	0.283	<0.001
Traditional safety planning is labor-intensive and highly time-consuming.	0.445	<0.001
Safety knowledge is difficult to share and transfer by safety regulations alone.	0.465	<0.001
Contractors are frequently responsible solely for construction site safety.	0.453	<0.001
Construction site size, work system, and project delivery method are factors that influence occupational safety.	0.483	<0.001
Traditional safety analysis is referred safety history to estimate risk situations and adjust the schedule.	0.403	<0.001
Traditional safety analysis is referred safety history to estimate risk situations and adjust the schedule.	0.389	<0.001
Inappropriate work planning, insufficiency of necessary equipment, communication between partners, training, and leadership.	0.479	<0.001
The unique nature of the industry, human behavior, difficult site conditions, and poor safety management are causes of the accident.	0.529	<0.001
Availability of skilled labor and resources, limited experience, poor safety attitudes, project size, time, and budget are factors that influence safety.	0.486	<0.001

RESULTS AND FINDINGS

- **Validity Test**

Factors	Correlation Coefficient	P-Value
Lack of integration of health and safety is the main cause of accidents during the design phase.	0.480	<0.001
Traditional communications are low efficiency of the process and poor quality of information exchange.	0.539	<0.001
Challenges for analyzing the considerations for implementing effective safety measures due to poor communication.	0.330	<0.001
Time and economic resources are lost with the accident's occurrence.	0.241	<0.001
BIM help detects and determines physical spatial clashes on construction site.	0.456	<0.001
Construction models and schedules are automatically checked for safety through BIM.	0.459	<0.001
BIM visualizes, analyzes, and prevent project hazards throughout the life cycle of the construction project.	0.483	<0.001
Fall and cave-in hazards can be identified.	0.528	<0.001
Congestion hazards are identified by modeling the occupancy of the construction sites.	0.555	<0.001
BIM is used as a systematic risk management tool, core data generator, and platform for BIM-related technologies for risk analysis.	0.481	<0.001
Incorporating H&S data into BIM can increase the focus on identifying high-risk schemes and raising awareness.	0.483	<0.001

RESULTS AND FINDINGS

- **Validity Test**

Factors	Correlation Coefficient	P-Value
BIM is rule-checking software to detect safety concerns and mitigate and optimize the design.	0.459	<0.001
BIM visual and predict hazard adjusts design options and incorporates the safety process in the model.	0.409	<0.001
Comprehend the consequences of design decisions through BIM by automatically recognizing possible safety risks.	0.468	<0.001
Decisions about upcoming tasks or construction techniques can be made and decided easily based on the situation.	0.375	<0.001
Suggestions on how to improve their designs are given for safer construction.	0.398	<0.001
Construction phases connected by BIM and schedules may be extracted and explained in real-time.	0.431	<0.001
BIM is a semantic-based and object-oriented technique that enables complex information system management.	0.469	<0.001
BIM can manage the connection between design and safety on-site and control the ideal time.	0.419	<0.001
Scheduling simulations provide a clear understanding of site conditions.	0.471	<0.001
The entire changing process of building construction sites is recorded and analyzed.	0.471	<0.001

RESULTS AND FINDINGS

- **Validity Test**

Factors	Correlation Coefficient	P-Value
BIM is a platform for elucidating construction, operation, and maintenance health concerns and devising strategies.	0.492	<0.001
Construction schedules, resources, and management expenses may analyze with BIM simulation models.	0.428	<0.001
Generate necessary temporary structures automatically and assess the safety risks.	0.500	<0.001
Established procedure for evaluating risks from visually displaced falseworks objects and their locations.	0.313	<0.001
Monitoring of confined spaces can be improved on construction sites.	0.560	<0.001
Temperature and oxygen values in the confined space are monitored.	0.523	<0.001
Construction hazards in the confined space can be identified.	0.534	<0.001
Traditional risk management is converted into visual data to increase efficiency in dynamic risk management.	0.414	<0.001
Time and cost are reduced.	0.461	<0.001
The BIM approach enables construction simulation, integrating work planning with the 3D model, and generating a 4D model.	0.369	<0.001

RESULTS AND FINDINGS

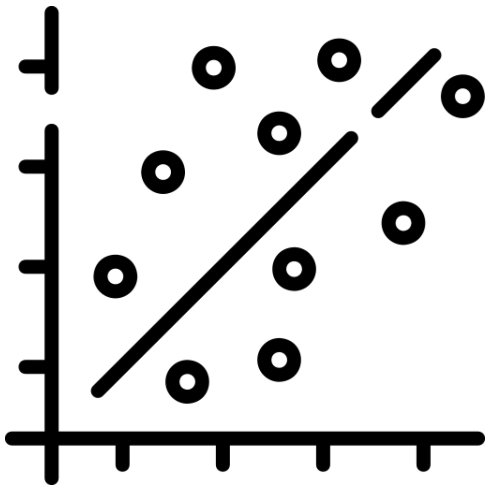
- **Validity Test**

Factors	Correlation Coefficient	P-Value
The quality of information available for decision-making can be improved.	0.522	<0.001
The quality of services delivered can be improved through BIM.	0.510	<0.001
Communication is critical at all stages of the project for clear understanding and safety measures.	0.486	<0.001
BIM provides a lot of parametric data and enables collaborative projects.	0.472	<0.001
With BIM authoring tools, virtual reality (VR) is utilized for virtual danger assessment, professional training, and design for safety.	0.416	<0.001
BIM increases communication between each other, resulting in more efficient project data and information sharing.	0.469	<0.001
Construction safety is improved by establishing a strong relationship between safety issues and construction planning and providing site layouts and safety plans to aid safety communication.	0.410	<0.001

- **Validity Test**
  - ✓ P-value for **all factors equals <0.001**, which is **less than the reasonable significance level (0.05)**.
  - ✓ Correlation coefficient of all factors were **greater than the r table product moment (0.1126)**.
  - ✓ It can be concluded that all the factors in this survey were **valid**.
  - ✓ **Null hypothesis is rejected**, it can be concluded that all factors were beneficial to be used for this study.


RESULTS AND FINDINGS

- **Correlation Test**
  - ✓ P-value for **all factors equals <0.001**, which is **less than the reasonable significance level (0.05)**. >>Showed there is a **significant relationship** between each factor.
  - ✓ **Pearson coefficient** of a few factors were in the range of **0.21-0.40. >>Low correlation.**
  - ✓ Remaining factors have a **Pearson coefficient** within the range of **0.41-0.60**. >>**Moderate correlation**
  - ✓ Result of the correlation is **still acceptable** and there is **less significant relationship** between each factor.



RESULTS AND FINDINGS

- **Relative Importance Index (RII)**

1) Implementation of Traditional Safety Planning

No	Code	Factors	RII	Rank
1.	B2	Traditional safety planning is labor-intensive and highly time-consuming.	0.8854	1
2.	B5	Construction site size, work system, and project delivery method are factors that influence occupational safety.	0.8219	2
3.	B3	Safety knowledge is difficult to share and transfer by safety regulations alone.	0.8205	3
4.	B6	Traditional safety analysis is referred safety history to estimate risk situations and adjust the schedule.	0.8099	4
5.	B4	Contractors are frequently responsible solely for construction site safety.	0.8007	5

RESULTS AND FINDINGS

2) Factors and Impacts of Higher Accident Rate From Happening

No	Code	Factors	RII	Rank
1.	C9	The unique nature of the industry, human behavior, difficult site conditions, and poor safety management are causes of the accident.	0.9000	1
2.	C10	Availability of skilled labor and resources, limited experience, poor safety attitudes, project size, time, and budget are factors that influence safety.	0.8940	2
3.	C8	Inappropriate work planning, insufficiency of necessary equipment, communication between partners, training, and leadership.	0.8881	3
4.	D14	Time and economic resources are lost with the accident’s occurrence.	0.8715	1
5.	D13	Challenges for analyzing the considerations for implementing effective safety measures due to poor communication.	0.8073	2

RESULTS AND FINDINGS

3) BIM for Safety Rule Checking And Design Validation

No	Code	Factors	RII	Rank
1.	E15	BIM help detects and determines physical spatial clashes on construction site.	0.9265	1
2.	E17	BIM visualizes, analyzes, and prevent project hazards throughout the life cycle of the construction project.	0.8788	2
3.	H36	Monitoring of confined spaces can be improved on construction sites.	0.8735	3
4.	I40	Time and cost are reduced.	0.8735	3
5.	G34	Generate necessary temporary structures automatically and assess the safety risks.	0.8702	5
6.	E22	BIM is rule-checking software to detect safety concerns and mitigate and optimize the design.	0.8616	6
7.	E16	Construction models and schedules are automatically checked for safety through BIM.	0.8576	7

RESULTS AND FINDINGS

4) BIM for Safety Communications

No	Code	Factors	RII	Rank
1.	J44	Communication is critical at all stages of the project for clear understanding and safety measures.	0.9040	1
2.	J45	BIM provides a lot of parametric data and enables collaborative projects.	0.8781	2
3.	I48	Construction safety is improved by establishing a strong relationship between safety issues and construction planning and providing site layouts and safety plans to aid safety communication.	0.8272	3
4.	I47	BIM increases communication between each other, resulting in more efficient project data and information sharing.	0.8179	4
5.	J46	With BIM authoring tools, virtual reality (VR) is utilized for virtual danger assessment, professional training, and design for safety.	0.7205	5

RESULTS AND FINDINGS

- **Framework Development**

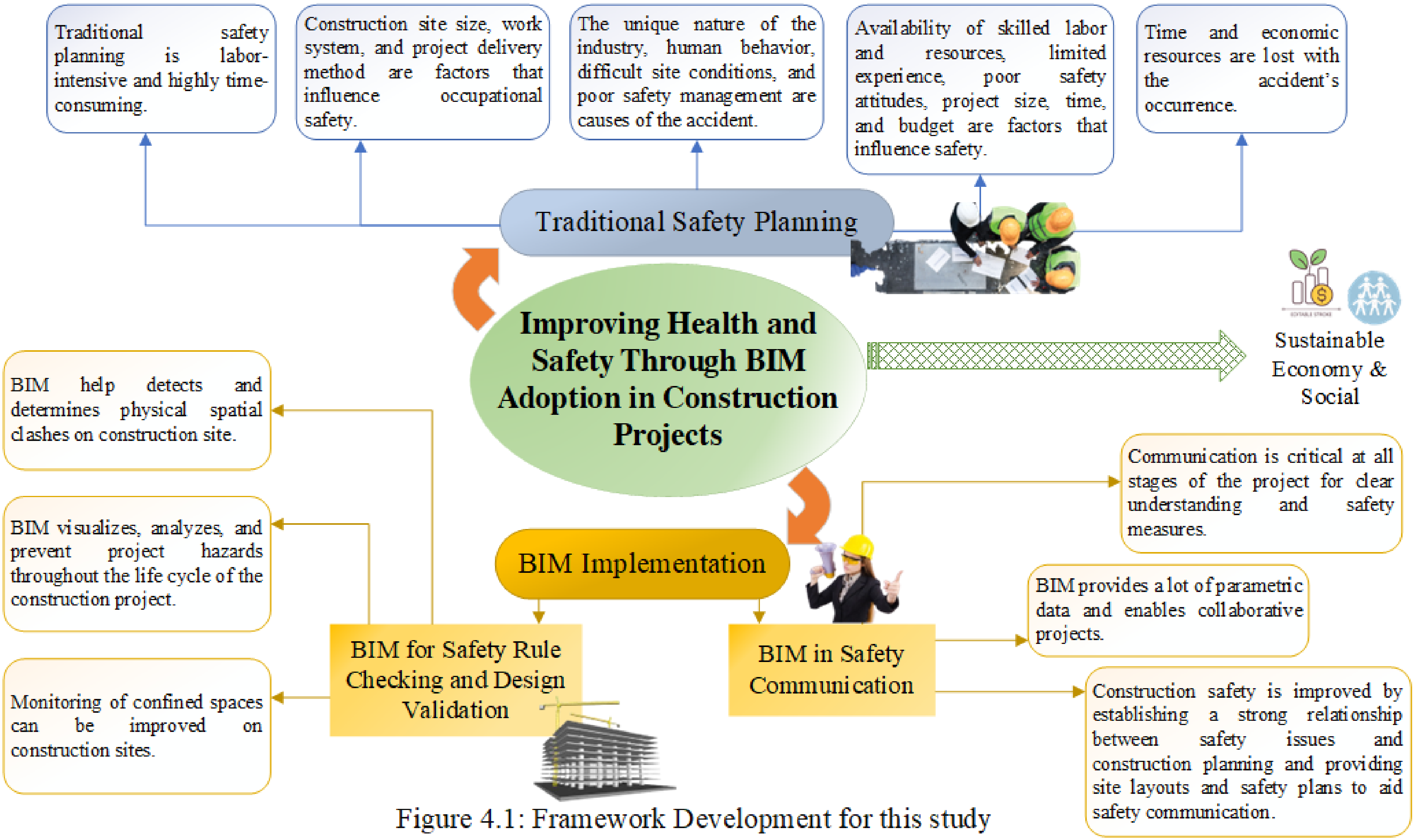
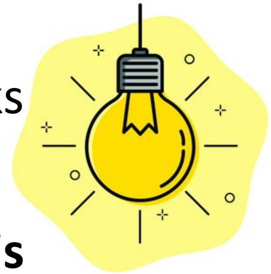


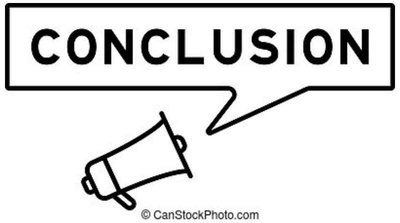
Figure 4.1: Framework Development for this study

CONCLUSION & RECOMMENDATION

CONCLUSION



- ✓ The uptrend use of new technologies, such as BIM has been used to control risks and reduce occupational accidents in the construction industry.
- ✓ This study can be concluded that **traditional safety planning implementation is labor intensive and time consuming.**
- ✓ BIM technology can be utilized for **systematic risk management**, as a **source of essential data**, and as a **platform for other BIM-based applications.**
- ✓ BIM can **detect, visualize, determine, analyze, and prevent project hazards and physical spatial clashes** on construction sites.
- ✓ BIM can as a **tool for automated safety checks** (rule checking) and **knowledge-based systems** throughout the building construction life cycle.
- ✓ BIM adoption is thus recommended to be used for planning, designing, and executing, as well as for effective communication about safety at all stages of the process.



RECOMMENDATION

- The importance and benefits of BIM should be emphasized by experts and government authorities as this might encourage its implementation at higher rates.
- Government should **take initiative to mandate the use of BIM** in construction projects beginning with the design phase.
- Government should **collaborate with the industry, professional organizations, and education institutes.**
- Most important strategy that improve health and safety with the usage of BIM is related to **human factors**.
  - Project managers encouraged to familiar with the project workflows, management, and technicalities required for using BIM.
  - Team leader encouraged to aware of the BIM software's ins and outs and make sure that the technological knowledge is the latest version.
  - Good practice to put all the information and data of the projects in the software to increase the accuracy of the software.

THANK YOU