

World Engineers Summit 2021

SafeSim Design: Answering the need for greater Design for Safety (DfS) competency in Singapore

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NUS
National University
of Singapore

National University of Singapore

Construction Industry

- ▶ Remained the **top contributor** to workplace fatalities in Singapore (MOM, 2021)
- ▶ **Cause of accidents:**
 - ▶ Unsafe acts and/or condition
 - ▶ Lack of design planning for safety*
- ▶ Can be eliminated or controlled effectively with **early intervention** (Goh & Chua, 2016)

- ▶ A lot of focus on contractors' duty
- ▶ Little focus on designers (i.e., architects, engineers)
 - ▶ Lack understanding of the implications of their unsafe design
- ▶ **Anticipate** and **“design out”** these potential hazards

Design for Safety (DfS)

Design for Safety (DfS) is the **process** where **stakeholders of a construction project¹** come together at the **earliest opportunity** during **different stages of a project²** to **identify and eliminate or reduce foreseeable design risks** throughout the **life cycle³** of a structure through good design.

¹*E.g., developer, designers, contractors*

²*From planning and design phases onwards*

³*E.g. construction, use/operation, demolition*

- I. **Reducing risk at source**
- II. **Collaborative and systematic risk assessment**
- III. **Conducted throughout the project lifecycle**

Using digital game-based learning (DGBL) to teach designers about DfS:

how to identify the design risk, how to mitigate them through design controls/changes

Advantages of DGBL

- ▶ Positively impact learners' interest and understanding of the topic
- ▶ Provision to make mistakes in the virtual world
- ▶ Helping learners understand the process and how their actions affect the outcome

SafeSim Design

A digital game-based learning software for designers to learn about design risk and how to mitigate them

Dept. of the Built Environment, NUS IT

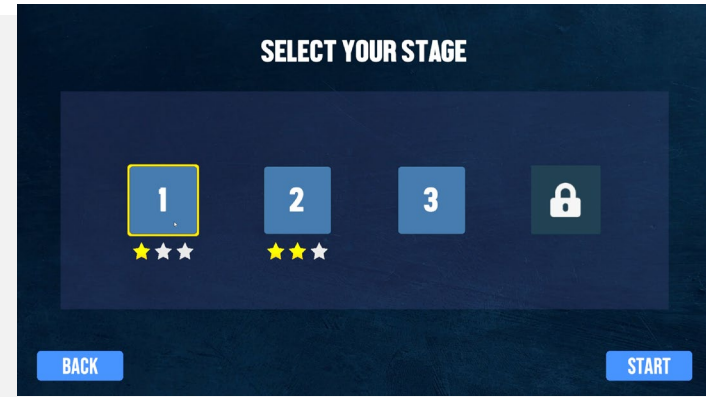
This study is funded by SkillsFuture Singapore under Workforce Development Applied Research Fund (WDARF) Grant.

The contributions of IES DfS Workgroup and other anonymous practitioners are greatly appreciated.

- 1. Utilise their roles as designers to apply the hierarchy of control in DfS process**
- 2. Identify common design risks that can affect the safety and health of workers**
- 3. Evaluate design risks based on severity and likelihood, risk levels and detailed safety review**
- 4. Identify industry standards, guidelines, and norms when mitigating design risks**
- 5. Critique different design alternatives to eliminate or reduce design risks**
- 6. Formulate alternative design changes to manage design risks**

Introduction to SafeSim Design

- ▶ Developed based on the authors' previous work, SafeSim Risk (SSR) **but** SSD extends beyond SSR
 - ▶ implications of unsafe design throughout the project lifecycle
 - ▶ educate designers on the difference between design risks and occupational hazards
 - ▶ how to conduct risk evaluation, and
 - ▶ how to design out issues through various design-related controls
- ▶ Content are based on the **IES-NUS Dfs Library**



SELECT YOUR STAGE

1 2 3 [Lock Icon]

★★★ ★★

BACK START

- **Four** stages of varying difficulty
 1. *different design limitations*
 2. *address different learning outcomes*
- **Two** phases at each stage
 - *Exploration Phase*
 - *Corrective Phase*

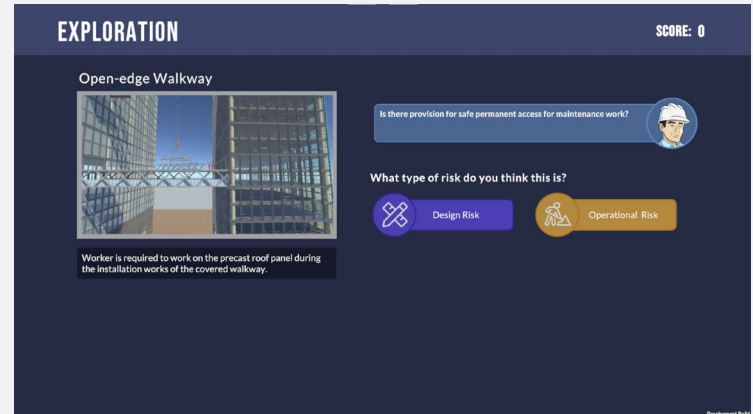
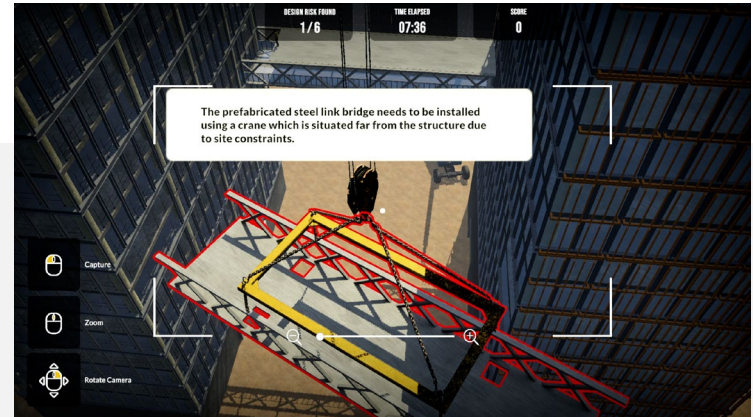
01. Guidance Tool

- ▶ Introduced to Mr Chief Designer (Mr CD)
- ▶ Non-playable character to guide players throughout the game
- ▶ Provide context
- ▶ Help with the introduction of the game controls and user interface



02. Exploration Phase

- ▶ **Capturing design risks**
 - ▶ Using the camera tool
 - ▶ Classify identified hazard as design risk or operational risk



- **Utilise their roles as designers to apply the hierarchy of control in DfS process**
- **Identify common design risks that can affect the safety and health of workers**

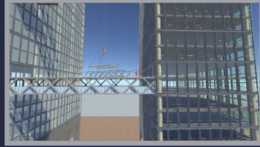
02. Exploration Phase

- ▶ **Answering MCQ**
 - ▶ Immediate feedback through scoring system
- ▶ **Explanations and Rationale**
 - ▶ To reinforce the concept of DfS

- **Identify common design risks that can affect the safety and health of workers**

EXPLORATION SCORE: 60

Open-edge on link bridge



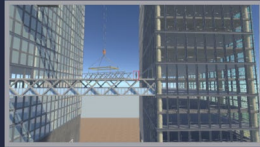
Identify the design risk in this image

- A Absence of proper harness being equipped by the worker during ...
- B Absence of guard rails on the open edges of the roof, leading to L...
- C Presence of open edges on the roof of link bridge between buildi...
- D Presence of non-load bearing material used for roof panels of th...

Development Build

EXPLORATION SCORE: 100

Open-edge on link bridge



Identify the design risk in this image

- A Absence of proper harness being equipped by the worker during ...
- B Absence of guard rails on the open edges of the roof, leading to L...
- C Presence of open edges on the roof of link bridge between buildin
- D Presence of open edges on the roof of link bridge between buildings that can lead to increased likelihood of bodily injury due to fall from height.

Explanation

Workers may fall from height during the installation of the roof panel, where there are open edges at the side of the bridge and sections with unfinished installation of panels. Workers may also fall from height during maintenance of the link bridge due to the open edges at the side.

NEXT

Development Build

02. Exploration Phase

- ▶ Rate identified risk based on severity and likelihood
 - ▶ Based on RM Code of Practice

EXPLORATION SCORE: 200

Prefab link bridge



Rate the severity and likelihood of the risk

SEVERITY: ● ● ● ● ● - CATASTROPHIC


LIKELIHOOD: ● ● ● ● ● - ALMOST CERTAIN

RPN: **25** - HIGH

SUBMIT

EXPLORATION SCORE: 150

Open-edge



		Likelihood				
		1 Rare	2 Unlikely	3 Possible	4 Likely	5 Almost Certain
Severity	5 Catastrophic	5 Moderate	10 High	15 Extreme	20 Extreme	25 Extreme
	4 Major	4 Moderate	8 High	12 High	16 Extreme	20 Extreme
	3 Moderate	3 Low	6 Moderate	9 High	12 High	15 Extreme
	2 Minor	2 Low	4 Moderate	6 Moderate	8 High	10 High
	1 Negligible	1 Low	2 Low	3 Low	4 Moderate	5 Moderate

PLAYER'S RATING: ●●●

CHIEF DESIGNER'S RATING: ●●

DONE

- Evaluate design risks based on severity and likelihood, risk levels and detailed safety review


03. Corrective Phase

- ▶ Choose **most suitable** measure
 - ▶ No right or wrong answer
- ▶ Option to provide **alternative solutions**
- ▶ Answers will be posted to the forum for further discussions

- Utilise their roles as designers to apply the hierarchy of control in DfS process
- Identify industry standards, guidelines, and norms when mitigating design risks
- Formulate alternative design changes to manage design risks

CORRECTIVE SCORE: 850

Protruding vertical fins

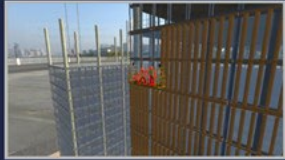


How do you want to minimise the design risk?

- A** Remove the fin design if possible.
- B** Design the fins to be part of the precast wall.
- C** Provide temporary working platform, e.g. scaffolding, for the fin installation works.

CORRECTIVE SCORE: 1000

Protruding vertical fins



How do you want to minimise the design risk?

- A** Remove the fin design if possible.
- B** Design the fins to be part of the precast wall.
- C** Provide temporary working platform, e.g. scaffolding, for the ...

Recommended Acceptable Least Applicable

YOUR SUGGESTIONS:

Please input alternative suggestions (if any). Your suggestions will be reflected in the forums.

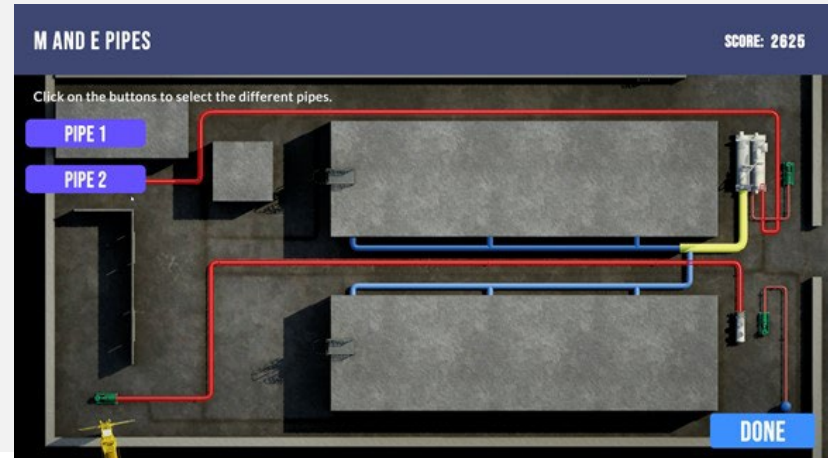
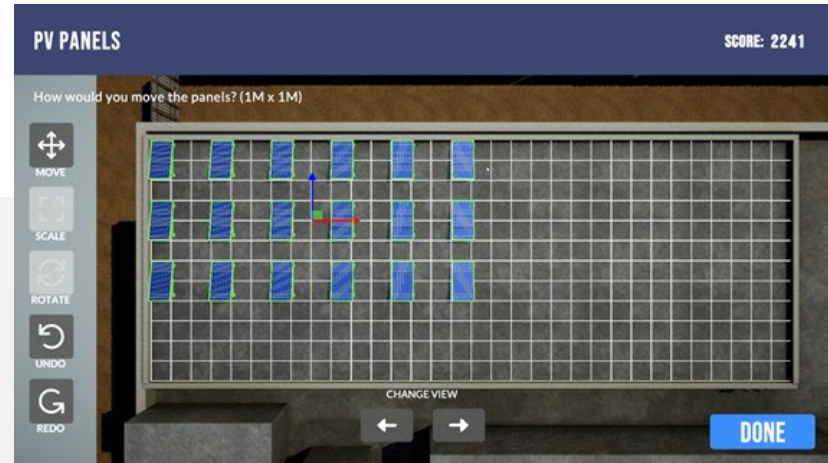
Chief Designer's Answer: B

It is frequently possible to satisfy requirements for aesthetics and safety even for projects that aims to develop an iconic structure. Designers should treat safety of construction and maintenance workers as important design considerations. With teamwork and creativity, it is possible to balance safety considerations with other design goals and constraints.

DONE

03. Corrective Phase

- ▶ **Bonus rounds (> Stage 2)**
 - ▶ Earn more points
 - ▶ Moving the elements, Manipulation, etc.
- ▶ **PV panels**
 - ▶ Move the PV panels within the specific grid based on the fire code
- ▶ **M&E Pipes**
 - ▶ Choosing the best layout to prevent tripping hazard during maintenance



- Identify industry standards, guidelines, and norms when mitigating design risks
- Formulate alternative design changes to manage design risks

04. Summary Page

- ▶ **Breakdown of scores**
- ▶ **Leaderboard**
 - ▶ Check ranking against peers
 - ▶ Motivate players to do better
- ▶ **Ability to redo**
 - ▶ Allowing players to do self-directed learning
- ▶ **Post questions/answer in the forum**
 - ▶ Able to critique alternative solutions

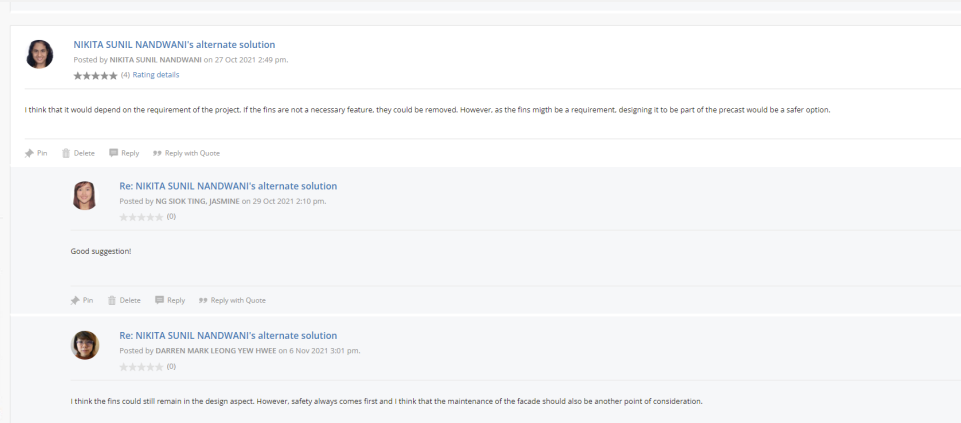
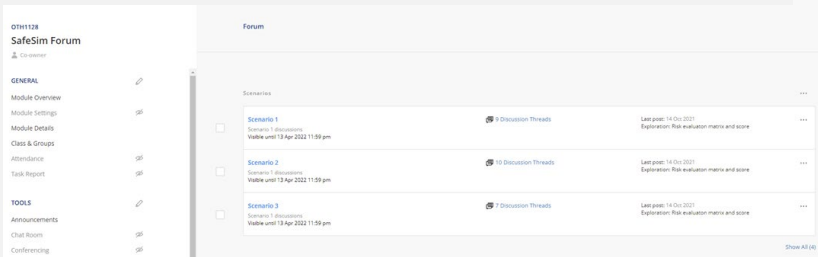
SCENARIO 1: COMPLETED

SUMMARY		★★★	LEADERBOARD		FORUM
Risks found	: 6 / 6		1. CHAI XIN TIAN	2700 pts	
Risks fixed	: 6 / 6		2. Ting Ting Tay	2325 pts	
Found Points Earned	: 850 / 1200		3. Mohammad Nashrulhaq Abdullah	2225 pts	
Corrective Stage	: 975 / 1200		4. Sufiana Safiena	2100 pts	
Bonus MCQ points	: 0 / 0				
Clues Bought	: 0				
TOTAL POINTS	: 1825 / 2400				

REDO **NEXT**

05. Forum Page (External)

- ▶ Allow players to view other players' alternative solutions
- ▶ Able to reply and rate post



- Critique different design alternatives to eliminate or reduce design risks
- Formulate alternative design changes to manage design risks

Thank You

Any questions?



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*Safety and Resilience Research Unit,
Department of Building, NUS*

This study is funded by SkillsFuture Singapore under Workforce Development Applied Research Fund (WDARF) Grant.

Invitation to join in this study

NUS Safety and Resilience Research Unit (SaRRU) invites you to join us in testing SafeSim Design. We need your help to evaluate the gameplay and the authenticity of the game. Your participation will help us understand the effectiveness of the game and identify areas for improvement.

If you are interested, please contact us at

bdgbox27@nus.edu.sg

(Attn: Ms Sufiana Safiena)