

Enhancing Children's Road Safety Awareness through Safety Features of Interactive Digital Media Applications in Malaysia

Nurul Hanny Zairudy¹, Nur Aniza Mohd Lazim², *Sharkawi Che Din³

^{1,2,3}*Faculty of Art & Design, Universiti Teknologi MARA, Selangor Branch, Puncak Alam Campus, Malaysia*

hannyzairudy713@gmail.com¹, aniza32@uitm.edu.my², *sharkawi237@uitm.edu.my³

***Corresponding author**

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ABSTRACT

Children remain one of the most vulnerable groups of road users in Malaysia, yet road safety education for this age group continues to rely largely on passive, print-based instruction. Interactive digital media applications offer a more engaging alternative, but the visual construction of such applications has received limited analytical attention. This study analyses how design principles and safety sign principles are applied in interactive digital media applications intended to build children's road safety awareness. A qualitative visual content analysis was conducted on six purposively selected applications, comprising mobile applications and web-based platforms containing child-directed road safety content. Each application was coded against six design principles attribute composition, hierarchy, balance, contrast, proportion and tone and three safety sign attributes colour coding, pictograms and typography. Applications combining clear visual organisation with standardised colour coding and pictograms present safety information in a form that is more legible and more readily distinguished at the interface level. As the study examines design facts rather than child users, the findings describe design characteristics consistent with established multimedia learning principles rather than measured learning outcomes. These will contribute a coding framework for the visual evaluation of children's road safety applications and identifies design inconsistencies that warrant attention in future development work.

Keywords: *Children, Road Safety, Safety features, Digital media, Interactive media, Interactive Digital Media Applications (IDMA)*



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1 INTRODUCTION

Road traffic injury remains one of the most persistent public health problems in Malaysia, and children are among those least able to protect themselves within it. Between 2011 and 2020, an average of one child died every day in a road accident, with children aged 0–15 accounting for approximately 7.25% of all road fatalities (Malay Mail, 2023). The wider picture is equally severe: Malaysia recorded 6,443 road deaths in 2023, approximately eighteen per day (Chan, 2024). This is consistent with a broader South-East Asian pattern in which rapid urbanisation and rising motorisation have increased exposure for young pedestrians and cyclists. Malaysia has responded with structural measures, including a commitment to reduce vehicle speeds to 30 km/h in school zones (World Health Organization, 2024), yet the Global Status Report on Road Safety 2023 records no national target for increasing child restraint use, indicating that child-specific safety objectives are not yet fully articulated in national policy (World Health Organization, 2023). Structural measures alone do not equip children to interpret the road environment. That task falls to road safety education, which in Malaysia has been delivered primarily through classroom instruction, printed materials and awareness campaigns (Roziana

et al., 2024). These approaches are informational rather than participatory: they provide instruction and modelling without opportunities for rehearsal and feedback. The consequence is well documented, children who complete passive learning programmes can often describe the correct action in an unsafe situation without performing it when assessed in situ (Miltenberger et al., 2013). Malaysian evidence points the same way, with self-reported safety behaviour poorly predicted by knowledge scores (Shahril, 2023). Knowledge acquisition and behavioural readiness are therefore not interchangeable outcomes, and the gap between them is where conventional delivery is weakest.

Interactive digital media applications are relevant to this gap because they change the mode of engagement rather than merely the medium of delivery. Gamified tasks, animation and touch-based interaction allow children to act within a represented road environment instead of being told about it, and the multimedia learning literature indicates that pairing visual and verbal channels produces stronger comprehension than text alone (Mayer, 2009; Moreno & Mayer, 2007).

Within Malaysian design research, content analyses of children's learning applications and augmented reality media have shown that the deliberate configuration of multimedia and visual elements shapes how young users engage with instructional content (Ahmad, Mohd Lazim & Che Din, 2025; Mahmud & Che Din, 2025). Interactive platforms, including augmented reality, have also been identified as a promising direction for children's road safety content specifically (Shahrir & Emran, 2023).

What has not been examined is how such applications are visually constructed whether the design decisions within them actually support the recognition of safety information. This study addresses that question through a qualitative visual content analysis of six interactive digital media applications, examining the application of design principles and safety sign principles in order to establish a design-level basis for developing road safety media for Malaysian children.

1.1 Problem Statement

Traditional methods of delivering road-safety education, such as lectures, printed materials, and static visuals, often relied on passive instruction, which did not sufficiently engage young learners or sustain their attention over time (Shahrir & Emran, 2023). Research indicated that although such conventional approaches could increase children's theoretical knowledge, these gains did not always translate into safer behaviour in real-world contexts (Shahril, 2023). For instance, in a Malaysian study, the level of self-reported behaviour was poorly predicted by knowledge (Shahril, 2023). In contrast, more active, technology-mediated approaches (e.g., virtual reality) showed promise in enhancing pupils' attention and reflection on risk (Van der Meij & de Jong, 2022). Consequently, many children only reached a superficial understanding of road-safety concepts, leading to reduced awareness and inconsistent application of safe practices in everyday traffic situations.

Recent studies emphasised the need for innovative and interactive educational tools to overcome these limitations. According to Shahrir and Emran (2023), the integration of digital media, particularly augmented reality (AR) and similar interactive platforms, offered a promising avenue for enhancing children's engagement, emotional connection, and comprehension in learning environments. Despite this potential, there remained a lack of research exploring how specific safety features within digital media applications could effectively support children's learning and behavioural outcomes in the context of road-safety education. This gap highlighted the need to investigate and develop technology-enhanced approaches that promoted sustained awareness and meaningful learning among young learners. Hence, this research aimed to propose design recommendations for integrating effective safety features into digital media applications to support children's road-safety education in Malaysia.

1.2 Research Objective

This study analyses the safety features embedded within six interactive digital media applications

directed at children's road safety awareness. Specifically, it examines how design principles composition, hierarchy, balance, contrast, proportion, tone and safety sign principles colour coding, pictograms and typography are applied within these applications and identifies the design configurations that present road safety information most clearly and consistently at the interface level.

1.3 Research Gaps

Research on children's road safety education in Malaysia has concentrated on behavioural training and knowledge transfer through classroom instruction, printed materials and awareness campaigns (Roziana et al., 2024; World Health Organization, 2023). These approaches establish foundational understanding but are less suited to children under twelve, who learn substantially through play, interaction and visual stimuli (Vygotsky, 1978). Where digital media has been introduced into this domain, attention has largely been directed at the technology itself augmented reality, virtual environments, gamification compared to the visual design decisions that determine whether the safety content within them is noticed and correctly interpreted (Shahrir & Emran, 2023; Skjermo et al., 2022).

The rationale for examining design principles and safety sign principles together follows from this. The two principle sets answer different questions and are individually insufficient. Design principles govern whether safety content is attended to at all: composition and hierarchy determine reading order, contrast and proportion determine what is seen first, and tone determines whether the interface reads as instructional or merely decorative (Poulin, 2018).

Safety sign principles govern whether the content, once attended to, is correctly recognised and transferable: standardised colour coding, pictograms and legible typography allow a symbol encountered in an application to be recognised as the same symbol on a real road (Israel, 2025). An application may therefore be visually well-composed while using non-standard signage that does not transfer beyond the screen or may embed correctly standardised signage within a cluttered layout that children never attend to.

Neither failure is visible if only one principle set is examined. Malaysian visual analyses of children's digital media have applied similar element-based coding to multimedia and illustration components (Kamaruddin, Mohamed Ghazali, Mohd Lazim & Che Din, 2024; Syed Rizakri, Mohamed Ghazali, Mohd Lazim & Che Din, 2024), but the joint application of design principles and safety sign principles to road safety content for children has not been undertaken.

2 LITERATURE REVIEW

This literature review examined the application of design principles and safety sign principles in interactive digital media, with particular attention to their theoretical and practical potential for enhancing road safety awareness among Malaysian children.

2.1 Road Safety

According to the Global Status Report on Road Safety 2023 by the World Health Organization, Malaysia currently reports N/A for national targets to increase child safety-restraint use, indicating that such targets have not yet been established (WHO, 2023).

ROAD USER BEHAVIOUR			E
Legislation on urban speed limits for passenger cars and motorcycles ²			=
National law setting a speed limit	Yes	=	
Maximum urban speed limit	90 km/h	=	
Maximum rural speed limit	90 km/h	=	
Maximum motorway speed limit	110 km/h	=	
Local authorities can modify limits	Yes	=	
Presence of targets to reduce speeds nationally (year) ²	National (2030)	N/A	
Available types of enforcement	Manual	↗	
Legislation on child restraint systems ²			↗
National child restraints use law	Yes	↗	
Children seated in front seat	No	↗	
Age or height specified for children requiring child restraint	12 y/ 135 cm	↗	
Child restraint standard referred to and/or specified	Yes†	↗	
Presence of targets to increase child safety restraint use (year)	Yes, subnational (2030)	N/A	

Figure 1 Global status report on road safety 2023; Malaysia
(Source: ©World Health Organization, 2023)

In Malaysia, road traffic accidents remained a major public health concern, with children identified as one of the most vulnerable groups of road users. Between 2011 and 2020, an average of one child died every day due to road accidents, with children aged 0–15 years accounting for approximately 7.25% of all fatalities (Malay Mail, 2023). The situation reflected a broader regional trend in South-East Asia, where rapid urbanisation and increased motorisation heightened the risk of road injuries among young pedestrians and cyclists. In response, Malaysia implemented several road safety interventions, including a national initiative to reduce traffic speeds to 30 km/h in school zones and the installation of speed bumps as preventive measures to protect children near educational areas World Health Organization (WHO), 2024. Despite these efforts, the country continued to record a high overall number of road traffic fatalities, with 6,443 deaths in 2023, or roughly 18 per day, and motorcyclists aged 16–35 comprising about 65% of fatalities (Paul Tan, 2024). These statistics highlighted the urgent need for innovative, child-focused educational approaches, such as interactive digital media, to raise awareness of safer road behaviours among children in Malaysia. In this research, the researcher will examine road-safety signage designed for children that appear within digital media applications, specifically on websites and in mobile games.

2.2 Design Principles

According to Poulin (2018), understanding design principles is fundamental to developing effective visual communication. He describes design as a language built upon a structured system of elements and principles, where mastery begins with learning their definitions, purposes, and visual relationships. These foundational components which includes balance, contrast, proportion, tone, hierarchy, and typography, forms the building blocks that determine how meaning is conveyed and perceived in any composition. When designers treat these elements as a visual vocabulary, they are better equipped to organise, analyse, and communicate ideas with clarity and intent. Through this framework, design transcends decoration and becomes a deliberate process of problem-solving and storytelling, guided by a coherent understanding of the underlying principles that shape visual structure and emotional response (Poulin, 2018). This study examines specific design-principle features which is hierarchy, composition, balance, contrast, proportion, and tone within interactive digital media applications, specifically mobile applications and websites.

2.3 Safety Sign Principles

Safety signage encompasses the use of standardised visual indicators, including signs, symbols, colours, and pictograms, to convey essential safety information within workplaces. These visual cues function as immediate, non-verbal instructions that enhance hazard awareness, guide safe behaviour, and facilitate effective responses during emergencies. By presenting complex safety procedures in an easily interpretable visual format, safety signage ensures that all individuals, irrespective of language

proficiency or literacy level, can quickly recognise hazards and take appropriate action (Emmanuel, 2023).

Clear, consistent, and highly visible safety signage plays a crucial role in guiding behaviour, minimising accidents, and ensuring that safety procedures are understood and adhered to, particularly in high-risk or high-traffic areas. Whether implemented as regulatory instructions, hazard alerts, or behavioural cues, such signage is fundamental to preserving the integrity of operational zones and maintaining overall workplace safety (Isreal, 2025).

Beyond fulfilling regulatory obligations, effective safety signage serves as a central element of proactive safety management. When carefully designed, strategically placed, and consistently maintained within a comprehensive safety system, signage not only mitigates the likelihood of incidents but also cultivates a culture of vigilance and accountability. In this research, the researcher investigated specific safety sign features, including colour-code consistency, the use of pictograms, and the selection of appropriate typography within interactive digital media applications such as websites and mobile games.

2.4 Interactive Digital Media

According to Griffey (2019), interactive digital media applications can take various forms, including websites, mobile apps, stand-alone kiosks, video games, or sensor-driven physical installations in museums and public spaces. Designing such experiences presents unique challenges, particularly when the interactions are open-ended, as predicting user behaviour becomes difficult. A crucial stage in the development of interactive applications is anticipating how users will engage with the system.

Since the advent of interactive digital media, advances in hardware have enabled new forms, functions, and modes of interaction, influencing communication, learning, shopping, and entertainment practices. Museums, for example, have increasingly embraced interactive experiences, where exhibit designers aim to combine technological novelty with open-ended engagement to sustain visitor attention. Among recent innovations are non-screen-based interactive experiences, which offer alternative purposes and contexts for user interaction (Griffey, 2019). The expected outcome of this research was the development of an interactive digital media application, specifically a gamified Augmented Reality (AR) experience and an interactive projection mapping that integrates validated safety features to effectively enhance children's road safety awareness in Malaysia.

The literature demonstrated that well-designed interactive media, using clear principles like balance, contrast, proportion, tone, hierarchy, and typography, helps children better understand road-safety information. Consistent safety-sign features such as colour codes, pictograms, and readable text also support quick recognition and stronger retention among young learners. Collectively, these insights provide a strong foundation for the development of the proposed gamified augmented reality (AR) application and interactive projection-mapping experience. By integrating evidence-based design and safety-communication principles, the project aims to create an engaging, developmentally appropriate platform that reinforces essential road-safety behaviours in a more immersive and effective manner.

3 METHODOLOGY

This study employed a qualitative content analysis approach to examine the safety sign features embedded within interactive digital media applications, with particular attention to both design principles and safety principles. According to Krippendorff (2013), content analysis is a systematic method for generating valid inferences from texts within their contextual settings, requiring clearly defined research questions and thorough contextual interpretation. Criterion sampling involves selecting participants who meet specific, predefined criteria directly related to the research objectives (Edmonds & Kennedy, 2017). A total of six interactive digital media applications, including mobile applications available on the App Store and web-based platforms related to the researcher's

requirements on road safety signage, were purposively selected for analysis. The selected applications met the criterion of incorporating safety-related sign features for children supported by interactive elements.

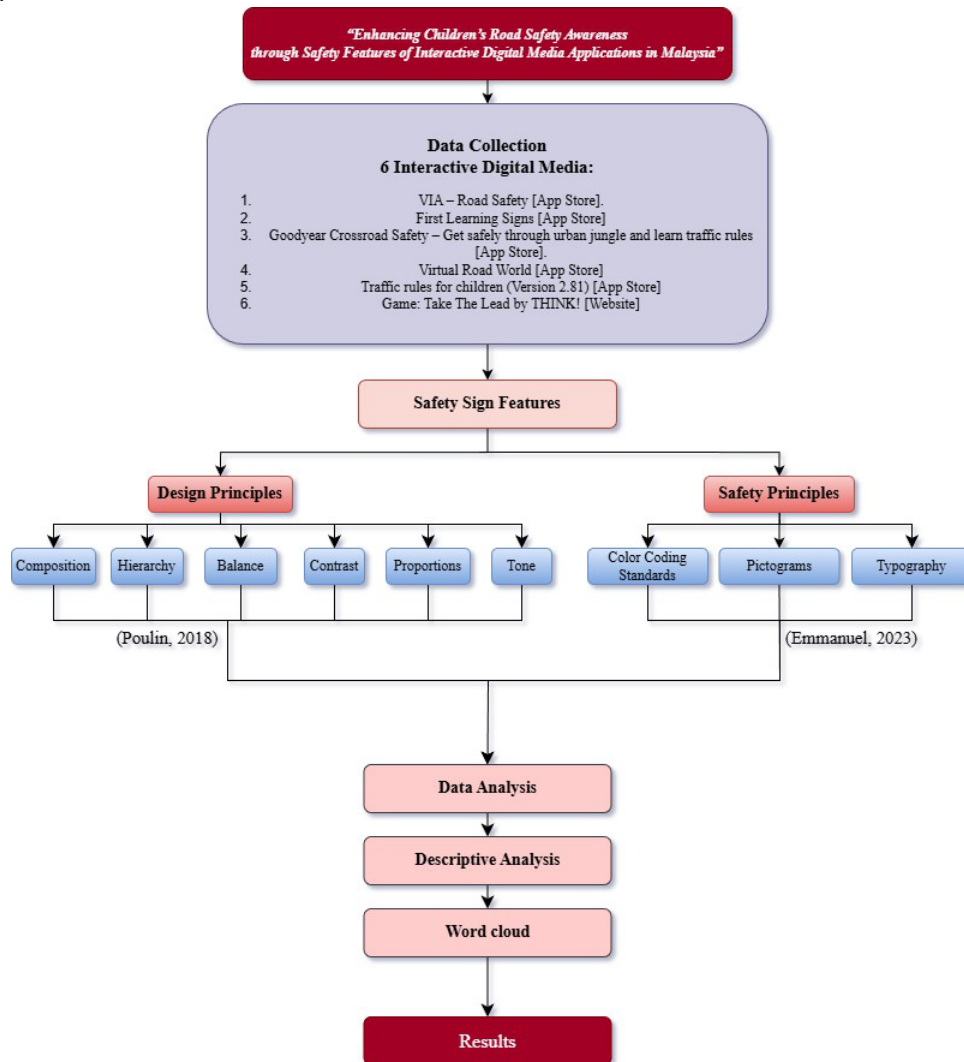


Figure 2 Framework of the study incorporating six interactive digital media applications related to road safety signage.

3.1 Sample of Interactive Digital Media Application (IDMA)

The selected Interactive Digital Media Applications (IDMA) were purposively sampled based on their global availability and the presence of child-friendly road-safety features. These applications exemplify how interactive digital media employ multimodal elements (e.g., gamified tasks, animation, and touch-based interactions) to capture and sustain user engagement. Selection criteria emphasised contemporary, evidence-based road-safety features presently implemented in such applications, ensuring the sample reflected current design practices relevant to child audiences.

Table 1 Selection Sample of Interactive Digital Media Application with The Presence of Child-Friendly Road Safety Features.

No	Code	Digital Media Application	Developer/ Country	Age Rating	Category & Year	Platform
1	IDMA 1	VIA- Road Safety	Egon.cx/ Germany	4+, Made for Ages 9-11	Education Game (2023)	Mobile Game
						
2	IDMA 2	First Learning Signs	Ed Choi/ Unavailable information	4+	Education (2025)	Mobile Apps
						
3	IDMA 3	Goodyear Crossroad Safety - get safely through urban jungle and learn traffic rules	GetWorksMedia/ United Kingdom	4+, Made for Ages 9-11	Games (2016)	Mobile Game
						
4	IDMA 4	Virtual Road World	Cardiff University/ United Kingdom	4+, Made for Ages 6-8	Education (2019)	Mobile Game (VR)
						
5	IDMA 5	Learn the traffic rules	Samuel Souza/ Brazil	4+	Education (2025)	Mobile Game
						
6	IDMA 6	Game: Take The Lead	THINK! / United Kingdom	7 to 12	Game (2025)	Website
						

Table 2 Analysis of Design Principles of Interactive Digital Media Applications

Code	Design Principles					
	Composition	Hierarchy	Balance	Contrast	Proportion	Tone
IDMA 1	Content is organized using a clear grid and alignment. User attention is guided to key content. Elements follow a common alignment system. Content is easy to scan and read. Too many areas demand attention. Elements are easily distinguishable. Interactive elements stand out clearly.	Clear primary information. Primary elements dominate visually. Uniform sizing. Effective contrast for emphasis. Clear reading order. Multiple competing focal points.	Visually uneven layout. Asymmetrical but stable balance. Even distribution of visual weight. Overly dominant colours or contrasts. Foreground and background in balance. Overcrowded or overly sparse layout.	Indistinct contrast. Contrast highlights key information. Readable text against background. Distinct visual differences. Guides user attention. Consistent use of contrast across screens.	Elements sized according to importance. Harmonious size relationships. Large primary elements, smaller secondary elements. Proportion supports usability and readability. One element type dominates excessively. Consistent proportion across screens.	Consistent visual tone. Tone matches application purpose. Appropriate emotional tone. Harmonious use of colour and style. Tone supports user experience. Unified tone across screens.
IDMA 2	Content is organized using a clear grid and alignment. User attention is guided to key content. Elements follow a common alignment system. Content is easy to scan and read. Too many areas demand attention. Elements blend together. Important elements blend into the background.	Clear primary information. Primary elements dominate visually. Uniform sizing. Weak or no contrast. Clear reading order. Multiple competing focal points.	Symmetrical and stable balance. Even distribution of visual weight. Overly dominant colours or contrasts. Foreground and background in balance. Balanced content density,	Low or indistinct contrast. Fails to emphasize important elements. Readable text against background. Elements appear too similar. Guides user attention. Random contrast.	Elements sized according to importance. Conflicting size relationships. Primary and secondary elements same size. Proportion hinders usability and readability. One element type dominates excessively. Consistent proportion across screens.	Inconsistent visual tone. Tone conflicts with application purpose. Confusing emotional tone. Clashing colours and styles. Tone distracts from user experience. Fragmented tone across screens.

Code	Design Principles					
	Composition	Hierarchy	Balance	Contrast	Proportion	Tone
IDMA 3	Content is organized using a clear grid and alignment. Important content is obscured or delayed. Elements follow a common alignment system. Interface feels cluttered. Too many areas demand attention. Elements are easily distinguishable. Important elements blend into the background.	Clear primary information. Primary elements dominate visually. Uniform sizing. Effective contrast for emphasis. Unclear reading order. Multiple competing focal points.	Symmetrical and stable balance. Even distribution of visual weight. Balanced use of colour and contrast. Foreground and background in balance. Balanced content density.	High contrast between elements. Contrast highlights key information. Readable text against background. Distinct visual differences. Contrast guides user attention. Consistent use of contrast across screens.	Elements sized according to importance. Harmonious size relationships. Large primary elements, smaller secondary elements. Proportion supports usability and readability. Balanced ratio between text, imagery, and UI elements. Consistent proportion across screens.	Consistent visual tone. Tone matches application purpose. Appropriate emotional tone. Harmonious use of colour and style. Tone supports user experience. Unified tone across screens.
IDMA 4	Content appears scattered with no clear order. Important content is obscured or delayed. Elements follow a common alignment system. Content is easy to scan and read. Too many areas demand attention. Elements are easily distinguishable. Important elements blend into the background.	No clear primary information. Secondary elements dominate visually. Uniform sizing. Weak or no contrast. Unclear reading order. Multiple competing focal points.	Symmetrical and stable balance. Even distribution of visual weight. Balanced use of colour and contrast. Foreground lost in background. Balanced content density.	Low or indistinct contrast. Contrast fails to emphasize important elements. Readable text against background. Elements appear too similar. Contrast distracts or confuses. Inconsistent contrast.	Elements sized without priority. Conflicting size relationships. Primary and secondary elements same size. Proportion hinders usability and readability. One element type dominates excessively. Consistent proportion across screens.	Consistent visual tone. Tone matches application purpose. Appropriate emotional tone. Harmonious use of colour and style. Tone supports user experience. Unified tone across screens.

Code	Design Principles					
	Composition	Hierarchy	Balance	Contrast	Proportion	Tone
IDMA5	Content is organized using a clear grid and alignment. User attention is guided to key content. Elements follow a common alignment system. Content is easy to scan and read. One dominant area attracts attention. Elements are easily distinguishable. Interactive elements stand out clearly.	Clear primary information. Primary elements dominate visually. Strong size differentiation. Effective contrast for emphasis. Clear reading order. Single clear focal point.	Symmetrical balance. Asymmetrical but stable balance. Even distribution of visual weight. Balanced use of colour and contrast. Foreground and background in balance. Balanced content density.	High contrast between elements. Contrast highlights key information. Readable text against background. Distinct visual differences. Contrast guides user attention. Consistent use of contrast across screens	Elements sized according to importance. Harmonious size relationships. Large primary elements, smaller secondary elements. Proportion supports usability and readability. Balanced ratio between text, imagery, and UI elements. Consistent proportion across screens.	Consistent visual tone. Tone matches application purpose. Appropriate emotional tone. Harmonious use of colour and style. Tone supports user experience. Unified tone across screens.
IDMA6	Content is organized using a clear grid and alignment. Important content is obscured or delayed. Elements follow a common alignment system. Interface feels cluttered. Too many areas demand attention. Elements are easily distinguishable. Important elements blend into the background.	Clear primary information. Secondary elements dominate visually. Strong size differentiation. Weak or no contrast. Clear reading order. Multiple competing focal points.	Symmetrical balance. Asymmetrical but stable balance. Heavy visual weight on one side. Overly dominant colours or contrasts. Foreground overpowers or is lost in background. Overcrowded or overly sparse layout.	Low or indistinct contrast. Contrast fails to emphasize important elements. Readable text against background. Elements appear too similar. Contrast distracts or confuses. Random contrast.	Elements sized according to importance. Awkward size relationships. Primary and secondary elements same size. Proportion supports readability not usability. One element type dominates excessively. Consistent proportion across screens	Consistent visual tone. Tone matches application purpose. Appropriate emotional tone. Harmonious use of colour and style. Tone supports user experience. Unified tone across screens.

Table 3 Analysis of Safety Sign Principles of Interactive Digital Media Applications

Safety Sign Principles			
Code	Colour-code	Pictograms	Typography
IDMA 1	Not Applicable	Not Applicable	Not Applicable
IDMA 2	Colour coding in signage adhered to ISO standards.	Shapes and colours were standardized using GHS (Globally Harmonized System) pictograms.	Clarity and simplicity were achieved using internationally recognized standards, ensuring universal understanding, with signs placed near the hazard or relevant area.
IDMA 3	Colour coding in signage adhered to ISO standards.	Shapes and colours were standardized using GHS (Globally Harmonized System) pictograms.	Typography in signage was minimal, using recognizable standard typefaces positioned in relevant areas.
IDMA 4	Not Applicable	Not Applicable	Not Applicable
IDMA 5	Colour coding in signage adhered to ISO standards.	Shapes and colours were standardized using GHS (Globally Harmonized System) pictograms.	Clarity and simplicity were ensured through internationally recognized standards, with signs placed near the hazard or relevant area for universal understanding.
IDMA 6	Not Applicable	Not Applicable	Not Applicable

4 RESULTS

Table 4 Result Analysis of Design Principles and Safety Sign Features of Interactive Digital Media Applications

Design Principles (Composition)	Design Principles (Hierarchy)	Design Principles (Balance)
 A word cloud for Composition design principles. The most prominent words are 'ELEMENTS', 'CONTENT', 'ALIGNMENT', 'ATTENTION', 'SYSTEM', 'DEMAND', 'GRID', 'FOLLOW', 'BACKGROUND', 'AREAS', 'SCAN', 'READ', 'COMMON', 'IMPORTANT', 'ORGANIZED', 'CLEAR', 'MANY', 'DISTINGUISHABLE', 'EASILY', 'KEY', 'DELIVERED', 'BLEND', 'CONTRAST', 'POINTS', 'READING', 'EFFECTIVE', 'EMPHASIS', 'MULTIPLE', 'VISUALLY', 'INFORMATION', 'DOMINATE', 'COMPETING', 'SIZES', 'ORDER', 'VISUAL', 'FOCAL', 'HIERARCHY', 'INTERRELATIONSHIP', 'CONTRAST', 'EFFECTIVE', 'EMPHASIS', 'MULTIPLE', 'VISUALLY', 'INFORMATION', 'DOMINATE', 'COMPETING', 'SIZES', 'ORDER', 'VISUAL', 'FOCAL', 'HIERARCHY', 'INTERRELATIONSHIP'.	 A word cloud for Hierarchy design principles. The most prominent words are 'PRIMARY', 'ELEMENTS', 'CLEAR', 'VISUALLY', 'INFORMATION', 'DOMINATE', 'COMPETING', 'SIZES', 'ORDER', 'VISUAL', 'FOCAL', 'HIERARCHY', 'INTERRELATIONSHIP', 'CONTRAST', 'EFFECTIVE', 'EMPHASIS', 'MULTIPLE', 'VISUALLY', 'INFORMATION', 'DOMINATE', 'COMPETING', 'SIZES', 'ORDER', 'VISUAL', 'FOCAL', 'HIERARCHY', 'INTERRELATIONSHIP'.	 A word cloud for Balance design principles. The most prominent words are 'BALANCE', 'WEIGHT', 'STABLE', 'VISUAL', 'EVEN', 'COLOURS', 'SYMMETRICAL', 'CONTRASTS', 'USE', 'OVERLY', 'SPREAD', 'FOREGROUND', 'DISTRIBUTION', 'BALANCED', 'ASYMMETRICAL', 'DENSITY', 'CONTRAST', 'DOMINANT', 'CONTENT', 'BACKGROUND'.
Design Principles (Contrast)	Design Principles (Proportion)	Design Principles (Tone)
 A word cloud for Contrast design principles. The most prominent words are 'CONTRAST', 'ELEMENTS', 'READABLE', 'TEXT', 'BACKGROUND', 'DIFFERENCES', 'INTERACT', 'INFORMATION', 'INDISTINCT', 'GUIDES', 'SIMILAR', 'CONSISTENT', 'ATTENTION', 'LOW', 'EMPHASIS', 'USER', 'KEY', 'APPEAR', 'TAILED', 'IMPORTANT', 'CONTRAST', 'EFFECTIVE', 'EMPHASIS', 'MULTIPLE', 'VISUALLY', 'INFORMATION', 'DOMINATE', 'COMPETING', 'SIZES', 'ORDER', 'VISUAL', 'FOCAL', 'HIERARCHY', 'INTERRELATIONSHIP'.	 A word cloud for Proportion design principles. The most prominent words are 'ELEMENTS', 'PROPORTION', 'SIZE', 'TYPE', 'PRIMARY', 'SECONDARY', 'READABILITY', 'ACROSS', 'IMPORTANCE', 'COMPARISON', 'RELATIONSHIPS', 'CONSISTENT', 'SCREENS', 'ACCORDING', 'LARGE', 'SMALL', 'SUPPORTS', 'IMPORTANCE', 'COMPARISON', 'RELATIONSHIPS', 'CONSISTENT', 'SCREENS', 'ACCORDING', 'LARGE', 'SMALL', 'SUPPORTS'.	 A word cloud for Tone design principles. The most prominent words are 'TONE', 'UNIFIED', 'SCREENS', 'EMOTIONAL', 'CONSISTENT', 'APPLICATION', 'VISUAL', 'MATCHES', 'COLOUR', 'ACROSS', 'PURPOSE', 'APPROPRIATE', 'HARMONIOUS', 'STYLE', 'SUPPORTS', 'EXPERIENCE', 'USE', 'USER', 'MATCHES', 'COLOUR', 'ACROSS', 'PURPOSE', 'APPROPRIATE', 'HARMONIOUS', 'STYLE'.
Safety Sign Principles (Colour-code)	Safety Sign Principles (Pictograms)	Safety Sign Principles (Typography)
 A word cloud for Safety Sign Principles (Colour-code). The most prominent words are 'APPLICABLE', 'ISO', 'COLOUR', 'STANDARDS', 'CODING', 'ADHERED', 'SIGNAGE'.	 A word cloud for Safety Sign Principles (Pictograms). The most prominent words are 'STANDARDIZED', 'GLOBALLY', 'APPLICABLE', 'GHs', 'COLOURS', 'USING', 'SHAPES', 'SYSTEM', 'HARMONIZED', 'PICTOGRAMS'.	 A word cloud for Safety Sign Principles (Typography). The most prominent words are 'SIMPLICITY', 'RECOGNIZED', 'APPLICABLE', 'RELEVANT', 'PLACED', 'NEAR', 'UNIVERSAL', 'CLARITY', 'UNDERSTANDING', 'HAZARD', 'INTERNATIONALLY', 'STANDARDS', 'AREA'.

Table 5 Findings of Design Principles of Interactive Digital Media Applications

Design Principles					
Composition	Hierarchy	Balance	Contrast	Proportion	Tone
Elements	Clear	Balance	Contrast	Elements	Tone
Content	Primary	Stable	Elements	Proportion	Visual
Alignment	Elements	Visual	Background	Size	Purpose
Attention	Visually	Weight	Text	Primary	Application
Important	Dominate	Foreground	Readable	Readability	Experience

Table 6 Findings of Safety Sign Features of Interactive Digital Media Applications

Safety Sign Principles			
Colour-code	Pictograms	Typography	
Applicable	Shapes	Relevant	
Colour	Colours	Simplicity	
ISO	Standardized	Clarity	

5 FINDINGS & DISCUSSIONS

The analysis of the six applications indicates that the two principle sets are applied with markedly different degrees of consistency across the sample.

5.1 Design principles

Composition and hierarchy are the most consistently applied attributes. All six applications organise content on a defined grid with a common alignment system, and most establish a clear primary element that dominates visually, giving a legible reading order. Divergence emerges in the remaining four attributes. Contrast varies from high separation between foreground safety content and background environment to configurations in which important elements blend into the scene, at which point the layout no longer directs attention to the safety message. Proportion shows a similar split: several applications size elements according to informational importance, while others assign primary and secondary content equivalent visual weight, removing the size cue that signals what matters. Tone is the least consistent attribute. Where the visual tone matches the instructional purpose, the application reads coherently across screens; where decorative or entertainment-driven styling dominates, the tone competes with the safety content rather than supporting it. These patterns correspond to what the multimedia learning literature identifies as extraneous processing visual competition that draws limited attentional capacity away from the instructional message (Mayer, 2009, Moreno & Mayer, 2007).

5.2 Safety sign principles

Applications applying ISO-consistent colour coding and standardised pictogram shapes present safety information in a form that is visually distinguishable from surrounding game content and corresponds to the signage children encounter in real road environments. Typography follows the same pattern: simple, high-legibility typefaces at adequate scale keep instructional text readable, whereas stylised display type embedded in illustrated scenes reduces legibility at the sizes used. Since children rely more heavily on visual cues than on text at this developmental stage, the standardisation of colour and symbol carries proportionally greater communicative load than the written instruction accompanying it.

5.3 Interpretation

Taken together, the analysis indicates that clarity in these applications is a function of both principle sets operating jointly. The applications in the sample that combine consistent composition and hierarchy with standardised colour coding and pictograms present road safety information in the most legible and

recognisable form. Where one set is applied without the other coherent layout with non-standard signage, or correct signage within a visually competitive layout the presentation of safety information is weakened even though the application may appear well-designed. This finding is consistent with content analyses of other Malaysian children's digital learning media, in which the configuration of visual and multimedia elements, rather than the presence of the technology itself, distinguished the more effective examples (Ahmad, Mohd Lazim & Che Din, 2025; Mahmud & Che Din, 2025).

Limitation

This study analyses design facts, not users. The visual content analysis establishes how design principles and safety sign principles are applied within the six selected applications and which configurations present safety information most clearly at the interface level. It does not measure children's comprehension, emotional engagement, retention or road behaviour, and no claim to that effect is made here. Establishing whether the design configurations identified in this analysis produce measurable learning or behavioural outcomes requires user testing with children in the target age group, which the authors identify as the necessary next stage of this research.

CONCLUSION

This study analysed the application of design principles and safety sign principles in six interactive digital media applications containing child-directed road safety content. The analysis indicates that composition and hierarchy are applied consistently across the sample, while contrast, proportion and visual tone vary considerably, and that applications combining coherent visual organisation with standardised colour coding, pictograms and legible typography present safety information in the most distinguishable and recognisable form. The two principle sets function jointly rather than independently: coherent layout without standardised signage limits transferability to real road environments, while standardised signage embedded in visually competitive layouts risks not being attended to at all.

These findings are design-level observations derived from samples analysis and should be read together. They provide a coding framework and a set of design considerations for practitioners developing road safety media for Malaysian children, and they establish the basis for the next stage of this research, user testing with children aged below twelve to determine whether the design configurations identified here produce measurable gains in comprehension and safety behaviour.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to the development and completion of this paper.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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