AN EXTENDED IXD-BASED MODEL FOR DIGITAL GRAPHIC NOVELS: INCORPORATING AESTHETIC VALUES AND MEASURES

HAFIZAH BINTI ABDULLAH @ ALI

MASTER OF SCIENCE (INFORMATION TECHNOLOGY)
UNIVERSITI UTARA MALAYSIA
2025

AN EXTENDED IXD-BASED MODEL FOR DIGITAL GRAPHIC NOVELS: INCORPORATING AESTHETIC VALUES AND MEASURES

BY
HAFIZAH BINTI ABDULLAH @ ALI

Thesis Submitted to
Awang Had Salleh Graduate School of Arts & Sciences
Universiti Utara Malaysia,
in Fulfilment of the Requirement for the Degree of Master of Science
(Information Technology)

**Awang Had Salleh
Graduate School
of Arts And Sciences**

Universiti Utara Malaysia

PERAKUAN KERJA TESIS / DISERTASI
(Certification of thesis / dissertation)

Kami, yang bertandatangan, memperakukan bahawa
(We, the undersigned, certify that)

HAFIZAH ABDULLAH @ ALI

calon untuk Ijazah
(candidate for the degree of)   **MASTER OF SCIENCE**

telah mengemukakan tesis / disertasi yang bertajuk:
(has presented his/her thesis / dissertation of the following title):

"AN EXTENDED DXD-BASED DIGITAL GRAPHIC NOVEL MODEL: CAPTURING AESTHETIC VALUES AND MEASURES INTO THE DESIGN"

seperti yang tercatat di muka surat tajuk dan kulit tesis / disertasi.
(as it appears on the title page and front cover of the thesis / dissertation)

Bahawa tesis/disertasi tersebut boleh diterima dari segi bentuk serta kandungan dan meliputi bidang ilmu dengan memuaskan, sebagaimana yang ditunjukkan oleh calon dalam ujian lisan yang diadakan pada: **04 Februari 2025**.
That the said thesis/dissertation is acceptable in form and content and displays a satisfactory knowledge of the field of study as demonstrated by the candidate through an oral examination held on:
04 February 2025.

Pengerusi Viva: (Chairman for VIVA)	Assoc. Prof. Dr. Mohd Khairudin Kasiran	Tandatangan (Signature)
Pemeriksa Luar: (External Examiner)	Assoc. Prof. Ts. Dr. Shamsul Arrieya Ariffin	Tandatangan (Signature)
Pemeriksa Dalam: (Internal Examiner)	Assoc. Prof. Noraziah Che Pa	Tandatangan (Signature)
Nama Penyelia/Penyelia-penyelia: (Name of Supervisor/Supervisors)	Assoc. Prof. Dr. Husniza Husni	Tandatangan (Signature)

Tarikh:
(Date)   **04 February 2025**

Permission to Use

In presenting this thesis in fulfilment of the requirements for a Post Graduate degree from the Universiti Utara Malaysia (UUM), I agree that the University Library may make it freely available for inspection. I further agree that permission for copying this thesis in any manner, in whole or in part, for scholarly purposes may be granted by my supervisor(s) or, in their absence, by the Dean of Awang Had Salleh Graduate School of Arts & Sciences. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the Universiti Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Request for permission to copy or to make other use of materials in this thesis, in whole or in part, should be addressed to:

<div align="center">

Dean of Awang Had Salleh Graduate School of Arts & Sciences

UUM College of Arts and Sciences

Universiti Utara Malaysia

06010 UUM Sintok

</div>
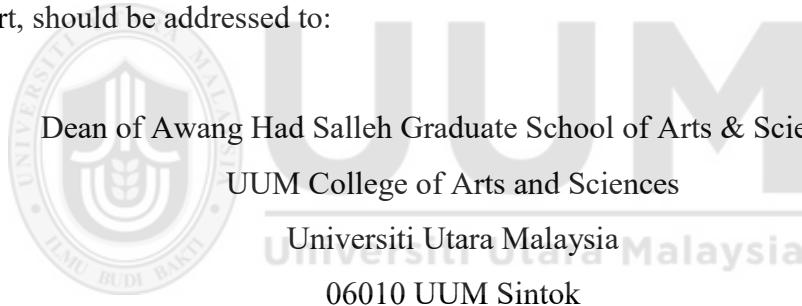
ABSTRAK

Novel Grafik Digital (DGN) telah mendapat reputasi dalam beberapa tahun kebelakangan ini berdasarkan manfaatnya. Kajian ini meneroka aspek teori DGN yang menjadikannya sumber yang bernilai dalam penyelidikan dan perkongsian maklumat. Pada masa ini, DGN dibangunkan tanpa menyedari kesannya terhadap nilai estetika. Kajian ini dimotivasikan oleh kekurangan kandungan tempatan yang menumpukan kepada teori reka bentuk interaksi (IxD) yang betul. Objektif utama adalah untuk membangunkan DGN berasaskan IXD yang diperluas dengan menekankan nilai estetikanya. Kajian ini merangkumi empat fasa bermula dengan kajian literatur, pengembangan dan pengesahan model DGN berasaskan IxD melalui penilaian pakar, reka bentuk dan pembangunan arketip DGN yang merangkumi bekas DGN dan arketip itu sendiri, dan akhirnya penilaian terhadap nilai estetika DGN berasaskan IxD menggunakan Ukuran Estetika Birkhoff (BAM). Proses penilaian ini adalah berdasarkan nilai dan komponen yang telah diperoleh daripada proses pengumpulan data menggunakan kaedah penyelidikan kualitatif. Secara umumnya, dapatan kajian ini merumuskan literatur semasa dan mengenal pasti nilai serta komponen estetika yang disintesis dalam model lanjutan berasaskan Reka Bentuk Interaksi (IxD) untuk DGN yang boleh mempengaruhi reka bentuk produk DGN yang menarik.Sebagai kesimpulan, kajian ini membentangkan satu model lanjutan bagi DGN berasaskan Reka Bentuk Interaksi (IxD) yang menggabungkan ukuran estetika menggunakan BAM. Model lanjutan ini berfungsi sebagai panduan untuk penyelidik dan pengamal, dan disertakan dengan rangka penyelidikan yang menawarkan beberapa peluang untuk meneroka dengan lebih mendalam nilai estetika dalam reka bentuk novel grafik digital.

Kata Kunci: Reka Bentuk Interaksi, Novel Grafik Digital, Nilai Estetika, Ukuran Estetika Birkhoff

ABSTRACT

Digital Graphics Novel (DGN) has gained its reputation in recent years based on its benefits. This study explores the theoretical parts of DGNs, which make them a valuable resource in research and information sharing. Currently, DGN is developed without realising its impact on aesthetic values. This study is motivated by the limited local content that focuses on proper interaction design (IxD) theory. The main objective is to develop an extended IXD-based DGN by capturing its aesthetic values. This research covers four phases, starting from the literature study, model extension, and validation of IxD-based DGN model using expert evaluation, design and development of the DGN archetype, comprising a DGN container and archetype, and lastly, evaluation on the aesthetic values of IxD-based DGN using Birkhoff's Aesthetic Measure (BAM). The evaluation process is based on the values and components derived from the data collection process using the qualitative research method. In general, findings from this study summarise the current literature and identify the aesthetic values and components that are synthesised in an extended model for IxD-based DGN that could impact the design of appealing DGN products. In conclusion, this study presents an extended model for IxD-based DGN, incorporating aesthetic measures using the BAM. The extended model serves as a guideline for researchers in interaction design and practitioners and is complemented by a research outline with several opportunities to further explore aesthetic values in DGN design.

Keywords: Interaction design, Digital graphic novel, Aesthetic value, Birkhoff aesthetic measure.
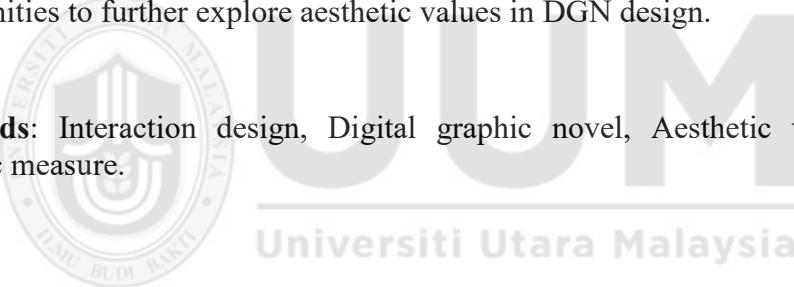
ACKNOWLEDGEMENT

I would like to express my heartfelt appreciation to all my lecturers and my supervisor for their constant encouragement, valuable advice, and continuous reassurance throughout my research journey. My deepest gratitude goes to **Associate Professor Dr. Husniza Husni,** you have been truly wonderful for taking on my research and guiding me with patience and understanding. I could never have completed this work without your support.

My special thanks and love go to my beautiful daughters, **Anis Zahirah and Anis Khadeeja**, and my family for their endless tolerance, love, and strength. You have been my greatest pillars throughout this journey, and I could not have done this without you. I am also deeply grateful to my dear friends for their unwavering support, companionship, and for always being there to listen and lift my spirits when I needed it most. Finally, my sincere thanks to all the wonderful people around me who have been part of this journey. Without each of you, I would not be where I am today.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

DGN	Digital Graphic Novel
IxD	Interaction Design
VN	Visual Narratives
BAM	Birkhoff Aesthetic Measure
GN	Graphic Novel
RWD	Responsive Web Design
VNG	Visual Narrative Grammar
SLR	Systematic Literature Review
HCI	Human Computer Interaction
UX	User Experience
CC	Creative Cloud
HTML	Hypertext Markup Language
PHP	Hypertext Preprocessor
UI	User Interface
SUS	System Usability Scale

CHAPTER ONE
INTRODUCTION

1.1 Background

One of the most exciting teaching and learning methods is the use of visual narratives. The visual narrative has been growing fast as one of the most popular learning styles. It is also appealing and motivates learners to enhance their knowledge (Truong, 2012; Roberts et al., 2020). In addition, some visual narratives tell the story containing moral values in life to the learners. However, visual narratives, as implemented in digital graphic novels (DGN), are widely used without realizing their impact on aesthetic value and users. Aesthetic values in design can compel how people think and feel (Gaziulusoy, 2021). Research by Candi et al. (2017) supports that aesthetic value affects the functional design and aesthetic design based on behavioural responses, emotional arousal, and level of product involvement. Aesthetic values in DGN can lead to positive engagement and productivity (Pandey, 2022). DGN development based on the appropriate aesthetic value can produce good and valuable narrative content and influence the design of the DGN viewer.

The DGN provides an attractive medium concept of characteristics that may aid user learning more effectively than traditional textbooks. DGN can stimulate learner interests and be used in multiliteracies and support to employ multimodality in teaching and learning, especially in Malaysian schools (Rajendra, 2018). However, local content is very limited, especially in the form of DGN with a proper interaction design (IxD) theory.

IxD is the discipline of using products and services to support human interactions. According to its definition, IxD is the art of creating interactive digital products, environments, systems, and services (Cooper et al., 2014). This research aims to capture and evaluate the aesthetic values of IxD-based DGN design and extend the current model. Using IxD theory and aesthetic values for DGN design, the result is be used to design DGN Container and Player. The content and themes are derived from comparing several DGNs at the data collection phase in this research.

1.2 Problem Statement

DGN is still considered reading material in Malaysia, and it will never triumph over the people of Europe and Japan (Jamaludin, 2015; Mamat et al., 2019). It is supported by Peng (2020), who asserts that digital content in Malaysia is still limited, uninteresting, and only available as part of an entertainment website. Nonetheless, Farah Nadia et al. (2016) state that multidisciplinary comic studies in various media, including digital form, cannot be ignored. According to Matuk et al. (2021), more research is needed to investigate how educators can effectively use graphic novels (GN) in teaching and learning. It shows that GN can be used as an educational tool in Malaysia, but more research is needed.

DGN is developed without realizing its impact on aesthetic values and user appeal. Ngo et al. (2000) stated that look (beauty) had not been appropriately documented and neglected the aesthetic issues in design. The aesthetic values of DGN are significant because the users demand functional and emotional satisfaction. Aesthetic is related to product/design functionality and usability (Khalighy, 2015; Ablart, 2017; Yanagisawa et al., 2017; Meltzer & Williams, 2018;). In the best of cases, the products

2

should also be delightful and enjoyable, which means that not only must the requirements of engineering, manufacturing, and ergonomics be satisfied, but attention must be paid to the entire experience, which means the aesthetics of form and the quality of interaction (Norman, 2013). Ayer (2014) suggested that studies related to the effects of rich media in DGN should be implemented and focus on the impact on online users as well as the appealing-ness of interactive element content. Aesthetic values reflect an interactive storytelling system that has a profound aesthetic impact on the user inside and outside of the story (Roth et al., 2009). Pantaleo (2014) investigated that visual aspects were closely related to aesthetic values in the graphic novels of learner learning in the classroom. In an early study, Pantaleo (2013) examined how graphic elements in graphic novels influenced learners' composition of multimodal texts. Pantaleo reports how understanding the visual conventions helped learners to use graphic elements to convey a particular message intentionally.

The development of DGN is closely related to the growth of DGN content design. The IxD-based model for DGN is reported as a model that shows the relationship between local content with local narratives and visual narratives and aesthetic measures that made up the visual narrative grammar using guided by IxD theory (Husni et al., 2021). In this model, only one dimension, namely IxD content, is covered. The model only emphasizes visual narrative (VN) relevance within the DGN only. Nevertheless, the latest IxD dimension has been introduced in Yu Siang (2020) of the Interaction Design Foundation, covering five main dimensions, as shown in Figure 1.1. Therefore, the existing model needs to be extended to discuss the relevance of IxD-based DGN in design development and focus on the aesthetic value in designing DGN archetype tailored to the 5 IxD dimensions.
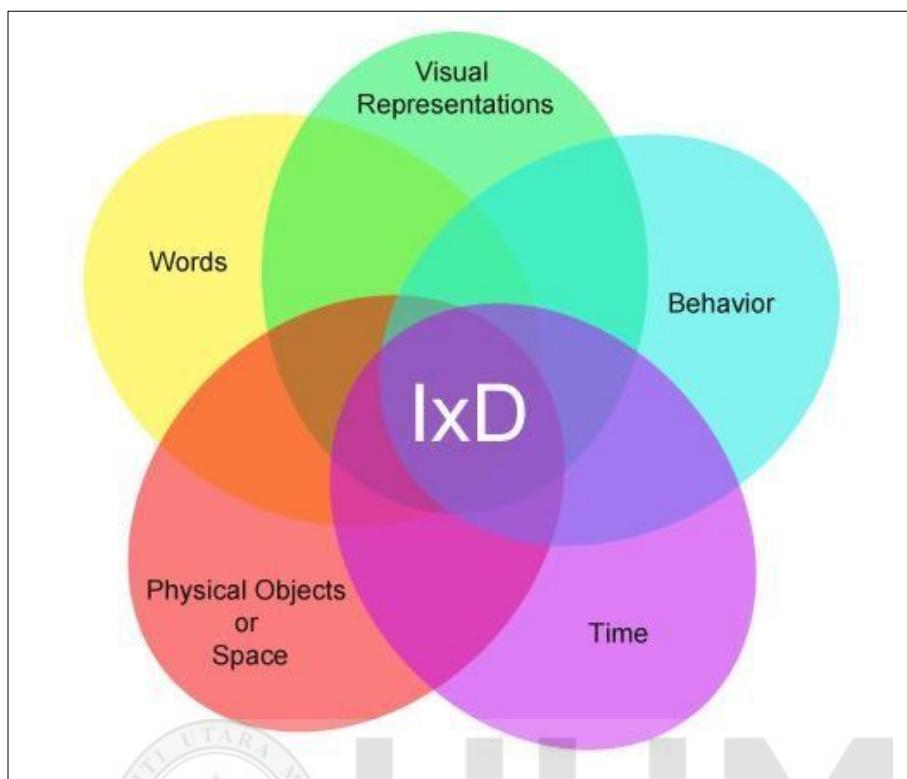
Figure 1.1. Five Dimension of IxD (Source: The Five Languages or Dimensions of Interaction Design. (n.d.).

Local content is less approachable and still far from appealing to children. Mahamod and Noor (2011) and Aziz et al. (2021) state that using DGN in teaching methods is still limited because teachers are content with using the conventional way. Critics include language, values, performances, culture, and images making an impact where local content of graphic novels is viewed as joke and escapism. One of the reasons why such sentiments exist is because the reader fails to understand the positive message behind the funny, tragic, and adventurous stories (Azman et al., 2015). According to Short and Reeves (2009), DGN can serve as one of the exciting ways that can facilitate the learning stimulation for a new generation that is growing around television and the Internet. It is a usable and effective medium for transferring

4

knowledge (Hermann et al., 2012; Rigaud et al., 2015). Leong (2013) in his book stated that more than 80% of readers want DGN to entertain as opposed to as a medium of knowledge, so an attractive aesthetic design is crucial to evaluate DGN design. Research related to aesthetic value should be carried out to measure aesthetic values. Birkhoff's Aesthetic Measure (BAM) theory is be adopted to assess the aesthetic values. BAM can use to measure various designs and is not specific to DGN (Ali & Husni, 2021).

Since DGN lacks a systematic approach to integrating aesthetic measures, the evaluation of its design appeal and effectiveness is not certain. There is also limited research that examines how the IxD dimensions could further enhance the aesthetic and interactive qualities of DGNs. Therefore, this study intends to explore the BAM on DGN guided by the IxD dimensions.

1.3 Research Questions

1. What are aesthetic values and aesthetic measures that affected the DGN design?
2. How aesthetic values can be integrated in the existing IxD-based model?
3. How can the identified aesthetic measures help to measure the aesthetic values of IxD-based DGN design?

1.4 Research Objective

The main objective is to design and develop the extended version of existing model of Digital Graphic Novel (DGN). The sub-objectives are as follows:

1. To identify aesthetic values and aesthetic measures of DGNs.

5

2. To design and develop an extended model of IxD-based DGN based on the aesthetic values.

3. To evaluate the extended model of IxD-based DGN using Birkhoff's Aesthetic Measure.

1.5 Research Scope

This study investigated the aesthetic value of DGN design and measured the aesthetic values on IxD-based DGN focusing on local digital content. The DGN design focuses on three user scopes which is the school children ages between 8-12 years old, parent as the DGN viewers and the teacher who will manage the DGN container. The DGN design targets on developing positive attitudes/identity among school children. Based on Mustafa and Sannusi (2017), early school children (8-10 years old) have a curious nature and are suitable to use pictorial reading material such as graphic novels with a strong storyline and has constructive character. Understanding these target groups facilitates designing a storyline in graphic novels that are appropriate for them.

Moreover, the content focuses on values that are considered positive by Muslim scholars (Mohd Zulkifli, 2010; Mohamad Khairi, 2016) and can be divided into four categories, namely hikmah (knowledgeable, wise), 'adaalah (being fair or 'adl), iffah (able to control oneself from doing an illegal act) and syajaah (ever willing to stand for good cause). These four categories are used as the sample of Visual Narrative (VN) in the IxD-based DGN archetype due to its suitability to be implemented with children between 8-10 years old. This statement is supported by Zaini and Dewi (2017), children at this stage are more eager to learn and better able to understand six key areas

of value development: moral and religious values, language, social and emotional skills, motor and physical abilities, cognitive growth, and artistic expression.

The beauty and attraction of the DGN are connected with aesthetic values. This research focused on aesthetic values closely related to visual design. Visual design is used to frame and highlight the important elements in the DGN interface to capture people's attention. Besides, the DGN archetype has been designed to focus on web-based and using responsive web design (RWD) approach and framework. Responsive design simplified everything, and the DGN archetype is optimized for a mobile environment.

1.6 Research Significance

The significance of the study provides theoretical contributions to knowledge in the field of IxD and DGN. On the theoretical side, it introduces an IxD-based model that helps us better understand and assess the aesthetic values of DGN, shaping how these digital works are designed. This model serves as a foundation for future researchers who want to explore ways to make digital content more engaging and effective. Meanwhile, DGN developers can apply these findings to craft more visually appealing and meaningful digital narratives, making digital storytelling even more impactful. This study focused on aesthetic values that can inform the design of DGN and significantly contribute to the production of digital work, especially the creation of GN. The aesthetic value of DGN based on IxD has influence the design features, and it is crucial because the production of digital design affects the content delivery of digital works that attract attention and have appeal value. This research explores the quantitative approach using BAM to measure aesthetic values. BAM is usually used

to measure the aesthetic values of objects with different modes of perception, such as visual, 3D objects, and auditory artwork. For this study, BAM is used to measure the aesthetic values based on the complexity of the object, in this case, DGN, and the feeling of value or aesthetic measure that rewards this effort.

Besides, this research has produced a practical contribution where the DGN archetype has been designed based on the IxD-based DGN model. The archetype was developed and applied the IxD-based DGN development model and used the elements in the aesthetic value which are the findings of this study. The archetype contributes to various benefits to DGN researchers, teachers, and children. This study also benefits children between 8-10 years old to develop positive attitudes through verbal or visual learning styles based on practical contribution to developing the DGN archetype. The combination of pictures and text for storytelling has made DGN a popular medium for children and adults. DGNs can serve as an exciting medium in teaching and learning. Razak (2013) found five effects of GN on digital learning: learner motivation, creating meaningful learning, improving learner understanding, achievement and creativity.

In addition, this study also impacts the development of teaching methods and tools for teachers, parents, and children. They can apply the context in the DGN player, where it can be used as a learning tool at home or in the classroom for formal or informal teaching and learning activities. The spread of information technology has increased mainly in internet usage, websites, and networks in various fields. This study also provides added value to DGN developers in developing an attractive visual narrative interface according to the outcomes of IxD theory. The developer can apply the context to give a DGN archetype packed with preferred narratives.

1.7 Thesis Organization

This thesis is organized into six chapters, that addressing the specific aspects of the research. Chapter 1 introduces the study's context, problem statement, research questions, research scope and significance, providing a briefly explain on the topics. Chapter 2 investigates the existing literature on DGN, synthesizing the theories and past studies that create the research framework and highlight knowledge gaps of this study. Chapter 3 brief the research methodology in detail, explaining the model extension, expert selection and questionnaire design, design and development of prototype, and evaluation process using BAM to evaluate aesthetic and evaluation of system usability using schematic scale. Chapter 4 presents the study's findings, interpreting data the extended IxD-Based DGN Model and discuss on model verification through expert's evaluation. Chapter 5 offers a discussion of the evaluation result for usability testing of the archetype and result for accessing aesthetic using BAM. Finally, Chapter 6 explain the conclusion, recommendation, and potential for future research.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Almost 65% of people are visual learners (Vakos, 2013), accounting for two-thirds of the global population. Graphic novels are visual narrative media that communicate stories using many static images (panels) arranged sequentially throughout the book (Cohn, 2019; Hefter et al., 2019). The graphic novel is a digital graphic novel (DGN) if it is a digital book/application (physical or digital). Sequential art refers to putting images successively in each panel where the overall plot develops (Pantaleo, 2018; Friesen et al., 2018). A graphic narrative is a story communicated via sequential art (Kuttner et al., 2021; Moore et al., 2018; Rajendra, 2018).

This chapter attempts to review the relevant literature and research related to the IxD-based DGN and the aesthetic values of DGN. The chapter first discusses the definition of a functional Graphic Novel (GN), followed by DGN. The second part discusses the benefits of DGN. The third part discusses the theory of IxD in DGN. The fourth part emphasizes identifying aesthetic values in designing DGN and its component. The fifth part is to explain the appealing measures in IxD-based DGN. Then, the final part focuses on measuring appealingness and the aesthetic values in IxD-based DGN design using BAM.

2.2 Graphic Novel and Digital Graphic Novel

A GN is a story portrayed in the form of a comic strip that belongs to a specific category of graphic narratives (Oliinyk, 2021; Jamaludin, 2015). GN is also defined

as thick comic books juxtaposed pictorial and other images in sequence, intended to deliver information and produce an aesthetic response in the viewer (Biese, 2021; Skwarzyński, 2019). Alan Moore defines GN as an expensive comic book and a graphic story medium to create a continuous present (La Cour, 2022; Dunst & Hartel, 2021). GN is a digital graphic novel (physical or digital) if it is a digital book when the medium is digitized (Jamaludin, 2017). DGN provides the learner the opportunity to learn in a medium with which they are comfortable. DGN combines stories in a linear narrative and picture books through text, illustration, and dialog as a medium. Sequential art is structured as a series of panels that deliver a story. These panels can remain as a single page or multiple pages. Eisner (1996) also created the term visual narratives referring to texts that carry stories through images and words.

Therefore, the term GN will be defined to generalize a definition for the term digital graphic novel. DGN draws a noticeable link between narrative, form, and format (Pagliaro, 2014). According to Jamaludin (2015), learning DGN needs to understand the learning narratives operation, such as the respondents' real-life experiences and the connection between the incidents. Interactive techniques and expanded visual elements can be used to develop DGN, which will contribute to understanding the subjects acquired (Crucifix & Dozo, 2018). According to Cohn (2013, 2014), DGN can establish a link between learner-identified sequential images and how they acquire other modes of communication. DGN often challenges the conventional specificity of comics, blurring boundaries with other media through a hybridization process (Tseng & Bateman, 2018).

11

2.3 Benefits of Digital Graphic Novels

DGN assist readers in a variety of ways. Crucifix and Dozo (2018) stated that screen renewal enables the narrative and aesthetics of DGN by offering new dimensions to the delivery panel. By reading DGN, readers must actively decode text and images to synthesize information. It will guide learners to describe what was happening in pictures and the evidence that led them to those conclusions (Rosenberg, 2018; Barbre, 2019). DGN makes learning facts easier by triggering the verbal and visual focuses of the mind at the same time.

Most researchers agree on the importance of DGN in engaging children in reading (Wong & Neuman, 2019; Putri, 2019). The summarising text and images in DGN help children access complex stories. The combination of attractive design, colour, and image allows learners to engage in sustained reading at all levels. DGN also can build visual literacy. The multimedia interaction between images and text is critical in understanding increasingly complex information.

Based on a systematic literature review (SLR), there are five benefits of DGN as follows:

    i.   *Image can Encourage Reader/Learner to Read*

        Images in DGN can encourage readers to read the whole thing in the story. DGN makes learning facts easier by triggering the verbal and visual focuses of the mind at the same time. Besides, DGN also can improve and promote vocabulary acquisition (Neuman et al., 2019; Wong & Neuman, 2019). The visual support allows learners to rapidly understand new words with their meaning. Putri (2019) states that DGN is not only entertainment

but can be beneficial as a medium of instruction to a learner. DGN also is one of the instructional media for learners, so the learning process can be more effective, efficient, and fun (Putri, 2019; Begoray & Brown, 2018; Golding & Verrier, 2020). It is believed that the benefits of DGN can serve as an exciting medium for teaching and learning. Gardner (2006) acknowledged the advantages of DGN, stating that three out of every seven human bits of intelligence can benefit from the application of GN. Linguist, spatial, and interpersonal intelligence are the three.

ii.   *DGN improve Critical Thinking*

DGN help readers to sharpen critical thinking, discover visual literacy, and encourage vocabulary acquisition (Newman & Ogle, 2019; Marlatt & Dallacqua, 2019). Most researchers agree on the importance of DGN in engaging children in reading (Kucirkova & Flewitt, 2020; Ortega, 2020; Cook & Kirchoff, 2017). The summarising text and images in DGN help children access complex stories. Learners of all levels can engage in continuous reading due to the engaging design, colour, and image (Fenty & Brydon, 2020). DGN allows users to send a message faster. The use of visuals has been claimed to make it more engaging, motivational, and less intimidating. Children and adults can benefit from the pictures and images provided in a well-constructed storyline since they can assist them not only understand the content, but also learn a new language, advancing through the story, and promoting text interpretation (Hughes & Morrison, 2014).

iii.   *DGN as New Dimension of Learning*

Digital screen for narrative in DGN becomes a new dimension of learning. Reading DGN, readers must actively decode text and images together to synthesize information. Besides that, this study also has an impact on the development of teaching methods and tools for teachers, parents, and children. They can apply the content in the DGN player where it can be used as a learning tool at home or in the classroom for formal or informal teaching and learning activities.

iv.   *DGN can Build Visual Literacy*

DGN also can build visual literacy. Visual literacy is the ability to interpret, negotiate, and make sense of the information presented in the form of images. Visual literacy is based on the idea of pictures that can be read and the meaning can be communicated through a reading process. Visual literacy involves making judgments of the accuracy, validity, and trustworthiness of visual images (Grimm & Meeks, 2017; Serafini, 2017; Wallace, 2017). The interaction between images and text in multimedia is an important component in understanding increasingly complex information. The use of colours, light, shadows, and lines also has an effect on the story's tone and mood. Due to the visual character of DGN, it has the ability to provide a context-rich, high-interest environment conducive to the acquisition of new vocabulary, contextual support, and indications of the meaning of the written story, as well as to assist in clarifying the text and increasing understanding (Rosly et al., 2016; Hammond; 2009).

v.   *Give Positive Values in Learning*

Gen-Y and Gen-alpha children are exposed to digital gadgets and they are often unmotivated by simply seeing texts in textbooks (Linnes & Metcalf, 2017). They preferred graphics before texts. Hence, DGN player in local content is seen to be able to have a positive effect on children's learning. Hargadon (2019) states that DGN can motivate readers to desire to read and attract some of those reluctant readers as well.

2.4 Interaction Design Theory in Digital Graphic Novel

Interaction Design (IxD) continues to evolve, especially within the realm of Digital Graphic Novels (DGNs), where the fusion of narrative and interactivity offers unique user experiences. Building upon foundational definitions such as IxD being the practice of designing interactive digital products, environments, systems, and services (Benyon, 2019; Lee et al., 2021) recent research provides deeper insights into how IxD principles are applied in DGNs. Sayılgan (2023) emphasizes that the digital revolution has reconditioned our media landscape, instigating hybridity in traditional forms and reshaping the nature of storytelling through enhanced interactivity. This evolution allows for new narrative structures that engage readers more deeply.

Furthermore, Antonini, Brooker, and Benatti (2020) propose an interaction model of web comics that considers the unique lifecycle of the medium and its relationship with infrastructures of feedback and distribution. This model highlights how the calibration of technology-based interaction in web comics facilitates a structure that is greater than the sum of its parts, enhancing the reader's experience. Incorporating these advanced IxD theories into DGNs ensures that the medium not only tells compelling

15

stories but also offers interactive experiences that are contextually relevant and user-centered.

Interaction design prioritizes the user's experience, ensuring that interfaces are intuitive and engaging. In digital graphic novels, this means designing navigation, visual cues, and interactive elements that enhance the storytelling experience. Based on Norman (2013) IxD-theory, a good design starts with a clear understanding of users, their tasks, and the environments in which they operate the software or applications in this research, DGN itself. Besides, based on theory by Laurel (1991), DGNs can offer non-linear narratives, where users choose different paths or perspectives. This theory fits perfectly with what interaction design is all about which are giving users more control and making their experience feel personal and meaningful. In DGNs, when readers can make choices, click through different story paths, or explore content at their own pace, they're no longer just watching a story unfold. That freedom to interact and shape the experience makes the story feel more alive and it's like the book is responding to the reader, which creates a deeper emotional connection and makes the whole experience more memorable and engaging.

The integration of motion graphics and dynamic visuals in mobile user interfaces has been shown to enhance user interaction experiences. Applying these principles to digital graphic novels can lead to more engaging and cognitively stimulating storytelling. Nannan Li (2024) highlights how dynamic graphics in mobile user interfaces can significantly improve user interaction by making experiences more fluid, responsive, and visually engaging. These dynamic elements such as animated

transitions, responsive gestures, and interactive visuals not only make navigation smoother but also provide intuitive feedback that helps users feel more connected to the content. This aligns with Norman's (2013) principle of feedback in interaction design, which emphasizes the importance of the system responding clearly to a user's actions. Similarly, Salen and Zimmerman (2004) stress that interactive systems should create meaningful play, where every user input leads to a satisfying outcome. When applied to digital graphic novels, these dynamic UI features can turn static panels into living experiences, enhancing immersion and user satisfaction.

2.5 Aesthetic Values in Designing Digital Graphic Novel

As defined by the SLR in Chapter 3, aesthetic value refers to experiences and features that have the capacity to generate aesthetically appreciated experiences. Arumugam and Ali (2019) describe aesthetic value as a decisive factor, encompassing both the beauty and the artistic nature of a work. It involves how users perceive and emotionally respond to design elements, whether the aesthetics are conventionally beautiful or abstract. Forsey (2017) and Goffin (2019) further stress that aesthetic value is rooted in the conceptual experience of art, which varies based on individual appreciation and subjective perception.

In the context of DGN design, aesthetic value plays a critical role in user engagement. Jiang et al. (2016) and Bleier et al. (2019) highlight that visually attractive interfaces are often perceived as more usable, valuable, and trustworthy. This is reinforced by studies on perceived attractiveness (Leong et al., 2019), visual appeal (Zaibon et al., 2019), visual impact (McClanahan & Nottingham, 2019), and factors like visual complexity, order, and readability (Abrams et al., 2019). These aesthetic elements not

17

only influence emotional response but also guide users' understanding and navigation of the content, directly contributing to the storytelling experience of a DGN.

2.5.1 Components in Designing Digital Graphic Novel

The aesthetic value discussed above is strongly influenced by the visual and structural components that make up a digital graphic novel. As supported by various researcher, colour, text, and panel layout are consistently identified as the most critical components in shaping the aesthetic and functional quality of a DGN. These elements serve as the building blocks for delivering both visual impact and narrative clarity.

For example, colour is essential in establishing mood, tone, and emotional connecting directly to Leong et al.'s (2019) findings on perceived attractiveness and Zaibon et al.'s (2019) work on visual appeal. Text, in its typographic form and placement, influences readability and narrative pacing, aligning with Abrams et al.'s (2019) examination of order and complexity. Panel design impacts both the visual flow and story segmentation, which directly ties to the user's perception of structure and coherence, reinforcing the aesthetic value discussed in Section 2.5.

Thus, the aesthetic experience of a DGN is not formed solely through abstract beauty but is deeply embedded in the design decisions surrounding these visual components. Table 2.1 below presents a consolidated view of these design features as identified in the existing literature.

Table 2.1

The component in designing DGN.

References	Image / Picture	Text	Panel Layout	Colour	Image	Hyperlink	Viewing Tools	Symbol	Sound	Format	Zoom	Speech Balloon	Video	Gutter
Poai (2020)	√	√	√	√					√			√		√
Pentury et al. (2020)	√	√	√		√	√			√					
Aggleton (2019)		√			√		√	√			√			
Putri (2019)	√		√		√				√				√	
Rengur & Sugirin (2019)	√	√	√		√				√		√			
Endarini (2018, November)		√	√	√										
Rajendra (2018)	√	√	√	√	√									
Rigaud & Burie (2018)		√	√			√								
Smith & Pole (2018)	√	√	√	√			√			√				√
Dunst et. al (2017, November)	√	√	√		√							√		√
Hasan (2017)		√	√		√									
Marianthi et. al (2016)	√	√				√	√					√		
Kirchoff & Cook (2015)	√	√	√	√	√		√					√		√
Moorefield-Lang & Gavigan (2012)	√	√	√	√		√								
Cooney (2011)	√	√		√	√									

Table 2.1 continued.

Shipwright et. al (2010)	√	√				√	√	√	
Kelley (2010)	√	√	√						
Ponsard & Fries (2008)	√	√	√	√	√		√	√	√

Based on Table 2.1, the previous researchers suggest 14 components that could be considered in designing a DGN which are image/picture, text, panel layout, colour, image sequence, hyperlink, viewing tools, symbols, sound, format, zoom, speech balloon, video, and gutter. Based on these 14 components, text is the most crucial component of designing a DGN, followed by image and panel layout. All these components are mapped with specific aesthetics, as shown in Table 2.1. According to previous research, the elements used in designing the DGN archetype are image/picture, text, panel layout, colour, image sequence, hyperlink, and speech balloon.

2.5.2 Aesthetic Design in Human-Computer Interaction

Aesthetic design is a fundamental design principle that reflects appealing design characteristics. Aesthetics is a fundamental design element that establishes the attractive features of a design. Designers employ aesthetics to enhance the usefulness of their designs and to improve functioning with appealing layouts (Bader & Lowenthal, 2018). Aesthetic values influence an interface's UX in four (4) categories, which are significant in user UX design and IxD (Ablart, 2017; Cnattingius, 2021). Table 2.2 provides a more in-depth explanation of each area.

Table 2.2

Categories of Aesthetic Values that Impacts Interface's UX

Category	Visual Aesthetic Key Elements	Advantages
Vision	Colour, Shape, Pattern, Line, Texture, Visual weight, Balance, Scale, Proximity, and Movement	Help to achieve good visual aesthetics.
Hearing	Loudness, Pitch, Beat, Repetition, Melody, Pattern, and Noise	Create the enjoyable for users
Touch (Haptic)	Texture, Shape, Weight, Comfort, Temperature, Vibration, and Sharpness	Make customers adore our products
Taste and Smell	Strength, Sweetness, Sourness, and Texture (for taste)	Possible to enhance the full picture, so our users can feel the aesthetics even deeper

Based on table 2.2, vision is a category of aesthetic value that is closely related to the visual element. Aesthetics in visual elements refers to characteristics such as balance, colour, movement, pattern, scale, shape, and visual weight. In design, the visual element is the most intuitive carrier of emotional expression (Zhang & Hao, 2021). The following section describes aesthetic values for Digital Graphics Novel.

2.5.3 Aesthetic Values for Digital Graphic Novel

From the previous studies, Kirchoff and Cook's aesthetic values in designing DGN (2015) are representation, speech balloons, image sequences, words and pictures,

panel layouts, colour choice, typography, and image selection. Ponsard and Fries (2008) explain that the aesthetic value in designing DGN are sequence panels, interface to navigate, sequential ordering of image files, single and dual page display support, zoom support, colour correction and enhancement, spread suppression, and support for several file formats. In addition, Dunst et al. (2017) added that DGN consists of text, character, balloon, caption, onomatopoeia, and diegetic text alongside their properties, visual areas of the objects, and the transition between two panels, and relationships between objects. Marianthi et al. (2016) concludes that DGN needs to have proper text and picture, viewing tools, focusing on the vital point, and digital book function. Rigaud and Burie (2018) analyse the values included in DGN, such as panels, balloons, verbal text, and characters. Cooney (2011) recommends in his book that the key to characterization is to observe people every day. The DGN values included characters, plot, dialogue, composition, layout, inking, colouring, and lettering. The developed DGN archetype, incorporate all of these values.
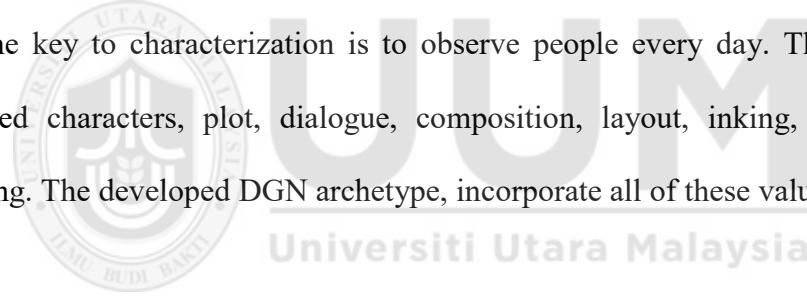
Aesthetic value, according to Aramugum and Ali (2019), is a dominant element in a work that includes the nature of beauty, whether natural or artistic and the nature of art, whether beautiful or not. Aesthetic value is, first and foremost, the value of a conceptual art experience (Goffin, 2019). The aesthetic value of experiences varies. Only when someone enjoys or finds value in themselves, their experiences have positive aesthetic value. Aesthetic values in DGN design focus on an essential design principle that describes the pleasing qualities of a design. Beautiful products and user interfaces are perceived to be more valuable and to possess more qualities (Bleier et al., 2019). Aesthetic elements literature was developed by Nikolajeva (2005), but the element focuses on developing the printed book and the storyline of the children's

book. There are eleven (11) aesthetic values proposed by Nikolajeva (2005) which consists as aesthetic of author, aesthetic of work, aesthetic of genre, aesthetic of content, aesthetic of composition, aesthetic of scene, aesthetic of character, aesthetic of narration, aesthetic of language, aesthetic of medium, and aesthetic of reader. Table 2.3 shows 5 aesthetic values associated with designing digital content specifically for DGN, related to IxD and will be discussed in Chapter 4.

Table 2.3.

The aesthetic value in designing digital content

Aesthetic Value	Explanation	Relationship Aesthetic in Designing Digital Content
Aesthetic of Content	Concept of work (related to the content of visual narrative)	Types of story/narrative, Theme and motive, Image / Picture
Aesthetic of Composition	Combination of visual elements and visual principles.	Visual elements which include: lines, shapes, values, colours, sizes, textures, and spaces (Archibald, 2011) Visual principles which include: balance, rhythm, proportion, dominance, and unity (McClurg-Genevese, 2005)
Aesthetic of Character	Agents performing actions in a story: Person. Personified animal or object	Image / Picture (Gender of character), Speech Balloon (emotion / speech of character)

Table 2.3 continued.

Aesthetic of Narration	The way a story is told	Narrative voice (Sound), Narrative Text (Text)
Aesthetic of Medium	Crossroads of different media: film, theatre, television, video, music, computer games, and so on. Three aspects of multimodality: illustration, trans mediation, and translation	The view of Text, Image/Picture, icon, and Panel layout based on different medium. In this research, it focus on hybrid application (mobile web friendly interface) using RWD approach.
Aesthetic of Author	Communication term by writer (the sender)	Not Related in Designing
Aesthetic of Genre	The theme or types of works.	Not Related in Designing
Aesthetic of Language	The poetic function of language	Not Related in Designing
Aesthetic of Reader	How the reader feels, what they sense, and how they react to what they are reading.	Reader feeling
Aesthetic of Scene	Seeing the idea of the story	Reader feeling based on scene / idea of story
Aesthetic of Work	Interpreting the signs / communication and information that try details by writer to reader.	Story that writer try to interprets to the reader

2.6 Extended IxD-Based DGN Model

Improving the existing IxD model for DGN shows in Figure 2.1 is crucial to better meet the changing needs of today's users. As people seek more personalized, immersive, and interactive experiences, traditional models simply don't capture the full complexity of modern digital storytelling. By incorporating a deeper understanding of user behavior and aesthetic values, we can create more emotionally engaging and personalized experiences. Enhancing the model allows us to combine both aesthetic values and functionality in ways that connect with users. It also ensures the model remains adaptable where new technologies like augmented reality and real-time interactions are becoming more common. An extended model can also help designers make sure their work is accessible and meaningful to a diverse audience, no matter where or how they're interacting with the content. In the end, improving the model will enable us to create more engaging, emotionally powerful stories that resonate with readers today and in the future.

As users increasingly demand more personalized, immersive, and interactive experiences, existing models, such as the one proposed by Husni, Jamaludin & Alobaedy (2021), may not fully capture the diversity of user interaction or the emotional impact of DGNs. By incorporating aesthetic values and understanding user behavior more deeply, the extended model can be more aligned with latest version of IxD elements, emphasizing user agency and personalization in the narrative experience (Jiang et al., 2016; Leong et al., 2019).

Previous models, like Rigaud et al.'s (2015) unsupervised DGN framework, focused primarily on functional interaction and knowledge bases without fully accounting for

25

aesthetic appeal and its role in engagement. The revised model integrates findings related to aesthetic values such as visual appeal, perceived attractiveness, and narrative flow as core components of the user experience. As Bleier et al. (2019) argue, a visually appealing design is crucial not only for attractiveness but for improving user satisfaction and emotional connection with the content. The incorporation of these aesthetic factors leads to a more holistic design approach that goes beyond functionality.

The process of validating extended models is an essential step in ensuring that design principles are grounded in user experiences. The extended model will go through a validation process, as discussed in Chapter 3, where it will be tested, refined, and adjusted based on real user preferences. This ongoing refinement ensures that the model remains relevant and effective, always keeping the user's needs and experiences at the design process. By continuously improving and adapting to how users interact with DGNs, the model stays true to the core principles of IxD, creating experiences that are both engaging and intuitive for the audience.
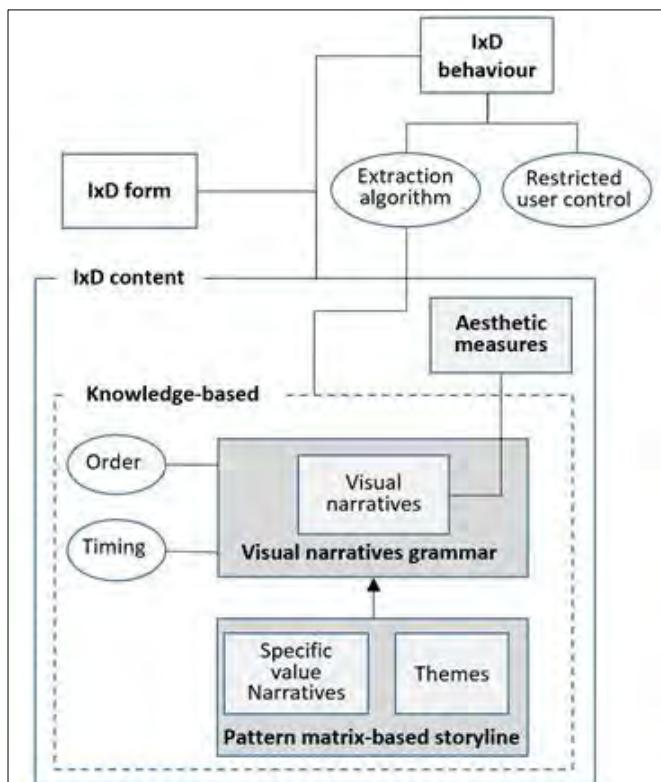
Figure 2.1. An IxD Model for DGN, Husni, Jamaludin & Alobaedy (2021),

Technical Report

2.7 Measuring Aesthetic using Birkhoff Aesthetic Measure

The impact of DGN, on the other hand, is highly dependent on content and appealing

measures. The basis of any DGN is undoubtedly materially organized in a logical,

sequential order (Smetana et al., 2009). Beyond content, we must strive for

engagement. To achieve that, appealing measures are a must-have factor, especially

when having the DGN in digital form. The aesthetic values of digital works are

founded on design elements that are difficult to understand rationally. Applying

aesthetic values to DGN is very important because the users demand functional and

emotional satisfaction.

The central concept of aesthetics consists of beauty and attractiveness (appealing) (Khalighy, 2015). Theoretically, beauty can be considered an internal reality, while attraction is more external (Meltzer & Williams, 2018). To put it another way, beauty is a persistent phenomenon unaffected by external factors. Attractive, on the other hand, is a variable that is derived from target definitions that can shift over time due to external influences such as age, gender, and culture. This study transfers the mathematical principle for aesthetic measurement and serve as a justification for the study's existence. There has never been a classification of aesthetic characteristics of the DGN archetype. In this study BAM is selected as measurement theory to assess aesthetic values on the DGN itself. It is a quantitative approach to various aesthetic fields.

Based on Birkhoff's theory, a method of aesthetic measurement that attempts to capture the tendencies of human aesthetic perception has been developed. Birkhoff's aesthetic method is then widely used as a foundation for analysing aesthetics by cross-disciplinary researchers. The application of Birkhoff's theory was developed to assess layouts, computer interfaces, fine artworks such as paintings, and the aesthetics of geometric shapes and curved shapes. Some inspired researchers, such as David Chek Ling Ngo, have developed aesthetic assessment methods based on Birkhoff's method. Ngo developed applications and empirical studies of aesthetic methods and developed aesthetic measurement methods based on design principles combined with Birkhoff's aesthetics.

Birkhoff defined aesthetic measurement as the ratio of order to complexity (Rigaud et al., 2008; Sahyun, 2018, Hafizah & Husniza, 2021). BAM is a mathematical formula-based evaluation and uses a simple equation:

$$M = \frac{O}{C}$$

where M is the aesthetic value

O is the aesthetic order

C is the complexity

Based on a previous study, BAM can be applied in measuring many designs such as vases, buildings, digital works, and music. Research by Saputro (2019) uses BAM in measuring building aesthetics. Based on Figure 2.2 shows example and how the aesthetic can be measured and reported in Figure 2.3. In his research, Saputro uses Birkhoff to measure each aesthetic value based on each arrangement and complexity using a scale of 0 to 2, where scale of 0 is the lowest and 2 indicates the scale for aesthetic value is high.

Figure 2.2. Symmetry evaluation of building facade based on visual balance measuring aesthetics using BAM

Responden	Order(O)						Complexity(C)				Birkhoff		
	S	R	E	D	H	Nf	Fc	Or	Sd	Cc	(O)	(C)	Measure(M) O/C
1	1	0	2	2	2	0	1	1	2	0	7	4	1.75
2	1	0	2	0	2	0	2	2	1	1	5	6	0.833333333
3	0	0	2	1	1	0	1	1	1	0	4	3	1.333333333
4	1	2	2	1	1	2	0	1	2	0	9	3	3
5	2	1	2	1	1	2	2	2	2	1	9	7	1.285714286
6	2	0	0	0	2	1	1	0	1	0	5	2	2.5
7	2	1	1	2	1	0	2	1	2	1	7	6	1.166666667
8	1	1	2	1	2	0	1	2	1	1	7	5	1.4
9	1	2	0	1	0	2	0	0	1	1	6	2	3
10	0	2	2	2	2	1	2	2	0	1	9	5	1.8
11	2	1	1	0	1	0	1	2	1	0	5	4	1.25
12	1	2	2	2	1	2	0	1	2	0	10	3	3.333333333
13	2	1	1	0	0	1	1	0	2	1	5	4	1.25
14	1	1	1	1	1	1	2	1	1	0	6	4	1.5
15	1	1	2	2	2	1	1	0	0	2	9	3	3
16	1	0	2	1	1	2	0	2	1	1	7	4	1.75
17	2	1	0	1	1	1	1	2	2	2	6	7	0.857142857
18	1	2	0	2	0	1	1	1	1	0	6	3	2
19	2	1	2	1	1	1	0	1	1	1	8	3	2.666666667
20	2	1	0	2	2	1	2	2	2	0	8	6	1.333333333
	1.3	1	1.3	1.15	1.2	0.95	1.05	1.2	1.3	0.65	6.9	4.2	1.85047619

Figure 2.3 Example of BAM calculation for each respondent

According to Birkhoff, the aesthetic measure consists of three sequential phases: (1) a preliminary effort of attention, which is required for the act of perception and increases proportionally to the complexity (C) the aesthetic value, (2) the sense of value or aesthetic measure (M), which rewards this effort, and (3) the verification that the aesthetic value is characterized by a specific order (O), which appears to be necessary for the aesthetic effect. The greater the Order (O) value, the higher the Measure (M) value, or the ultimate value. It will be inversely related to the Complexity value (C). For this research, the order is focused on the principle of design that is related to the IxD-based DGN model while complexity is a component that influences the designer or developer's efforts in designing the DGN interface.

To support and expand on Nikolajeva's theory, more recent studies have taken a closer look at how aesthetic values apply specifically to digital graphic novels (DGNs). While Nikolajeva (2005, 2018) originally identified eleven aesthetic elements, later

work has shown that not all of these fully translate to digital formats. A study by Ali and Husni (2022) offers a more focused perspective, identifying six core aesthetic values that are especially relevant to comic and graphic novel design—such as the aesthetic of work, content, composition, character, narration, and medium. These six elements are more adaptable to the digital context, especially when considering visual storytelling techniques like visual narrative grammar (VNG) and how the DGN is experienced on different devices. Ali and Husni's approach especially useful is that they not only narrowed down the key aesthetic elements, but also outlined fourteen important design components that help shape the visual and emotional appeal of a DGN things like layout, color, font choices, and interactive features. Compared to Nikolajeva's more print-focused theory, their findings provide a more practical and updated view for digital creators. That's why using a broader and more flexible model like the BAM may be more effective it allows for a more general evaluation of aesthetic quality across various formats, rather than being locked into one type of medium.

2.8 Summary

This section identified and measured the aesthetic values of IxD-based DGN and focused on local digital content. Several problems were unravelled in this research, that is applying and testing the IxD-based model in the development of DGN. Besides, other issues related to local content are very limited and less approachable. This study also aims to identify the significance of designing DGN and to get the impact between aesthetic value and user appeal. This chapter explains the critical implications of interaction design, especially on the development of DGN. Its significance exists in education, which is to introduce visual narrative in developing positive values to

children via digital graphic novels. Besides, it can help to produce teaching methods and tools for the teacher, parent, and children, where the development phase for this tool is discussed in Chapter 3. It also enhances value to DGN developers in developing an attractive visual storytelling interface.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Overview

As previously stated in Chapter 1, this research aims to investigate the aesthetic values of a DGN design. There are three objectives for this study. The first objective is to identify the aesthetic values and aesthetic measures of DGNs. Aesthetic value plays a key to satisfying user requirements of design, and this objective focuses on the previous literature on aesthetic values in designing a DGN. Based on the first objective, the identified aesthetic and measurement values is used to design and develop the extended model of IxD-based DGN, which is the second objective of this research. The current model mainly focuses on the aesthetic narrative design of a DGN but does not demonstrate the aesthetic value used in the archetype DGN layout. The archetype design applied to the aesthetic values that are obtained in the first objective. The third objective is to evaluate the extended model of IxD-based DGN using Birkhoff's Aesthetic Measure. This evaluation technique is used to assess the aesthetic values that applied in designing DGN. This study aims to be a helpful resource in the theoretical part of developing DGN and useful to DGN developers and researchers. The goal is not only provide the theoretical part but also to provide the DGN archetype based on a proper interaction design model and appealing to users.

3.2 Research Design

The method of this research follows the experimental research methods. Various forms of experimental research can help to increase the understanding of the content and theoretical parts of aesthetic values and DGN. The perspective of the research is

33

already discussed in Chapter 2 where it focuses on the initial exploration of previous and current literature about IxD, DGN aesthetic values and issues, and the measuring aesthetic using BAM. This research involves four (4) main phases: literature study using SLR, model extension and validation, design and development, and evaluation phase. Figure 3.1 shows the research design of this research.
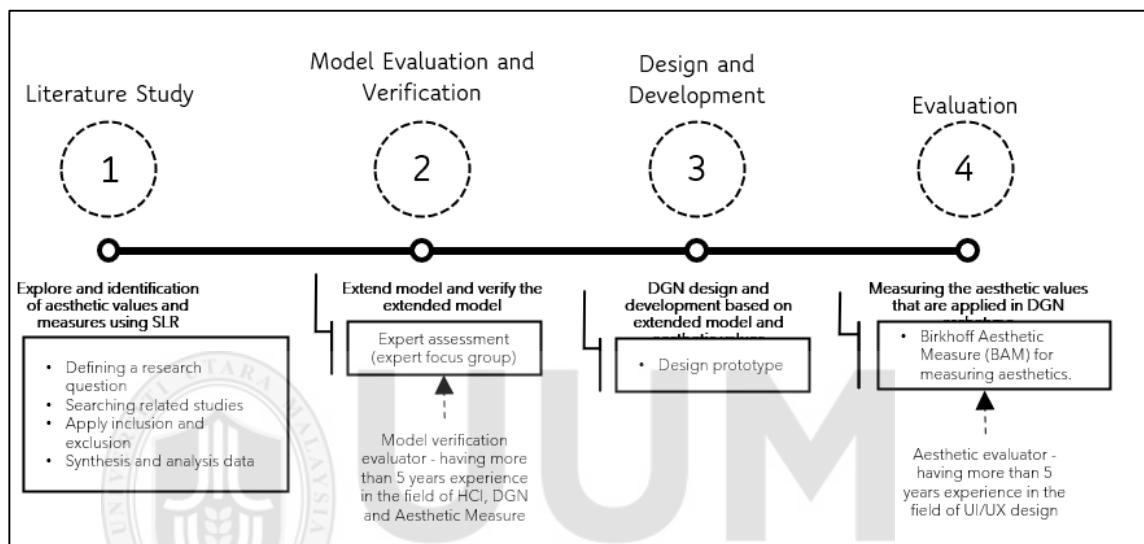
Figure 3.1. Research Design

Based on the research design, all issues, existing knowledge, analysis, design and development, and evaluation were carried out in a systematic manner to provide suggestions and find the desired solutions for this research. Figure 3.2 depicts a summary of activities, as well as instruments and outcomes, for each phase of this research.
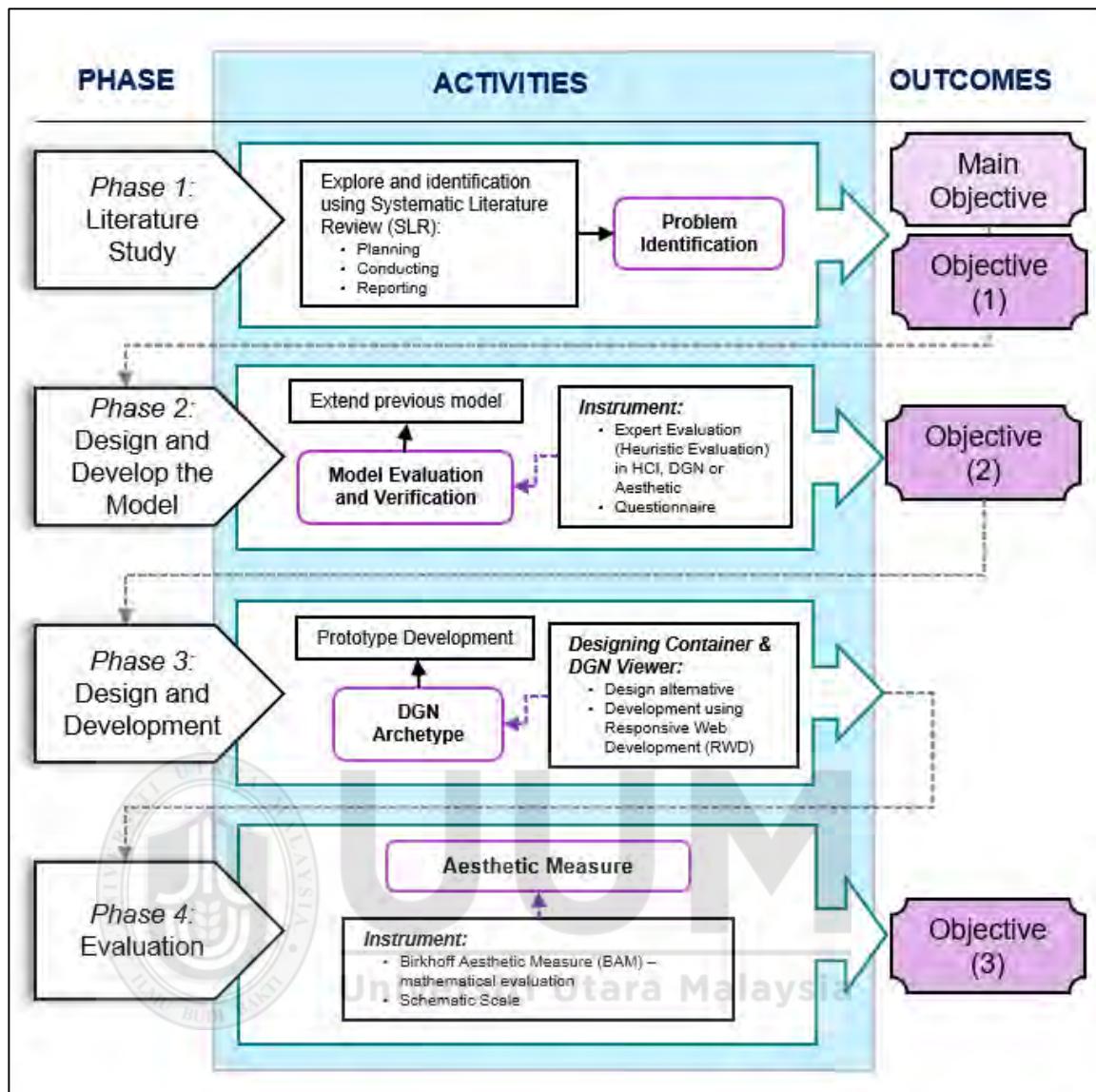
Figure 3.2. Summary of Research Activities

3.2.1 Phase 1 – Literature Study

This section examines the introductory study of the research issues and ideas. Its focus is on the initial exploration of how a researcher needs to answer the research aims and objectives (Kumar, 2018; McKenney & Reeves, 2018). Issues related to interaction design, graphic novel and digital graphic novel, aesthetic values, and BAM were studied. This is being done by referring to previous studies and papers on a related keyword discussed in the analysis phase. Using keywords in a certain online database

35

narrows the focus to list out all the questions needed as discussed in Chapter 1. Based on the research question, the research planning includes all the sources and documents in a particular step and interpretation in the next phases.

This research uses an SLR to identify and answer the specific research question and related issues in DGN. SLR in the definition refers to a method that is used to answer specific research questions, examining a particular research topic, or phenomenon of interest (Kraus et al., 2021; Fischer et al., 2017). Based on guidelines for SLR stated by Kitchenham (2004), this research follows the activities shown in Figure 3.3. According to Kitchenham (2004), the purpose of performing SLR are as follows: to summarise existing evidence about technology; (ii) to identify gaps in current research in order to suggest areas for further investigation; and (iii) to provide a framework or background in order to appropriately position new research activities.
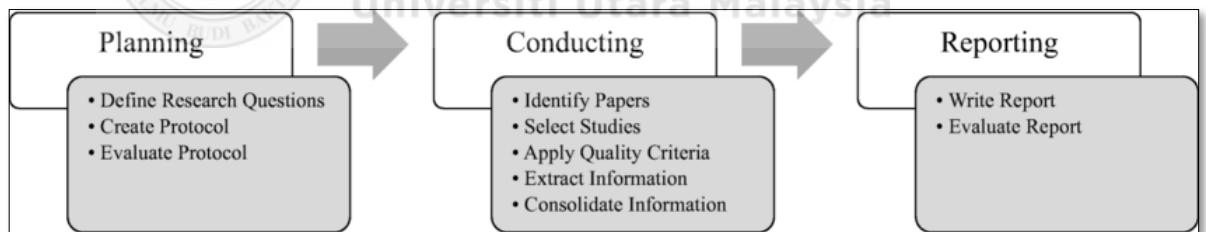
Figure 3.3. Step for conducting SLR according to Kitchenham et al. (2004)

3.2.1.1 Planning Phase

To guide an SLR, a protocol was developed to identify the steps to conduct the review process. The planning phase consists of a review using the following steps: (i) define the research question, (ii) create protocol, and (iii) evaluation of the review protocol. The best strategy for achieving this research goal is to specify research questions and

create a review protocol for this research. At this phase, the research questions were constructed to accomplish this research's aim. The research questions can be a strategy in conducting the review step, as shown in Table 3.1.

Table 3.1

Research Question of SLR

Q.	Research Question
Q1.	What is a digital graphic novel (DGN)?
Q2.	What are the common aesthetic values using Birkhoff's Aesthetic Measure?
Q3.	What are the aesthetic values and components in designing DGN?

3.2.1.2 Conducting Phase

The steps to conduct the review consist of five steps: (1) identify papers, (ii) select studies, (iii) apply quality criteria, (iv) extract information, and (v) consolidate information. The identification and selection process uses electronic database and manual search of the journal, conferences, books, and thesis related to the research question keyword. The conducting phase includes the searching process of papers' titles, year, sources, and types of study. The selection and filtering of the contents process were conducted to filter the sources by the title, abstract, and the findings of the paper. The accessibility of many resources through electronic libraries gives a relevant publication. The theoretical data, such as aesthetic values in graphic and digital graphic novels, can be reviewed and adopted explicitly in the exclusion and inclusion process in the select studies. The aesthetic value in designing and other issues related to DGN was collected based on the exclusion and inclusion table shown in Table 3.2.

Table 3.2:

Inclusion / Exclusion Criteria in Select Studies Process

Inclusion Criteria	Exclusion Criteria
• Articles that mentioned digital graphic novel and graphic novel terminologies	• Articles that are not related to a graphic novel such as novel
• Articles that analysed the appealing-ness of DGN	• Articles that discussed the aesthetic value of the non-digital product
• Articles that discussed specifically DGN and aesthetic value.	• Articles with a similar study and do not lead to a research question.
• A study was written 5 years or more recently	• Not a full article
• For the theoretical part, relevant sources will be accepted.	
• Only English article as exclusion criteria in SLR.	

All the adopted information were transformed into organized theories and aesthetic values shown in the table. The aesthetic values specified from the reference search were analysed and studied in-depth to see the relationship between each value with IxD-based DGN. This section sets the synthesis and analysis process. A database has been created to manage and store data from the selected study. Before choosing the papers for SLR, it is checked to ensure that there is no duplication, for instance, if the same research is published in different journals or many electronic databases with another first author. If this occurs, the latest study is selected. After eliminating and

categorizing the sources, some papers have been removed, and only the chosen sources remain. Some keywords are used to search for the terms keyword such as "graphic novel" and "digital graphic novel" or combination keywords such as "definition + digital graphic novel", "appealingness of graphic novel", "aesthetic in designing graphic novel" or "aesthetic value + digital graphic novel" in the primary studies and the papers were checked whether it provided related information with the research question. Then the papers are coded in the database, however, combination keywords are highly recommended as search engine keywords because of the limitation of sources using a single keyword search.

Figure 3.4 shows the activities included in the conducting phase. N is a value representing the result found in the conducting phase. This figure presents a process of selecting studies from a database search related to DGN. Initially, 128 records were identified through database searches. After a screening process, 30 records were excluded, leaving 98 studies deemed eligible for further review based on their abstracts and research titles. The eligible studies were then divided into two categories for synthesis. The first category included studies focused on introducing DGN (26 studies), theoretical papers on DGN (17 studies), and the benefits of DGN (29 studies). The second category consisted of studies related to aesthetic theory (10 studies) and components essential for designing DGN (18 studies). This categorization helps in systematically organizing the literature for an in-depth synthesis of both foundational and aesthetic aspects of DGN.
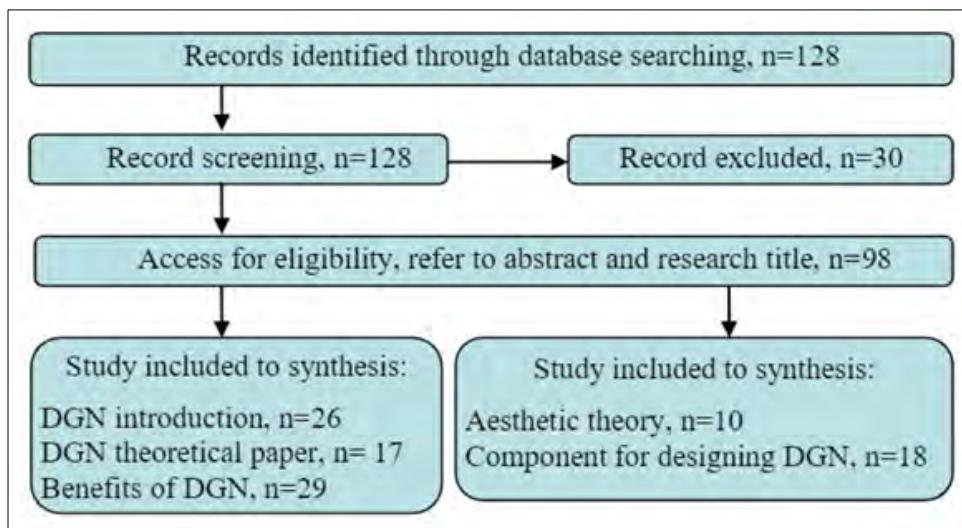
Figure 3.4. Process in Conduction Phase

3.2.1.3 Reporting Phase

The final stage is the reporting phase, wherein the results of the conducting phase were recorded using Google Sheets and Microsoft Excel to manage the final literature analysis. The report findings were concluded and analysed in the reference lists. The information is used to separate the primary studies based on research questions using specific software to store databases.

3.2.2 Phase 2 – Model Extension and Validation

The second objective is to expand upon the current model. As depicted in Figure 3.5, any values attracted from SLR during this phase were expanded to the previous model. Figure 3.5 shows a list of the aesthetic value that were used for measuring aesthetics in the design of DGN. The extended model listed the values that were used to utilize and measure using DGN, and also update the new dimension of the most recent IxD dimension. The left box is Aesthetic Values that labelled from A to I, these represent various aesthetic aspects or principles considered in the design. Each aesthetic value

informs the overall appearance and feel of the interaction design (IxD). The elements labelled from A to I will be discussed in Chapter 4.
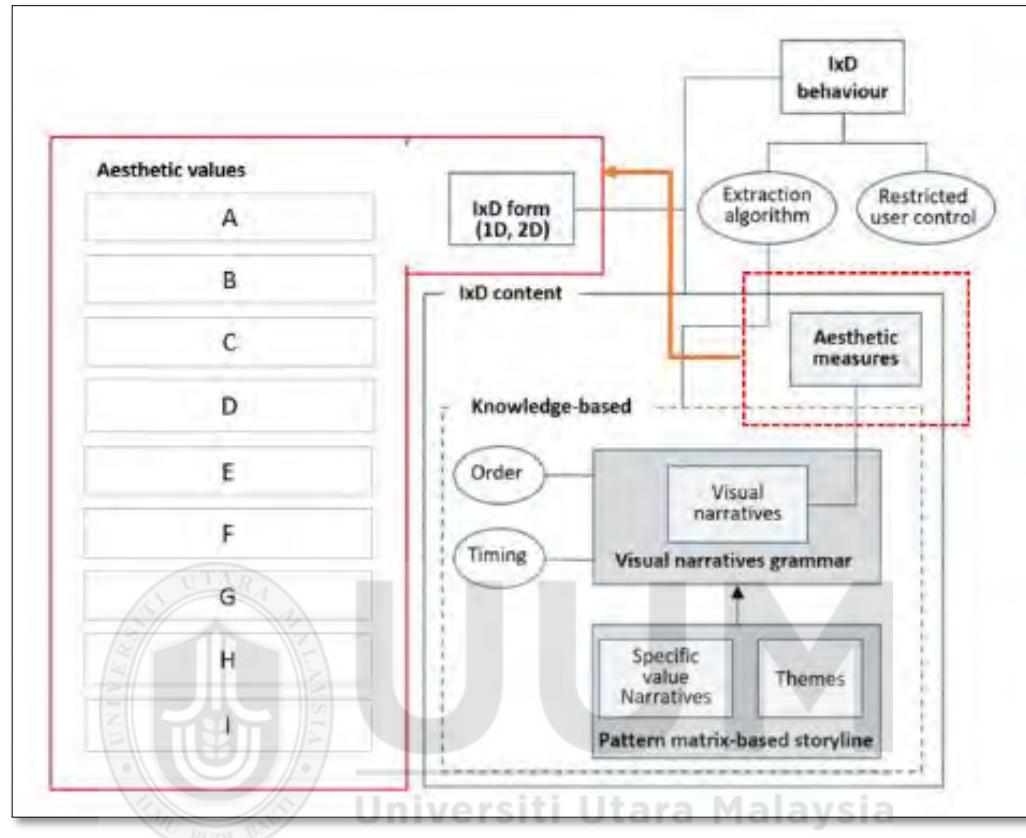
Figure 3.5. Extended model of IxD-based DGN

Expert review is also known as heuristic evaluation (Nielsen, 1995). This strategy was chosen because it allowed a more systematic and comprehensive assessment of the extended model. According to Nielson (1995), the exact number of evaluators is depending on the cost benefits evaluator. For this research, five experts were chosen to examine the expanded model, which is held with at least five years of experience in HCI, DGN, and aesthetic measurements. The experts were well-versed in the definitions of variables and a general description of the variables represented in the

models. That is, whether the factors and their relationships are suitable for knowledge transfer and valuable to designers when developing DGN development.

The model was then evaluated and validate to determine if it complied with the IxD-based DGN and the extended model. Nielsen and Molich (1990) explained in their study that expert review is used to identify the most significant usability issues with products. All potential usability issues are compiled into a single, comprehensive list. After all, the evaluators have the potential to offer suggestions for beneficial solutions to each problem. According to Fernandez et al. (2011), the expert review process is quick and can be completed in a couple of hours because these experts are knowledgeable and rely primarily on the functional prototype and interaction description to conduct the verifications.

In the expert evaluation, each expert evaluates the level of uncertainty in their respective fields (HCI, DGN, and aesthetic measure). The focus group then analysed their combined estimates for each factor. All the experts evaluated the proposed model and recommend how to apply DGN in their respective professions. The comments are used to validate the model's existing variables and relationships.

3.2.2.1 Expert Selection

Several guidelines were taken into consideration in this study when determining the expert to be chosen for expert review evaluations. According to Hallowell and Gambatese (2010), the expert must meet at least two of the following requirements: (i) authorship, (ii) conference presenter, (iii) committee member or chair, (iv) employed in practise with five years of experience, and (v) employment as a faculty

member at higher education institutions. Therefore, these requirements were followed in order to choose the most suitable experts for this study. In addition, the number of experts involved in the evaluation depends on the suitability of the verification process. In this study, there are a total of five experts contributing their time and knowledge, including researcher, academician, and designer. The background of the experts is listed in Table 3.3 below.

Table 3.3

Background of Experts

Expert (E)	Academic Qualification	Expertise	Position	Years of Experience
E1	Bachelor's degree	Design	Designer / Lecturer	17
E2	Bachelor's degree	Design and Multimedia Application Development	Designer	9
E3	Master's degree	Application Development	Lecturer	11
E4	Ph.D	HCI	Lecturer	8
E5	Master's degree	Software Development	Lecturer	20

3.2.2.2 Instrument: Questionnaire

The processes to produce an overall verification process were verifying documents and online questionnaire. The online questionnaire aimed to evaluate user knowledge, understanding, and opinion of the proposed model. An appointment is scheduled if the expert requires additional clarification on the proposed model. In providing explanations during the discussion, the researcher conducted as interview to discuss on the subject. The interview session consisted of a semi-structured interview formats. These researchers utilized a semi-structured interview because the researcher wished to elicit richer and more detailed responses from the expert. The questions in the interview guide were described to achieve the richest possible data (Kallio et al., 2016).

Semi-structured interview guides include main themes and follow-up questions. The experts were encouraged to speak freely about their perceptions and experiences within the main themes. As mentioned in the sample selection, these experts analysed and verified the proposed model after receiving an email with the model and verification document. The verification document contains a hyperlink where expert must click to answer the online questionnaire. The online questionnaire was created using Google Forms since it is more flexible and easy to fill up. By using the online questionnaire, the experts can answer the questionnaire whenever they're available in less time. A meeting is scheduled if the expert needed more explanation on the proposed model. Refer Appendix A to see the expert review questionnaire.

3.2.3 Phase 3 – Design and Development

The third phase in this research is the core phase, where the design and development of DGN is completed to achieve the third objective of this research. The design phase consists of two major processes which is design alternatives and design prototypes. The design alternative focusses on sketching the interface and preparing the screen design. The screen design practices the aesthetic values and include the values in the DGN design based on the analysis phase. The wireframe focuses on the IxD-based DGN to adapt the workflow of visual representation in the DGN product. After completing the screen design, the prototype of the DGN is developed using specific software. This research creates an IxD-based DGN for web applications suitable for children, teachers, and parents. The development of the archetype consists of a container and a player. The DGN players consist of the flipping DGN, and containers consist of the list of DGN in various methods based on user uploads such as flipping, video, animation, or static images.

3.2.3.1 Prototype Development to Validate the Model

Prototype development is used to validate the extended model. In prototype development, design alternative is used to develop the prototype. It is essential to make sure that the design applies and follows the IxD-based model proposed in this research. HTML5, CSS, and JavaScript were used to create the front-end interface. Responsive web design (RWD) in HTML is a design and development technique that enables the design and development of websites that adjust to the user's behaviour and environment based on screen size, platform, and orientation. The RWD is used in the DGN development to supplement user requirements and preferences. This DGN's

programming language is written in Hypertext PreProcessor (PHP) and in order to store the data of the DGN, MySQL is used as the database.

By combining the aesthetic values established in Phase 1 of this research with user interface (UI) design theory, the whole DGN archetype was developed. A user interface (UI) is the interaction between a system and a user via instructions or strategies to control the system (Darejeh & Singh, 2013), enter information, and utilize the contents. The programming components were moved to a live production environment during the prototype phase and thoroughly tested (Joo, 2017). The evaluation of the DGN interface is discussed in detailed in the following section utilizing a method of evaluation known as BAM.

3.2.4 Phase 4– Evaluation

The evaluation process is a crucial part of this research because it will answer and attain the final objective of this research. The final objective relates to measuring the aesthetic values that are applied in the DGN archetype. It is estimated according to whether or not it is usable and appealing to target users. According to Altaboli and Lin (2011), measuring aesthetic value can be divided into two major approaches: objective screen layout-based and subjective questionnaire-based measures. BAM is selected as a measure to the physical layout of visual objects on the screen that are related to the aesthetic values of DGN. The aesthetic design identified in the IxD-based DGN design was assessed using BAM evaluation formulas. The outcome of this study are the result and discussion of the aesthetic value and the theoretical part in measuring DGN design.

The DGN archetype was evaluated not only in terms of aesthetics but also based on usability using the System Usability Scale (SUS). SUS is a widely used tool for measuring the usability of a system or product. It consists of a 10-item questionnaire that helps assess how user-friendly a system is. SUS is designed to be quick and easy to administer, making it a popular choice for both developers and researchers. The scale provides a quantitative score that reflects overall usability, helping teams identify areas where a product may need improvement. The SUS questionnaire includes 10 questions related to different aspects of usability. Users respond to these statements on a 5-point scale, ranging from "strongly agree" to "strongly disagree." The items are a mix of positive and negative statements, designed to assess various usability dimensions. These components are:

1. Usability: How easy the system is to use and learn.
2. Complexity: Whether the system feels unnecessarily complex or overwhelming.
3. Efficiency: How well the system helps users' complete tasks.
4. Correctness of the model: Whether the system performs its intended functions well for each component.
5. Satisfaction: Users' overall satisfaction with the system.

Listed below is a more detailed description of the 10 questions in the SUS:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.

5. I found the various functions in this system were well integrated.

6. I thought there was too much inconsistency in this system.

7. I would imagine that most people would learn to use this system very quickly.

8. I found the system very cumbersome to use.

9. I felt very confident using the system.

10. I needed to learn a lot of things before I could get going with this system

SUS was used in the evaluation the archetype because it provides a quick, efficient, and reliable method for assessing how usable the platform is for its intended audience. SUS allowed the researchers to measure overall user satisfaction and identify areas where the system could be improved. Overall, SUS helps identify key usability issues and areas for improvement, enabling developers to enhance user experience in a structured and manageable way. According to previous research on usability evaluation using SUS, SUS scores are classified into acceptability ranges (62.5 and above) and grade scales (F for values 60 and below, D for the range 60-70, and C, B, and A for an acceptable grade of 70-100). The other class is adjective ratings, which are sorted from worst to greatest, with a range of 25 to 100. For this class, the value received was 52.5, which is acceptable. Derisma (2020) and Kurniawan et al. (2022) in their study shows that the rules for the percentage position and grade scale are as follows:

i. Grade A: score >= 80.3, percentage >= 90 %

ii. Grade B: 74 <= score < 80.3, 70 % <= percentage < 90 %

iii. Grade C: 68 <= score < 74, 40 % <= percentage < 70 %

iv. Grade D: 51 <= score < 68, 20 % <= percentage < 40 %

v. Grade F: score < 51, percentage < 20 %

Based on the literature, this study collects data through digital methods to evaluate the usability of the system. DGN archetype users received a SUS questionnaire through a link using Google form. The questionnaire that was implemented was a questionnaire regarding the usability of DGN archetype as a teaching and learning support medium. The evaluation is tested by 33 respondents who use the DGN archetype as educational tools. The results are discussed in the Section 5.2.

3.2.4.1 Aesthetic Measure Using Birkhoff Aesthetic Measure

This research makes use of BAM as an aesthetic measure to assess the value of designing DGN from an aesthetic standpoint. In order to carry out the validation process, five seasoned professionals were selected to serve as validators. The expert is required to have a minimum of five years of experience in visual design as well as expertise in HCI, DGN, and aesthetic measure. The specialists conducted their evaluation based on an aesthetic evaluation that has been coded and documented utilising a schematic scale. In accordance with the archetype's user interface, the measurements were coded. For instance, the principal interface design has been given the identifiers $Interface_{01}$, $Interface_{02}$, and $Interface_n$ in the coding. The order (O) is then encoded as follows: $O_1 = Aesthetic_1$, $O_2 = Aesthetic_2$, and $O_n = Aesthetic_n$. The degree of difficulty, denoted by C, will be represented by the values C_1, C_2, and C_n. The following section discusses in detail on the process of the evaluation's instrument.

3.2.4.2 Instrument: Schematic Scale

A schematic scale is selected to be used for the evaluation's instrument. In order to determine the values of order and complexity, this instrument is consulted to the expertise of a specialist whom responsible for determining the prior topic. Following

the coding, the experts selected to act as evaluators were assign values employing a schematic scale ranging from 0 to 1. The schematic scale is recorded in the formatted table so that the values can be calculated and recorded systematically. The measurement table for M is produced after the score has been analysed and after the total values of order and complexity have been summed up.

The process of extended model validation includes the utilisation of expert review. According to Fernandez et al. (2011), the expert review evaluation can involve three to five experts depending on the suitability of the verification process and can speed up the process of validating a model. For the purpose of the model validation, each of these specialists was given an online questionnaire to fill out. In addition to that, it was expected from the experts to provide comments and suggestions. It was decided to hold a meeting with the experts and record it so that any ambiguous comments or suggestions regarding the model verification could be discussed and clarified. The questionnaire served as the primary instrument in the model verification process. In addition to a section in which the experts could offer comments and suggestions, experts were also required to offer their assessments of the following, which are listed below:

(1)   Relevance of Extended Model and IxD

(2)   Understand Aesthetic Value in Designing IxD-based DGN

(3)   Understand of Aesthetic Measure in Designing IxD-based DGN

(4)   The connections and flows of all components (Comment / Suggestion)

(5)   Readability of proposed extended model (Comment / Suggestion)

For the first question, experts are necessary to check on the applicability of the suggested component, which is the applicability between the aesthetic measure based on the IxD dimension and the aesthetic value included in the extended model. The expert has to choose one of the following options: (1) all the proposed components are relevant; (2) some components may not be related; (3) all components are irrelevant.

While for the second and third questions, experts are required to confirm the comprehensibility of the elements for the aesthetic value in the DGN design and the aesthetic evaluation in the IxD-based DGN design. Experts have to choose one of the following options: (1) it is easy to understand; (2) need some explanation; (3) need a very detailed explanation. For the fourth and fifth questions, experts must confirm the connection and flow of all components and the readability of the proposed IxD-based DGN model by responding "yes" or "no" to three questions: (1) the component of the extended model; (2) connection and flows; and (3) model overalls. The final question will focus on the readability of the model, evaluating the relevance of font size, arrow, the component and box, and the overall appearance of the model. Finally, the experts are expected to make comments and ideas regarding the proposed IxD-based DGN based on the expert knowledge and expertise. Model validation results from the experts are discussed in the following part.

3.3 Summary

This chapter explains the research methodology that was used for this study. The methodology for the research consists of four main steps starting from preliminary investigation, model extension and validation, design and development, and lastly evaluation. In the preliminary study, SLR is used as a data analysis method. The first

objective was answered by one of the qualitative methods, and the second objective was resolved during the model extension and validation phase. The final stage of this research is the completion of the third objective, which involve measuring the DGN archetype and aesthetic measure using BAM. In conclusion, the primary focus of Chapter 3 is the overall procedure to address concerns and questions of the research methodology.

CHAPTER FOUR

THE EXTENDED IxD-BASED DGN MODEL

4.1 Overview

Based on the literature review in Chapter Two, the extended model of IxD-based DGN model that focuses on the latest interaction design dimension is needed to explore the impact of aesthetic values and user appeal to digital work specifically DGN container. Focusing on this gap, the current study was conducted to extend the IxD-based DGN model. The model can be used as a guideline to design DGN archetype with these aesthetic values according to the interaction design dimension. This chapter discusses on the development of the extended model, which includes the process of designing, developing, and validating the model through expert review, ensuring that it is practical, relevant, and adaptable for future DGN design initiatives.

4.2 Development of Extended Model of IxD-Based Digital Graphic Novel

As discussed earlier in Chapter Three, this study utilized an ideation approach for the development of the Interaction Design (IxD)-based DGN model. The process begins with a detailed description of the model's primary components, which consist of the interaction design dimension and the aesthetic value integrated into the DGN aesthetic measure. The design process involved creating multiple sketches and concepts, starting with a central idea that was progressively refined and distilled into the final version of the model. The design phase is particularly crucial in this study, as it must balance both theoretical foundations and practical application. This model serves as a helpful tool for DGN designers, especially when creating comics and interactive DGN experiences. Additionally, it contributes valuable insights to the broader field of

53

interaction design and user interface design, underscoring the importance of considering both perspectives.

The IxD-based DGN Model aims to enhance the understanding of interaction design and aesthetic value in the design process. It focuses on the three core dimensions of IxD that are integral to UI design: 1D - IxD Word, 2D - IxD Visual Representations, and 4D - IxD Time. The third dimension of IxD, 3D - IxD Physical Objects and Space, emphasizes the user's direct interaction with tools in relation to UI design. In DGN, the 3D - IxD Physical Objects and Space is not only about physical tools like a mouse or keyboard, but rather how users interact with and navigate the digital space where the content is displayed. It focuses on how the content (such as images, panels, and text) is arranged on the screen, and how the user moves through the story. Instead of physical interaction with objects, it's about how the design helps users engage with and experience the narrative visually and interactively.

Furthermore, the fifth dimension, 5D - IxD Behaviour, extends the previous model by incorporating visual narrative and storytelling elements into the DGN design. While the model discussed in Chapter Two considered only three dimensions, this expanded version introduces five dimensions and places greater emphasis on aesthetic evaluation, whereas the prior model mainly focused on visual narrative for DGN.

Figure 4.1 illustrates the extended version of the proposed IxD-based DGN model before it was assessed by five experts, who provided feedback on its correctness of the model. The following sections will provide a rationale for the selection of each IxD dimension and aesthetic value used in the design of the specified DGN archetype.

54
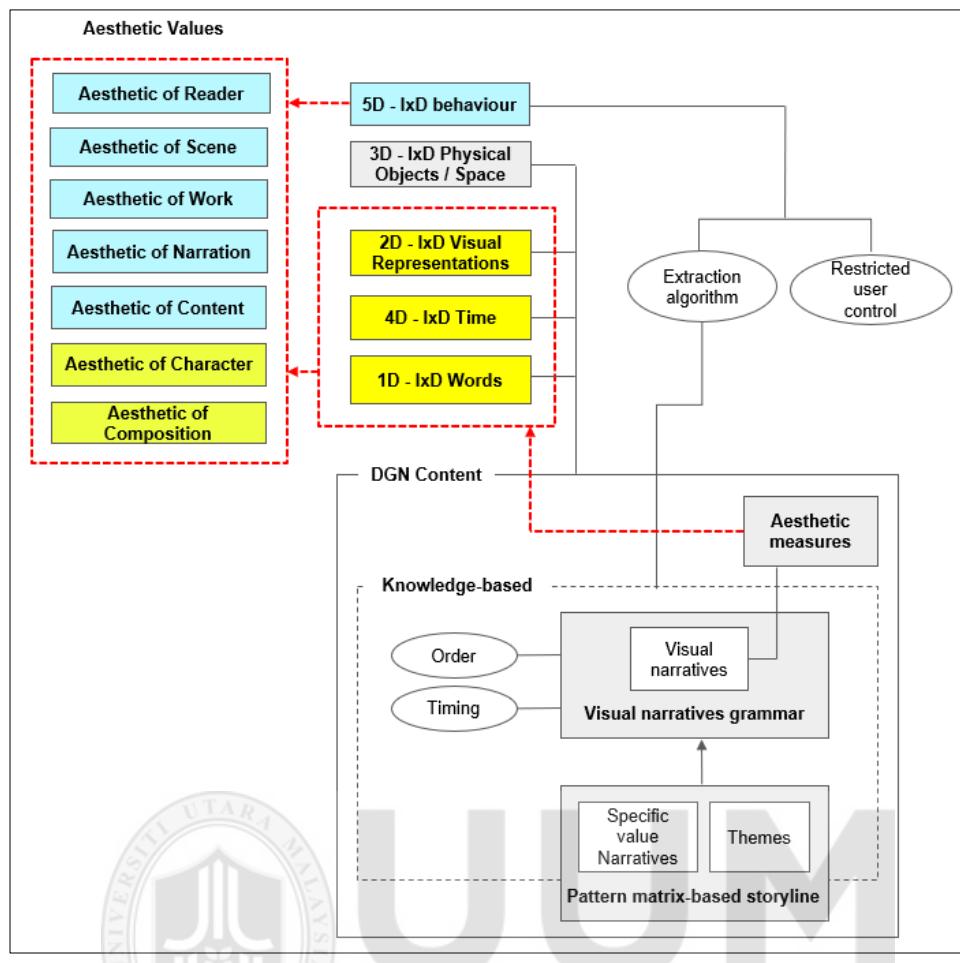
Figure 4.1. Proposed Extended Model of IxD-based DGN Model

4.2.1 Interaction Design Dimension in Design DGN Archetype

Interaction design is crucial to the creation of interactive products that support human life in its daily activities. It is comprised of the five dimensions outlined in Chapter Two. According to Designing Interactions by Smith (2007), the IxD dimension is divided into the following categories: 1D Words, 2D Visual Representations, 3D Physical Objects or Space, 4D Time, and 5D Behaviour. Table 4.1 provides a summary of the five dimensions and its relationship to the DGN prototype design in the proposed extended model.

Table 4.1

Interaction Design Dimension in Designing DGN Archetype

IxD Dimension	Relationship in Designing DGN Archetype
1D Words	Used for the communication of ideas or narration in DGN. Providing additional context for the narrative or text delivered by the character. Ensure the information will be delivered and written easily to the user.
2D Visual Representations	Displays the layout of the interface's graphic design, typography, icons, diagrams, and buttons. Become appealing to users by using the DGN archetype. Make this easier for the user to comprehend the required messages or instructions for interface interaction. Ensure that the arrangement of multimedia elements makes sense and helps the user concentrate.
3D Physical Object / Space	Displays user interaction with the developed DGN archetype design through the physical device. The utilisation of the device when the user interacts with an application (UI design developed in mobile friendly). For instance, when a user presses the search button on a mobile application or the mouse button on a laptop computer.
4D Time	Includes the amount of time utilised by the user to display a function on the DGN interface. Use of appropriate time intervals such as an animation or any changes involving movement in the UI design.
5D Behaviour	The emotion and reaction from the user when using or reading the DGN archetype.

According to Table 4.1, the results of this study indicate that all IxD dimensions are extremely significant in the process of constructing a DGN archetype. It is considered to be one of the fields of knowledge that is beneficial in ensuring that any research pertaining to DGN can be carried out in an appropriate manner and in accordance with the user's preferences.

The IxD-dimension are closely related to research objective 1, which is to identify the aesthetic values and measures of DGN archetypes. Each dimension contributes to how users experience and perceive the design visually and emotionally. The 1D words dimension focuses on how text is used to communicate ideas clearly and meaningfully. Well written text can enhance the overall look and feel of the DGN by supporting the visual style. The 2D visual representations dimension deals with visual elements like layout, typography, icons, and color schemes. These are key in creating an attractive and organized interface, which directly reflects aesthetic quality. The 3D physical object/space dimension looks at how users interact physically with the design through devices such as smartphones or laptops. A clean and user-friendly layout can make interactions feel smooth and visually pleasing. The 4D time dimension includes animation and timing, which add motion and flow to the design. Proper use of timing can make transitions feel natural and enjoyable. Finally, the 5D behaviour dimension considers how users feel and react while using the DGN. Positive emotions and engagement indicate that the design is not only functional but also aesthetically effective. Altogether, these dimensions help in understanding and evaluating the aesthetic value of DGN archetypes from both a visual and user experience perspective.

4.2.2 Justification for Aesthetic Value

This extended model includes components of aesthetic values that are involved in increasing the aesthetic value in design that is based on interaction design. As shown in Figure 4.2, based on previous research, there are a few aesthetic values that have been found to be significant in the IxD dimension.
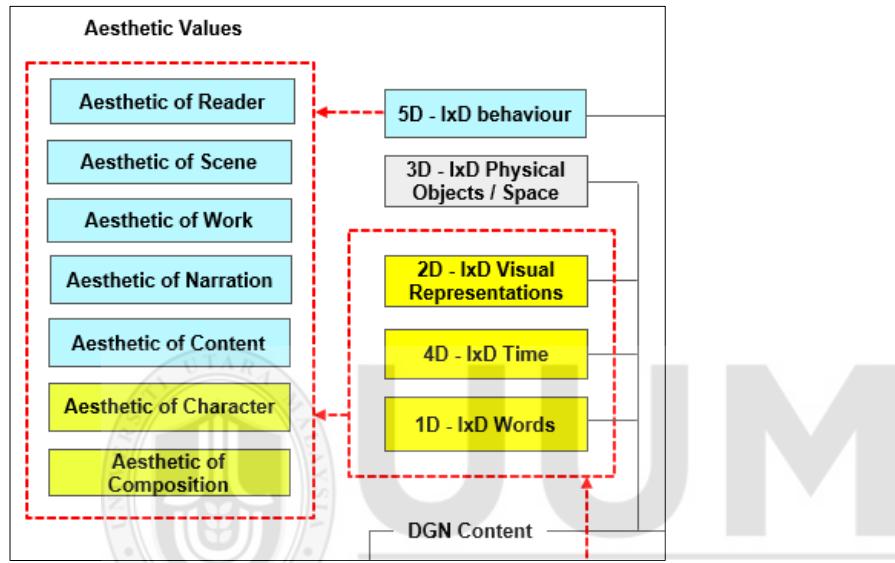
Figure 4.2. Aesthetic Values Element in IxD-based DGN

The selected aesthetic values element demonstrated a relationship with the IxD dimension, as shown in Table 4.2, which summaries the connections between the IxD dimension and the respective aesthetic values. Compared to the aesthetic value of the 5D dimension, which is not directly involved in the DGN UI design and focuses more on VNG and user's behaviour toward the DGN archetype. The model only evaluates the aesthetic values of the 1D, 2D, and 4D dimensions because it involves the aesthetic value of the DGN archetype. The aesthetic value of the 5D dimension, which will not be evaluated because it does not involve the aesthetic value of the DGN archetype.

58

Table 4.2

Relationship of Aesthetic Values based on IxD Dimension

IxD Dimension	Aesthetic Values	Relationship
1D Words	Aesthetic of Composition	The use of text in the button or hyperlink, the arrangement of the text in the menu, the search function, the text settings for the headline and the display of other texts in DGN.
2D Visual Representations	Aesthetic of Character	The use of graphic elements such as the use of speech balloons in DGN or any image used in the DGN display involves the use of the main character as an attraction.
	Aesthetic of Composition	The combination of visual element and principle that use in DGN such as colours, line, texture, balance, space, and unity.
3D Physical Object / Space	Aesthetic of Medium	The medium utilised to access the media and the DGN interface's architecture. Aesthetic value cannot be measured using the same evaluation of the IxD interface dimension.
4D Time	Aesthetic of Composition	Animation or movement that use in DGN archetype such as the hover effect

Table 4.1 continued.

		for button, slider, and drop-down menu effect.
	Aesthetic of Reader	The reader's feelings when reading DGN.
	Aesthetic of Scene	Each scene should be described in a way that will touch the reader's deepest emotion.
5D Behaviour	Aesthetic of Work	Story that the author attempts to convey to the reader.
	Aesthetic of Narration	Narrative technique to deliver the storyline.
	Aesthetic of Content	How the storyline in DGN affects the reader's behaviour and interest.

4.2.3 Aesthetic Measure in Designing DGN

Based on the IxD dimension, the aesthetic measure in the model is established to evaluate the aesthetic value. It was extensively described in Table 4.3, but was not incorporated in the existing element model. However, each aspect is considered during the BAM evaluation. Figure 4.3 depicts the connection between the aesthetic measure element and the IxD dimension.
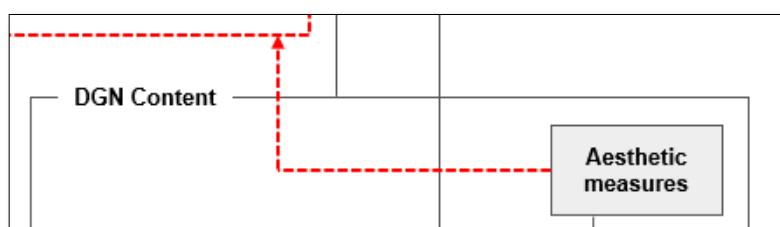
Figure 4.3. Aesthetic Measure Element

60

Table 4.3

Aesthetic Measure Element use in BAM

Aesthetic Measure	Description
Measure of balance	Distribution of optical weight in a picture.
Measure of equilibrium	Equilibrium on a screen is accomplished through centring the layout itself. The centre of the layout coincides with that of the frame.
Measure of symmetry	Screen is symmetrical in three directions: vertical, horizontal, and diagonal.
Measure of sequence	The arrangement of objects in a layout in a way that facilitates the movement of the eye through the information displayed.
Measure of Cohesion	Aspect ratios promote cohesion.
Measure of Unity	Unity is achieved by using similar sizes, shapes, or colours for related information and leaving less space between elements of a screen than the space left at the margins.
Measure of proportion	Aesthetically pleasing proportions should be considered for major components of the screen, including windows and groups of data and text.
Measure of simplicity	Combination of elements in a form.
Measure of density	Character positions on the entire frame containing data.
Measure of regularity	Standard and consistently spaced horizontal and vertical alignment.
Measure of economy	Styles, displays techniques, and colours.
Measure of homogeneity	Measure of how evenly the objects is distributed among the quadrants.
Measure of rhythm	Regular patterns of changes in the elements.
Measure of order and complexity	Order is written as the sum of the design complexity.

4.3 Results of Model Validation

Expert validation involves the five questions outlined in the previous sections. The responds and feedbacks to the following five questions are presented in the form of tables and percentages in order to illustrate each value provided by each expert. According to Table 4.4, the entirety of the model has been validated, and it can be seen that the model has been reviewed consists of three distinct components: the aesthetic measure, the IxD dimension, and the aesthetic values. The five experts agreed on the opinion that each of the components are significant. the feedback provided was clear and constructive, demonstrating the experts' understanding and involvement in the evaluation. The time taken to complete the questionnaire was reasonable, suggesting that the questions were well-structured and easy to follow. Overall, the results from the online validation were useful and helped confirm the validity and relevance of the model components.

Table 4.4

Validation Results of the Overall model

Parts	Frequency (n = 5)		
	All proposed components are relevant	Some components may be irrelevant	All components are irrelevant
Aesthetic Measure	5		-
IxD Dimension	5	-	-
Aesthetic Values	5	-	-

Table 4.4 presents the result of component in IxD dimension that relates to aesthetic values. All the experts agreed that the content is easy to understand for five aesthetics namely aesthetic of reader, aesthetic of scene, aesthetic of work, aesthetic of narration, and aesthetic. Meanwhile, one expert commented on the aesthetic worth of character, suggesting that it requires two types of aesthetic evaluation whether it involves character, related to the development of the character itself or the implementation of character in interface design. For this study, the aesthetic component of character is mainly focused on the utilization of existing characters in the DGN archetype's interface design. In terms of the aesthetic of medium and aesthetic of composition, three experts agreed that the component in the model is simple to understand, while two experts believed that the aesthetic value requires further explanation.

Table 4.5

Validation Results of Component in IxD dimension for each Aesthetic Values

Components	Frequency (n = 5)		
	It is easy to understand	Need some explanation	Need very detail explanation
Aesthetic of Reader	5	-	-
Aesthetic of Scene	5	-	-
Aesthetic of Work	5	-	-
Aesthetic of Narration	5	-	-
Aesthetic of Content	5	-	-
Aesthetic of Character	4	1	-
Aesthetic of Medium	3	2	-
Aesthetic of Composition	3	2	-

The outcome of the validation of the IxD dimension component is shown in Table 4.6. For the purposes of this study, the dimension that focuses on design consists of three dimensions: words, visual representations, and time. While the physical object / space dimension does not entail aesthetic value, it still comprises the IxD dimension because it involves the interaction between the user's access medium and the DGN archetype. Regarding IxD behaviour, it emphasizes the aesthetic value of how users can conduct actions on a DGN and the narrative within the DGN. This dimension was investigated in the previous model. Table 4.6 indicates that all experts believed that the 3D, 4D, and 5D components are understandable. Three experts believed that the 1D and 2D components are simple to comprehend, whereas two experts believed that they require further explanation.

Table 4.6

Validation Results of Component in Understand of Aesthetic Measure and IxD dimension

	Frequency (n = 5)		
Components	**It is easy to understand**	**Need some explanation**	**Need very detail explanation**
1D Words	3	2	-
2D Visual Representations	3	2	-
3D Physical Object / Space	5	-	-
4D Time	5	-	-
5D Behaviour	5	-	-

Figure 4.4 shows a pie chart showing the connections and flows between the model's components. 60% of the experts agreed that it was logical, whereas 40% disagreed. However, the expert provided suggestions for improvement to justify their decisions. Regarding connections and flows, experts recommended enhancing the aesthetic value of the aesthetic of medium, which is the focus of this study.
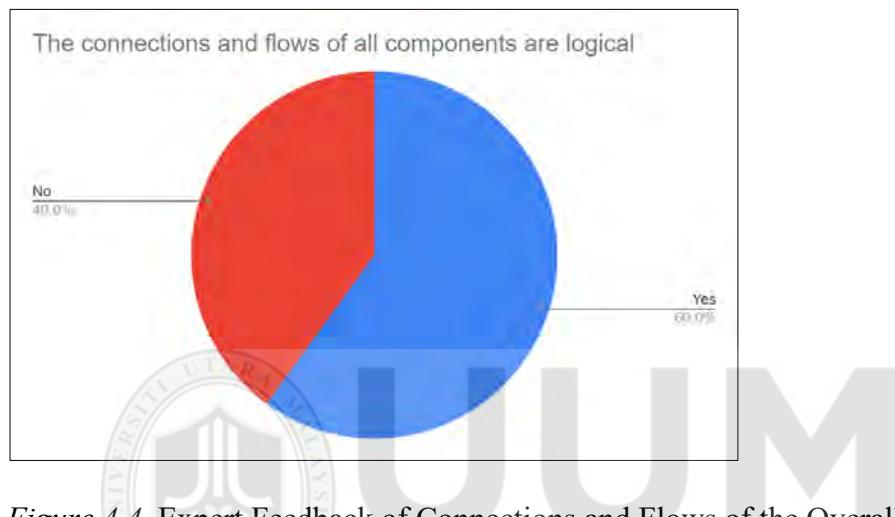
Figure 4.4. Expert Feedback of Connections and Flows of the Overall Model.

Figure 4.5 is a pie chart showing the readability of proposed extended model. 80% of the experts agreed that it was readable, whereas 40% disagreed. However, the expert provided suggestions for improvement to improve the readability of the model, which is to focus the line on the aesthetic of composition only because it is more related to IxD for the DGN interface.
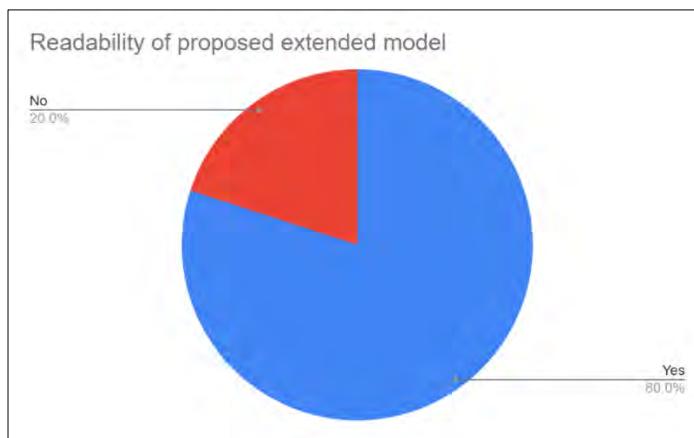
Figure 4.5. Expert Feedback of Model Readability

For the final section, experts were asked to make any comments or suggestions about the extended model. Expert comments and suggestions are discussed in Table 4.7.

Table 4.7

Comments and Suggestions from Experts

Element	Expert	Comments and Suggestions
Component of Model	E04	Some components need explanation, as they are hard-to-understand and interpreted into graphical elements.
	E05	Explain the details of each component at LR
Connections and Flows of All Components	E01	Put an element of measure in group
	E02	Focus on aesthetic of medium
	E03	Connection link (red colour) for aesthetic value just focus aesthetic of medium
	E04	Fix the group of aesthetic values based on each group
Overall Model	E02	Overall are good and interesting.
	E03	Group the aesthetic measure that focusses on IxD
	E04	Group the aesthetic measure that focusses on IxD.

66

It is feasible to draw the conclusion based on the experts' comments and suggestions that majority of experts agreed with the suggested model, and that the only component that needs to be improved is the part that deals with aesthetic value.

4.4 Revised Version of IxD-Based Digital Graphic Novel

In response to the discussions and expert feedback covered in the previous section, several important adjustments have been made to improve the clarity and usability of the model. Expert suggestions have been carefully reviewed and incorporated, particularly focusing on enhancing the flow of connections to make the model easier to understand.

Figure 4.6 shows the Revised Version of the Extended IxD-based DGN Model, which now offers a more readable and organized view of the framework. One of the main updates is the categorization of aesthetic values according to the type of IxD (Interaction Design) element they represent. Each type of IxD element is assigned a distinct colour, making it easy to identify different parts of the model at a glance.

This color-coding helps readers quickly distinguish between elements, highlighting relationships and patterns that might otherwise be overlooked. By improving the flow and organization, the model is now more intuitive, guiding the viewer through each component and making it simpler to understand how the parts connect and interact.

In addition to making the model more visually accessible, these updates also make it flexible enough to support future changes and expansions. With these improvements, the revised model serves as a clearer, more effective tool for both researchers and

practitioners, making it easier to navigate complex interactions within the DGN framework.
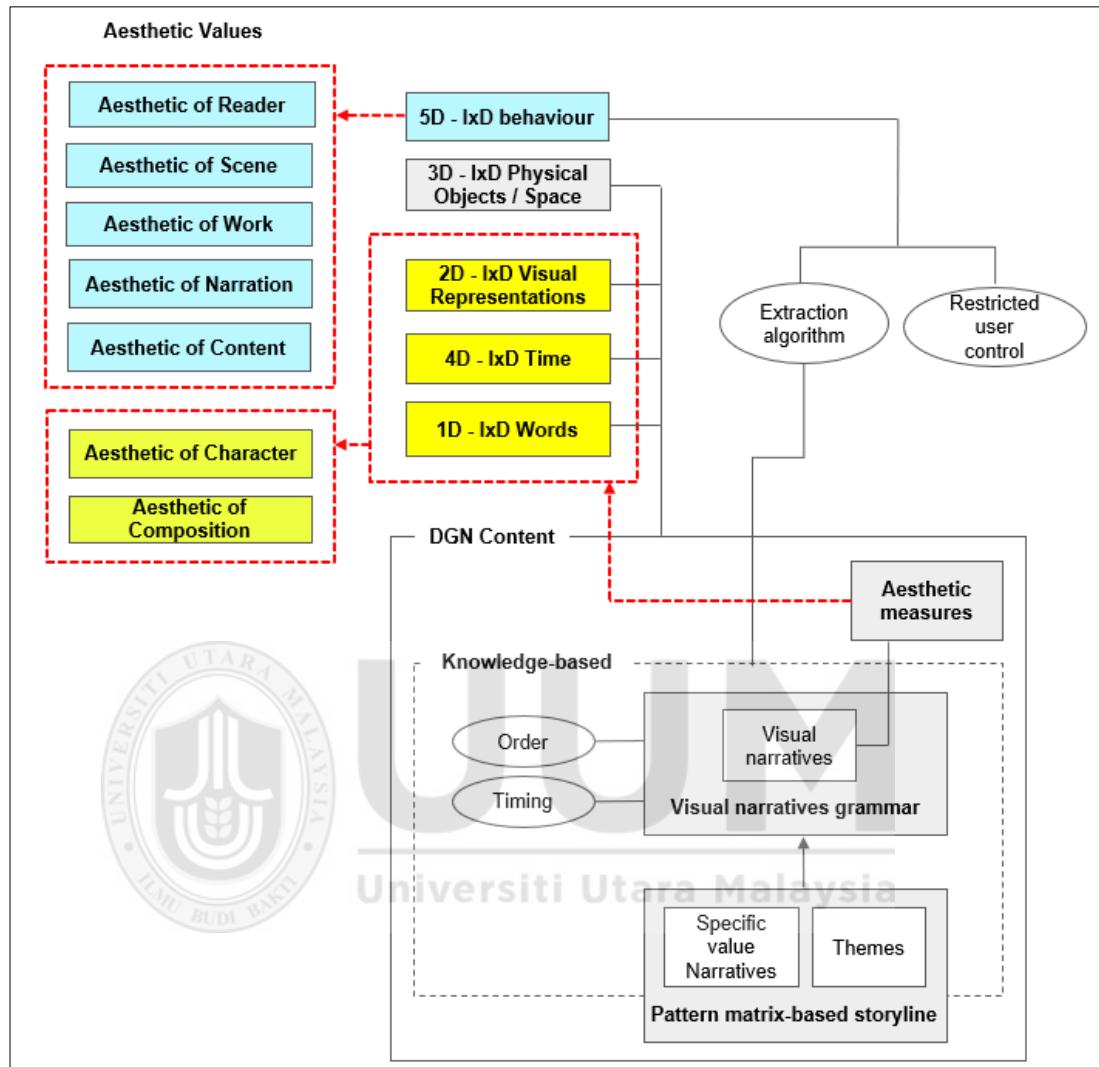
Figure 4.6. Revised Version of IxD-based DGN Model

4.5 Summary

The most important phase of a study is the design phase because the design must reconcile theoretical and practical considerations. Both perspectives should be considered because this model contributes to the existing body of knowledge and researchers in the disciplines of interaction design and user interface design. The findings of model validation and verification were discussed in this chapter. The IxD-

based DGN Model is utilized to aid designers and researchers in understanding interaction design and aesthetic value in design. It highlights the three IxD dimensions associated with UI design: 1D - IxD Word, 2D - IxD Visual Representations, and 4D - IxD Time. This extended model incorporates aesthetic value components that contribute to increasing the aesthetic value of interaction design-based design. Unlike the aesthetic value of the 5D dimension, which is not directly involved in the DGN UI design and instead concentrates on VNG and user behaviour toward the DGN archetype, the aesthetic value of the 5D dimension is more concerned with VNG and user behaviour toward the DGN archetype. Due to the aesthetic value of the DGN archetype, the model only evaluates the aesthetic value of the 1D, 2D, and 4D dimensions. In the process of model verification, the questionnaire served as the primary instrument. For the first query, experts are required to evaluate the applicability of the proposed component, specifically the applicability between the aesthetic measure based on the IxD dimension and the aesthetic value included in the extended model. Experts are required to validate the comprehensibility of the elements for the aesthetic value in the DGN design and the aesthetic evaluation in the IxD-based DGN design for the second and third questions, respectively. For the fourth and fifth questions, experts must validate the connectivity and flow of all components, as well as the model's legibility. The responds and feedbacks to the following five queries are presented in the form of tables and percentages to illustrate each expert's contribution. Each of the components, according to the consensus of the five experts, is significant.

69

CHAPTER FIVE

THE EVALUATION

5.1 Overview

Chapter 5 focuses mainly on the evaluation of the Digital Graphics Novel on the local contents focusing on the Malaysian culture which emphasizes on Islamic and moral content. The main objective of developing this Digital Graphics Novel is to educate youngster on the morals contents where the target user is children aged between 8-10 years old. Based on the results of IxD dimensions (1D-IxD Words, 2D-IxD Visual Representation and 4D-IxD Time) generated in Chapter 4: The Extended IxD-Based DGN Model, a Digital Graphics Novel were developed using a web-based platform that can be accessed using the following link https://ruangprojek.com/dgn/. In order to evaluate the Digital Graphics Novel that had been developed, Birkhoff Aesthetics Model is selected as the evaluation model based on its advantages as discussed in Chapter 2. The following section will discuss on the Digital Graphics Novel archetype, DGN archetype evaluation by experts and the summary of the chapter.

5.2 System Usability Scale Evaluation

The Digital Graphics Novel that is used in this study is developed using a web based platform called "Digital Comics and Education Media Archive" (DGN Mall). In addition to being used to assess aesthetics, DGN Mall was also tested for usability involving lecturers and comic students at Politeknik Tuanku Syed Sirajuddin. The students are digital comic developers who uses the archetype to upload their works to be tested by users. SUS is used to measure how user-friendly this system is, based on

a 10-question survey. The DGN Mall platform is intended to support education by providing local comics that can enhance teaching through visual storytelling.

The collected data was organized and compiled in the SUS database using Google Sheets, with built-in formulas to help streamline the final analysis. A pie chart highlights the background of the 33 respondents—66.7% are students, while the remaining 33.3% are lecturers. Table 3 displays the processed data, making it easier to calculate the overall SUS score. All responses from the 33 participants were included, and an average score was calculated from their input. This table provides an overview of how the respondents evaluated the system based on a 10-question usability survey. Based on the literature, the SUS structure is based on the following:

i. Respondents (R) for this survey are recorded with values R1 to R33.

ii. Respondents who answered SUS questions in the form of a Likert scale from 1 to 5 consisting of 10 questions.

iii. Total Odd Questions ($\sum Qo$) is the total marks for odd numbered questions which are questions Q1, Q3, Q5, Q7, and Q9.

iv. Total Even Questions ($\sum Qe$) is the total marks for the even numbered questions which are questions Q2, Q4, Q6, Q8, and Q10.

v. The SUS score for each respondent shows the overall perception of usability.

As a result of the usability analysis from the SUS survey, resulting in Table 5.1. The SUS total score for each respondent ranges from 52.5 to 97.5, with an average score of 72.3, indicating moderate usability. Higher scores in odd-numbered questions often correlate with higher overall SUS totals, while respondents with higher scores in even-

71

numbered questions tend to have lower SUS scores. Respondents R25 and R31 achieved the highest SUS score of 97.5, while R32 recorded the lowest score at 52.5. This suggests the system is generally considered usable, but there is room for improvement in achieving higher user satisfaction.

Table 5.1

Data analysis based on 33 respondents

Respondent	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	$\sum$Qo	$\sum$Qe	SUS Total
R1	5	4	5	5	5	2	5	4	5	3	20	7	67.5
R2	5	5	5	5	4	4	5	4	4	3	18	4	55.0
R3	4	2	4	2	4	3	4	2	4	3	15	13	70.0
R4	4	2	4	5	3	3	5	4	5	3	16	8	60.0
R5	4	3	3	3	4	3	3	3	4	2	13	11	60.0
R6	5	3	4	3	4	2	5	2	5	3	18	12	75.0
R7	4	3	4	3	3	3	4	3	4	2	14	11	62.5
R8	5	2	5	2	5	2	5	1	5	1	20	17	92.5
R9	3	2	3	2	2	2	3	2	3	1	9	16	62.5
R10	4	3	5	1	4	2	4	2	5	2	17	15	80.0
R11	4	3	4	3	3	3	4	3	5	2	15	11	65.0
R12	4	3	4	3	3	3	4	3	4	2	14	11	62.5
R13	5	5	5	5	5	5	5	3	5	4	20	3	57.5
R14	5	4	5	3	4	3	5	3	5	4	19	8	67.5

Table 5.1 continued.

R15	4	3	5	2	4	2	5	3	5	3	18	12	75.0
R16	5	3	4	4	3	3	5	3	4	2	16	10	65.0
R17	5	3	5	5	5	5	5	5	5	4	20	3	57.5
R18	4	3	4	3	3	3	4	3	4	2	14	11	62.5
R19	4	3	4	3	3	3	4	3	4	2	14	11	62.5
R20	5	3	4	3	3	3	4	3	4	2	15	11	65.0
R21	4	3	3	4	3	3	4	3	4	2	13	10	57.5
R22	5	4	5	1	4	2	5	2	5	1	19	15	85.0
R23	5	4	5	4	4	4	5	4	4	3	18	6	60.0
R24	5	2	5	1	4	2	5	4	5	1	19	15	85.0
R25	5	1	5	1	4	1	5	1	5	1	19	20	97.5
R26	5	5	5	1	4	2	5	1	5	1	19	15	85.0
R27	4	4	5	1	4	2	5	1	5	1	18	16	85.0
R28	5	4	5	1	4	1	5	1	5	2	19	16	87.5
R29	5	2	5	2	5	1	5	1	5	1	20	18	95.0
R30	5	3	5	1	3	2	5	1	5	1	18	17	87.5
R31	5	1	5	1	4	1	5	1	5	2	19	19	95.0
R32	5	5	5	5	5	5	5	5	5	4	20	1	52.5
R33	5	4	5	1	4	1	5	1	5	1	19	17	90.0
											AVERAGE		**72.3**

In the study, data was collected from 33 users, and the resulting SUS score was 72.3, which indicates moderate usability. This means that, overall, the system was considered somewhat effective and user-friendly, but there were areas that need

improvement. Nevertheless, issues were encountered with navigation and mobile accessibility. While most users were satisfied, some responses indicated that certain aspects of the system could be enhanced. The findings emphasized the importance of continuing to test usability throughout the development process to ensure the platform provides both educational value and a good user experience. Future improvements should particularly address mobile accessibility to increase user engagement and satisfaction.

5.3 Digital Graphics Novel Archetype

The Digital Graphics Novel that is used in this study is developed using a web-based platform that can be accessed using the following link https://ruangprojek.com/dgn/. DGN Mall is a digital platform that stores all the Digital Graphics Novel that are used in this study. As shown in Figure 5.1 below is the main page of the platform.

Figure 5.1. Main Interface of the platform

The main objective of DGN Mall is to be the one-stop centre for youngsters to read

the Digital Graphics Novel where users can easily access the required DGN. There are

three types of users who can access this platform - the administrator of the platform,

DGN designers, and the DGN readers. A DGN reader is classified into two types

which are the basic DGN reader and the registered DGN reader. The main differences

between these two readers are that the basic DGN reader can only read the DGN while

the registered DGN reader can read and also rate the DGN to improve and support the

artwork. In addition, registered user can also access the DGN that is set to be limited

by the DGN creator. Figure 5.2 shows the DGN that is available for user to access.

Figure 5.2. List of Digital Graphics Novels

To access the Digital Graphics Novel, the user will need to click the button "Papar"

on the required novels as in Figure 5.3: Example of Novel

Figure 5.3. Example of DGN

Once the user clicks on the button, the synopsis of the novel will be displayed as in Figure 5.4: Novel information. User can check on the category, genre, language, uploaded date, and rating. To display the novel, user need to click on the "Paparan" button as in Figure 5.5.

Figure 5.4. DGN information

Figure 5.5. "Paparan" button

User can choose to view the novel based on two types of display which is using the PDF viewer (Figure 5.6) and the flipbook version (Figure 5.7). Using the PDF viewer user have additional functionality where they want to download and print the novel while using the Flipbook version, user can only display the novel.

Figure 5.6. PDF viewer

Figure 5.7. Flipbook version

Based on the explanation above, it can be seen that the process of viewing the novel is quite easy and suitable to be used by youngster. The main benefit of DGN Mall is that it can be the main Malaysian local content hub which collect DGN from novel creators that are interested in displaying and sharing their creative artwork. To evaluate the interface of the DGN, five interfaces were selected as shown in Figure 5.8 until Figure 5.12 in the following section.

5.4 Evaluation of Digital Graphics Novel Archetype

The evaluation process of the DGN archetype interface based on the extended IxD model discussed in Chapter 4: The Extended IxD-Based DGN Model. The study uses mathematical calculation called Birkhoff Aesthetics Measure or BAM to calculate on the aesthetical values of the digital work. BAM uses the following formula to calculate the aesthetical values:

$$M = \frac{O}{C}$$

where M is the aesthetic value

O is the aesthetic order

C is the complexity

There are five interfaces that were selected to be evaluated. Each of the interfaces are important in graphics novel since it involved the elements of DGN reader, wording of the novel, layout of the novel and visual elements included in the novel. Figure 5.1, 5.2, 5.4, 5.6, and 5.7 are the selected interfaces of the evaluation purposes.
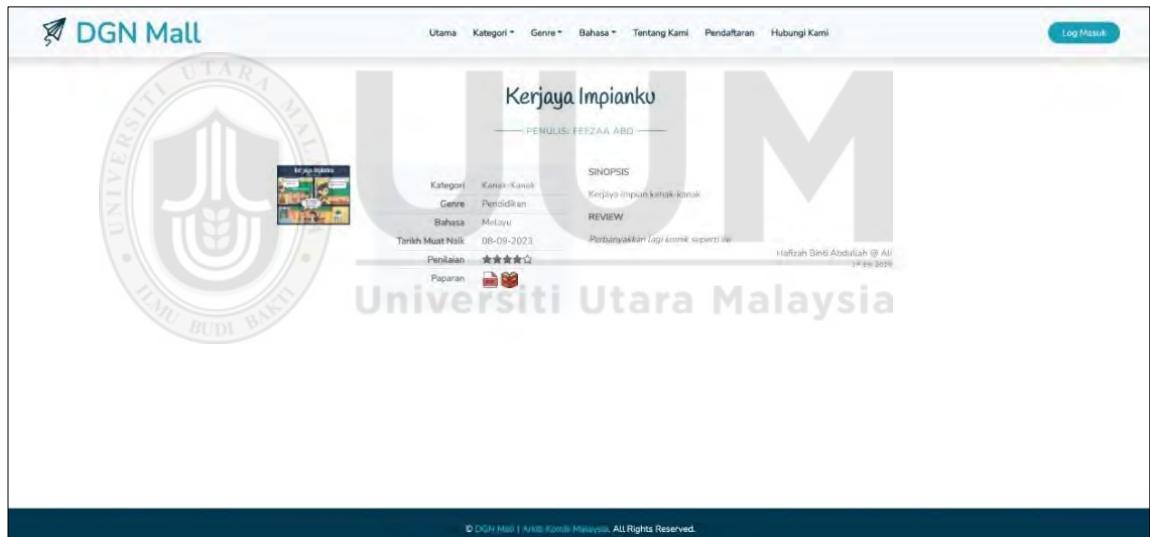
Figure 5.8. View details of DGN in DGN Container

Based on the BAM formula, each element of Order (O) and Complexity (C) is used based on research findings in the literature and coded as in Table 5.2 and Table 5.3. All relevant elements are determined by experts involved in the field of interaction design.

Table 5.2

Order Elements Details for Birkhoff Aesthetic Measure

Element	Abbreviation	Description
Symmetry	Sym	Symmetrical design will use uniform images / text / object to attract an equal amount of attention
Sequence	Seq	The arrangement of objects in a layout in a way that facilitates the movement of the eye through the information displayed.
Balance/Cohesion	Bal	Distribution of optical weight in a picture and typography in very good ways. The design or artwork work together seamlessly to create a unified whole
Proportion	Prop	Relationship between the different elements in a composition and relate with each other in good ratio
Rhythm	Rhy	A regular pattern of changes in well-displayed and organized elements.
Simplicity	Sim	Good minimalist design approach that emphasizes the use of negative space and clean lines

Table 5.3

Complexity Elements Details for Birkhoff Aesthetic Measure

Element	Abbreviation	Description
Colour Contrast	Col	Contrasting colors to create a visually interesting
Form Complexity	FCom	Shapes and forms create a sense of movement and energy within the composition that helps to draw the viewer's eye and make the design more engaging and impactful
Type of Font	Font	Typography in design and art to create a visually interesting is good
Size Ration	SRat	The use of varying sizes of elements in a design or artwork to create a different sizes to create a sense of visual hierarchy and interest
Whitespace	WSpace	Using negative space to create a sense of balance and contrast within the composition
Alignment	Align	Complexity alignment can be achieved by using elements with different levels of complexity and alignment to create a sense of visual hierarchy and interest such as intricate illustrations or decorative fonts, in combination with simpler elements

Five domain experts were chosen to evaluate the DGN archetype. These five expert domains as shown in Table 5.4 are experts who are directly involved in the field and

have experience in the field of application development or interaction design. Each of these experts have experience between 10 to 18 years in related field.

Table 5.4

Background of Experts for User Interface Evaluation

Expert (E)	Academic Qualification	Expertise	Position	Years of Experience
E1	Bachelor's degree	Computer Science (Interactive Media)	Lecturer	14
E2	Bachelor's degree	Science Computer/ System Development	IT Officer	10
E3	Ph.D	Graphic design, Interactive multimedia, New Media	Lecturer	11
E4	Ph.D	Computer Science	Lecturer	18
E5	Bachelor's degree	Software Engineering	Application Developer	17

These five experts were given a Google form which includes all the questions on DGN aesthetics values and its elements. The experts were given ten (10) scale measurements starting from very poor (0) to very good (10) to evaluate the DGN and provide feedback to the questionnaire. Although BAM emphasizes the value of 0-1, however, in Google form, there is a limitation where the values cannot be in the point form. The value is converted to the correct BAM values once the response is collected.

The questions are divided into two primary sections: user demographics and interface evaluation. User demographic information such as age, gender, highest level of education, field of studies, years of experience involvement, and experience in application development, and digital graphic novel design is collected from the expert. They are classified and coded with the labels E1, E2, E3, E4, and E5, as shown in Table 5.4.

The interface evaluation section is divided into five areas, each of which focuses on the major interface for the digital graphic novel. The five interfaces were chosen based on their relevance to graphic novel readers. It is identified with the codes UI01: Home, UI02: Display DGN List, UI03: Display DGN Details, UI04: View DGN in PDF, and UI05: View DGN in Flipping Book. Each element in Table 5.2 and 5.3 is placed into an evaluation form and individually examined by experts. The results generated from the responses are displayed in Table 5.5 to Table 5.9. The following section discusses on the generated result.

5.4.1 Analysis of Birkhoff's Aesthetic Measure

Birkoff's aesthetic measures analysis is based on two important components which are order, and complexity. For order, O as discussed earlier, six (6) components determine the order in the visual design of DGN as follows:

a)   Symmetry

b)   Sequence

c)   Balance / Cohesion

d)   Proportion

e)   Rhythm

f)   Simplicity

Referring to Figure 5.8 and Table 5.4, to facilitate the understanding of each interface is represented as a UI01 code, and R1 is referred to the expert code by giving the appropriate value in the range 0 to 1. This value is based on the value in the schematic scale stated in chapter 3. This is done for each panel in the DGN so that the O can be obtained.

O_{UI01R1} = Sym + Seq + Bal + Prop + Rhy + Sim

                = 0.8 + 0.8 + 0.6 + 0.7 + 0.8 + 0.9

                = 4.6

where

Sym - Symmetry

Seq – Sequence

Bal – Balance / Cohesion

Prop – Proportion

Rhy – Rhythm

Sim – Simplicity

As for C, six (6) components have been identified to influence the effort required to understand the visual design of DGN. Here are the components:

a)   Color Contrast

b)   Form Complexity

c)   Type of Font

d)   Size Ratio

e)   Whitespace

f)   Alignment

Based on the same concept as O, Figure 5.8 and Table 5.5 are referred to, for ease of understanding each interface is represented as UI01 code, and R1 is referred to the expert code by giving the appropriate value in the range 0 to 1. This is done for each panel in DGN so that C can be obtained.

$$C_{UI01R1} = Col + FCom + Font + SRat + WSpace + Align$$

$$= 0.7 + 0.8 + 0.9 + 0.8 + 0.8 + 0.7$$

$$= 4.7$$

Where

Col - Color Contrast

FCom - Form Complexity

Font - Type of Font

SRat - Size Ratio

WSpace - Whitespace

Align – Alignment

Based on the calculation of the aesthetic value of O and C for UI01 for expert R1 it is calculated as follows:

$$M_{UI01R1} = O_{UI01R1} / C_{UI01R1}$$

$$= 4.6 / 4.7$$

$$= 0.979$$

85

Table 5.5

Measurement for IxD Design Container for Home Design

UI Code	UI01-Home													
Respondent	**Order (O) - O01**						**Complexity (C) - C01**						**Birkhoff - Measure (M01)**		
	Sym	**Seq**	**Bal**	**Prop**	**Rhy**	**Sim**	**Col**	**FCom**	**Font**	**SRat**	**WSpace**	**Align**	**(O)**	**(C)**	**M=O/C**
R1	0.8	0.8	0.6	0.7	0.8	0.9	0.7	0.8	0.9	0.8	0.8	0.7	4.6	4.7	0.979
R2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	6.0	1.000
R3	1.0	0.9	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.8	6.0	0.967
R4	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.9	1.0	5.5	5.8	0.948
R5	0.9	0.9	0.9	0.8	0.8	1.0	0.9	0.9	1.0	1.0	0.9	0.9	5.3	5.6	0.946
AVG	0.92	0.9	0.88	0.86	0.9	0.98	0.92	0.94	0.98	0.94	0.92	0.92	5.44	5.62	0.968

Table 5.6

Measurement for IxD Design Container for Display and List of DGN Design

UI Code	UI02-Display and List														
	Order (O) - O01						Complexity (C) - C01						Birkhoff - Measure (M01)		
Respondent	Sym	Seq	Bal	Prop	Rhy	Sim	Col	FCom	Font	SRat	WSpace	Align	(O)	(C)	M=O/C
R1	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	1.0	0.9	5.5	5.6	0.982
R2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	6.0	1.000
R3	0.7	0.6	0.7	0.7	0.6	0.4	0.4	0.5	0.3	0.6	0.7	0.6	3.7	3.1	1.194
R4	1.0	1.0	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	0.9	1.0	5.7	5.9	0.966
R5	1.0	1.0	1.0	0.9	0.9	0.8	0.9	0.9	0.8	1.0	0.8	0.9	5.6	5.3	1.057
AVG	0.94	0.9	0.9	0.88	0.86	0.82	0.84	0.86	0.82	0.9	0.88	0.88	5.3	5.18	1.040

Table 5.7

Measurement for IxD Design Container for Display DGN Details Design

UI Code	UI03-Display DGN Details														
	Order (O) - O01						Complexity (C) - C01						Birkhoff - Measure (M01)		
Respondent	Sym	Seq	Bal	Prop	Rhy	Sim	Col	FCom	Font	SRat	WSpace	Align	(O)	(C)	M=O/C
R1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	5.4	5.5	0.982
R2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	6.0	1.000
R3	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.8	0.5	0.8	0.8	0.9	5.2	4.7	1.106
R4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	5.4	5.4	1.000
R5	0.9	0.9	0.8	0.8	0.8	0.9	0.9	0.8	0.9	0.8	0.7	0.8	5.1	4.9	1.041
AVG	0.9	0.9	0.9	0.9	0.9	0.92	0.92	0.88	0.86	0.88	0.86	0.9	5.42	5.3	1.026

Table 5.8

Measurement for IxD Design Container for Display DGN in PDF View

UI Code	UI04-Display DGN														
	Order (O) - O01						Complexity (C) - C01						Birkhoff - Measure (M01)		
Respondent	Sym	Seq	Bal	Prop	Rhy	Sim	Col	FCom	Font	SRat	WSpace	Align	(O)	(C)	M=O/C
R1	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9	1.0	1.0	0.9	0.9	5.5	5.6	0.982
R2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	6.0	1.000
R3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.9	0.7	0.9	5.4	4.8	1.125
R4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	6.0	1.000
R5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	5.4	5.4	1.000
AVG	0.94	0.94	0.94	0.94	0.94	0.96	0.94	0.94	0.88	0.96	0.9	0.94	5.66	5.56	1.021

Table 5.9

Measurement for IxD Design Container for Read and View DGN in Flipping Book Design

UI Code	UI05-Read and View DGN in Flipping Book														
	Order (O) - O01						Complexity (C) - C01						Birkhoff - Measure (M01)		
Respondent	Sym	Seq	Bal	Prop	Rhy	Sim	Col	FCom	Font	SRat	WSpace	Align	(O)	(C)	M=O/C
R1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9	5.4	5.5	0.982
R2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	6.0	6.0	1.000
R3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.5	0.6	0.7	0.9	5.4	4.4	1.227
R4	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	0.9	0.9	0.9	5.5	5.7	0.965
R5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	5.4	5.3	1.019
AVG	0.92	0.92	0.92	0.92	0.92	0.94	0.94	0.9	0.88	0.86	0.88	0.92	5.54	5.38	1.039

90

Table 5.5 until 5.9 shows a detailed description of the data for UI01 to UI05 according to experts coded using R1, R2, R3, R4, and R5. Based on the literature, a high aesthetic value is between the values of 0 (lowest) and 2 (highest). By measuring the aesthetics of DGN using the BAM method, the result of the expert evaluation shows that the value is in the figure 0.9 to 1.2 which shows the aesthetic value of the developed DGN archetype is interesting based on the measurements evaluated by the expert.

The results of the study show that all DGN interfaces produced are in the range of high aesthetic value. The high aesthetic value shown in user feedback using SUS and suggests that experts find the DGN archetype interface visually appealing, well-organized, and enjoyable to use. The BAM score, which assesses design beauty and appeal, works well here because it follows the universal design principles like balance and simplicity that most people appreciate. This high aesthetic appeal can create positive impressions, increases user satisfaction, builds trust in the design, and encourages users to return and experience both engaging and memorable.

5.5 Summary

This chapter assesses a DGN centered on Malaysian culture, specifically Islamic and moral elements, and intended for children aged 8 to 10. The DGN was created utilizing a web-based platform called DGN Mall, which may be found at https://ruangprojek.com/dgn/. BAM was chosen as the evaluation model because of its benefits. As stated in the previous section, DGN Mall is an online resource for young people to access DGNs. There are three types of users: platform administrators, DGN designers, and DGN readers. The basic DGN reader can just read the DGN; however, the registered reader can read and rate the DGN to help improve and support

the artwork. Registered users can also access DGNs that have been limited by the creator. The aesthetic value of the DGN archetype is evaluated using the Birkoff's Aesthetic Measure aesthetic formula and the evaluation is evaluated by five experts in the field mentioned in this chapter. BAM is calculated based on the formula $M = O/C$ where O is the order that shows the arrangement of principles of design that is related to the IxD-based DGN model and C is the complexity that is a component that influences the designer or developer's efforts in designing the DGN interface. In addition, usability was assessed through the SUS based on responses from 33 users. The DGN Archetype platform received a score of 72.3, indicating moderate usability. While most users found the system generally effective and user-friendly, challenges were noted in navigation and mobile accessibility. These findings highlight the importance of continuous usability testing to ensure the platform not only delivers educational value but also offers a satisfying user experience. Future enhancements should prioritize improving mobile responsiveness and navigation to boost user engagement.

CHAPTER SIX

CONCLUSION AND FUTURE WORK

6.1 Overview

This section reviews and summarizes the research findings obtained about the objectives. The main objective of this study is to design and develop the extended version of the existing model of DGN. To achieve this main objective, three specific objectives have been proposed.

The first objective aims to identify aesthetic values and measurements for DGNs. This objective addresses the first study question, "What are aesthetic values and aesthetic measures that affected the DGN design?". SLR is used to achieve the first objective, which involves implementing a problem identification process to collect the aesthetic value and aesthetic measures in designing DGN. SLR is discussed and explained clearly in section 3.2, which also includes a detailed explanation of the study question's findings. Data obtained using SLR was recorded and analysed using Google Sheets and Microsoft Excel. The report findings were summarized and analysed in the reference lists. The result is utilized to divide the major research depending on research questions using specific software to store databases.

The second objective is to design and develop the extended model of IxD-based DGN. For this objective, an extended process has been implemented for the existing model based on the data found from the first objective. This objective is achieved through the extension and verification phases of the model described further in Chapter 4. Expert review is used in the process of producing an extended model based on Nielson

(1995). There were five experts selected to evaluate the proposed extended model. The model was then evaluated to determine if it complied with the IxD-based DGN and validated the extended model. Experts have suggested beneficial solutions in the implemented verification process. For the second objective of the study, a semi-structured interview was used to collect data. This approach provided a balance between structure and flexibility, allowing meaningful conversations to unfold while still focusing on key topics. It also gave participants the space to share their thoughts openly, with room for follow up questions based on their responses. The proposed extended model uses five dimensions based on the Interaction Design Foundation website. The previous model was only restricted to designing interactions based on the previous IxD dimension and focused on the content dimension and visual narrative grammar (VNG) design.

Finally, the last objective of this study is to evaluate the extended model of IxD-based DGN using Birkhoff's Aesthetic Measure. BAM is the mathematical evaluation of aesthetic evaluation. To accomplish this objective, a DGN archetype design needs to be developed to test the visual design based on the proposed extended model. Once again, expert review is used to make an assessment. The experts were given ten scale measurements starting from very poor (0) to very good (10) to evaluate the DGN and provide feedback to the questionnaire. The value is converted to the correct BAM values once the response is collected. The evaluation process of the DGN archetype interface is based on the extended IxD. As for C, six (6) components have been identified to influence the effort required to understand the visual design of DGN. Based on the literature, a high aesthetic value is between the values of 0 (lowest) and 2 (highest). By measuring the aesthetics of DGN using the BAM method, the results

94

of the expert evaluation show that the value is in the figure 0.9 to 1.2. The results of the study show that all DGN interfaces produced are in the range of high aesthetic value.

6.2 Contributions of Study

The study introduces several theoretical and practical contributions, especially in the fields of Interaction Design, Human-Computer Interaction, and visual design. The main contribution is an extended IxD-based DGN model where aesthetic values and aesthetic assessments are captured for the design of digital novel graphics. Aesthetic assessment using mathematical evaluation using the Birkhoff's Aesthetic Measure was also one of the theoretical and practical contributions to the study. The following sections describe the contribution of this study.

6.2.1 Extended Model of IxD-Based Digital Graphic Novel

The main contribution of this study was the development and improvement of the Extended Model of IxD-Based Digital Graphic Novel. This model is based on the theoretical conclusions of a comprehensive literature study of prior research, as well as developments gathered from previous improved models. The previous framework was designed on three interaction elements: IxD Form, IxD Behaviour, and IxD Content. The model shows in Chapter 4, Figure 4.6 is organized from five IxD components: words, visual representation, physical objects or space, time, and behavior. Furthermore, the approach focuses on DGN's aesthetic assessment and visual design. In theory, this model improved the developer's DGN when building a visually appealing archetype. It also has an impact on researchers studying interaction

design. The model consists of five IxD elements and an aesthetic value element, which includes seven aesthetic values that impact the IXD element in visual design.

6.2.2 Aesthetic Measure using Birkhoff Aesthetic Measure for DGN

BAM is an approach used to assess geometric or artistic object aesthetics. The idea of BAM is to close the gap between art and mathematics by developing a formula that measures aesthetic value. It's also applicable to a variety of other forms of art. This study uses BAM, the DGN archetype designed based on the suggested extended model, to measure the aesthetic value of digital designs. It is one of the techniques for evaluating aesthetics that can be applied in addition to other techniques like subjective measurements using questionnaires, surveys, or reviews. BAM is categorized as an algorithmic method because it involves aesthetic evaluation based on its own algorithm. It is also seen as easier than evaluating aesthetics with a neurological or psychological approach. BAM assesses aesthetic value using the order-to-complexity ratio formula.

This study affects how designers working with interactions assess their work, particularly in designing digital graphic novel. Based on previous chapter, the results show individual and average scores for each UI interface (UI01 to UI05) rated by five experts (R1–R5). The aesthetic values range between 0.9 and 1.2, representing that the DGN Mall's visual design achieves a high aesthetic appeal. These values reflect a visually appealing, cohesive, and user-friendly interface, which aligned with universal design principles like balance, proportion, and simplicity.

6.2.3 Digital Graphic Novel Archetype

The archetype contributes to various benefits to DGN researchers, teachers, and children. The DGN archetype developed called DGN Mall which can be accessed via the link https://ruangprojek.com/dgn/. This archetype was developed based on design interaction characteristics from the findings of this study. The aesthetic value of the designed interface is also tested through BAM. This archetype has several advantages that can be a support tool for students, teachers, and parents. In addition, the archetype can also be a platform for comic creators to share their work with readers. DGN archetype turns a digital comic or graphic novel into reading material in the form of storybooks and educational comics that teach important concepts in a narrative format. It makes the learning process more enjoyable. The combination of pictures and text for storytelling has made DGN a popular medium for children and adults. The spread of information technology has increased mainly in internet usage, websites, and networks in various fields. The developer can apply the context to give a DGN archetype with preferred narratives.

6.3 Recommendation for Future Research

Future investigations should address the limitations of this study. The identified constraints and limitations are as follows:

1) The evaluation of DGN archetypes is mainly conducted by experts. Regular users can review DGN archetypes to assess their functioning and usability. The relationship between the design of interaction is the reason for this. This is due to the fact that a value comparison between aesthetic evaluation and usability

testing is carried out in order to evaluate and derive a correlation with interface design.

2) This DGN archetype has the potential to be adapted to many user variations. The potential of this archetype can be augmented within the content designer function. The rating systems can be expanded to include both paid and unpaid reader functions for limited or special edition works. It enhances the value and motivates comic or graphic novel artists to enhance the quality of DGN content and try to produce more high-quality work.

3) The use of BAM is a relevant study that serves as one of the approaches for aesthetic evaluation. Various mathematical evaluation methods can also be used to compare with BAM. Some evaluations that can be further researched and compared to BAM include Kolmogorov Complexity, Golden Ratio and Fibonacci Sequence, and Fractal Dimension. Mathematical evaluation enhances aesthetic evaluation by offering additional value in this field.

4) The SUS has already been conducted as part of the usability evaluation among new comic creator. For future work, it is suggested to analyze the SUS results based on different user types such as casual readers, professional content creators, or new users versus experienced users. This segmentation could offer deeper insights into how different user groups perceive the usability of DGN archetypes. By understanding the specific needs and expectations of each group, more targeted improvements can be made to the design and interaction elements of the system.

6.4 Summary

Visual storytelling is a highly stimulating approach to teaching and learning. The visual narrative has rapidly emerged as one of the most widely embraced learning modalities. The DGN offers a compelling medium that incorporates features that can enhance the user's learning experience more effectively than traditional textbooks. Interaction Design (IxD) is the field that focuses on utilizing products and services to facilitate human interactions. The objective of this research is to analyse and assess the aesthetic qualities of DGN design based on IxD, and to expand upon the existing model. The development of DGN is closely related to the growth of DGN content design. The local content is not easily accessible and lacks attraction for children. Local content is less approachable and still far from appealing to children. The major purpose of this research is to create and implement the enlarged version of the existing concept of an IxD-based digital graphic book. The significance of the study gives essential improvements to understanding in the field of IxD and DGN. The archetype was applied to the IxD-based DGN development approach and use features in the aesthetic value which are the findings of this study. This study also indicates that mathematical evaluation is suitable for testing the aesthetic values of a digital design using the Birkhoff Aesthetic Measure.

REFERENCES

Ablart, D. (2017, June). Integration of touch and taste with interactive media. In *Adjunct Publication of the 2017 ACM International Conference* on Interactive Experiences for TV and Online Video (pp. 109-112).

Abrams, R. J., Dorst's, D., & Danielewski's, M. Z. (2019). *The Readable Experimental Novel*.

Abu Yazid, A. B., Dayang Nurfaezah, A. A., & Melor, M. Y. B. (2020). Students' Acceptance to Using Graphic Novels in Learning Literature (L2): A Malaysian Case Study. *Social Sciences, Humanities and Education Journal (SHE Journal),* 1(2), 43-51.

Ali, H. A., & Husni, H. (2021). Birkhoff's Aesthetic Measure and Common Aesthetic Values in Digital Design. *Advanced Journal of Technical and Vocational Education*, 5(3). https://doi.org/10.26666/rmp.ajtve.2021.3.1

Ali, H. A., & Husni, H. (2022). Exploring The Aesthetic Values and Components of Digital Graphic Novels: A Systematic Review. Journal of Creative Industry and Sustainable Culture, 1, 49-70. https://doi.org/10.32890/jcisc2022.1.3

Altaboli, A., & Lin, Y. (2011, July). Objective and subjective measures of visual aesthetics of website interface design: the two sides of the coin. In *International Conference on Human-Computer Interaction* (pp. 35-44). Springer, Berlin, Heidelberg.

Antonini, A., Brooker, S., & Benatti, F. (2020). Circuits, Cycles, Configurations: An Interaction Model of Web Comics. In *Interactive Storytelling* (pp. 287–299). Springer. https://doi.org/10.1007/978-3-030-62516-0_26.

Arumugam, K., & Rohaya, M. A. (2019). Buku kanak-kanak: Analisis unsur Estetika. *Pendeta Journal of Malay Language, Education and Literature*, 10, 151-165.

https://doi.org/10.37134/pendeta.vol10.11.2019

Ayer, M. (2014). Interactive graphic novels: A hybrid advertising technique. Elon *Journal of Undergraduate Research in Communications*, 5(2).

Aziz, J., Mustaffa, N., & Hamzah, N. (2021). Proposing transmedia storytelling for Malaysian film industry: Thematic consideration. *Jurnal Komunikasi, Malaysian Journal of Communication*, 37 (4), 56–69. doi:10.17576/JKMJC-2021-3704-04

Bader, J. D., & Lowenthal, P. R. (2018). Using visual design to improve the online learning experience: a synthesis of research on aesthetics. In *Learner Experience and Usability in Online Education* (pp. 1-35). IGI Global.

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. *Intl. Journal of Human–Computer Interaction*, 24(6), 574-594.

Barbre, J. O. (2019). Crafting a Critical Literacy Skillset: An Improved Use of Visual Modalities. *International Journal of Education and Literacy Studies*, 7(2), 139-143.

Begoray, D., & Brown, A. (2018). Empowering Indigenous Learners through the Creation of Graphic Novels. *Journal of Media Literacy Education*, 10(3), 132-151.

Benyon, D. (2019). *Designing User Experience: A Guide to HCI, UX and Interaction Design*. Pearson.

Biese, A. J. (2021). *The Power of the Panel: How American Comic Book Media Utilizes the Panel to Alter Audience Interaction* (Doctoral dissertation, Michigan Technological University).

Bleier, A., Harmeling, C. M., & Palmatier, R. W. (2019). Creating effective online customer experiences. *Journal of Marketing*, 83(2), 98-119.

101

Bleier, A., Harmeling, C. M., & Palmatier, R. W. (2019). Creating effective online customer experiences. *Journal of Marketing*, 83(2), 98-119.

Candi, M., Jae, H., Makarem, S., & Mohan, M. (2017). Consumer responses to functional, aesthetic and symbolic product design in online reviews. *Journal of Business Research*, 81, 31-39.

Chen, S., Kamarudin, K. M., & Yan, S. (2021, April). Product innovation: a multimodal interaction design method based on HCI and TRIZ. In *Journal of Physics: Conference Series* (Vol. 1875, No. 1, p. 012012). IOP Publishing.

Cnattingius, L. (2021). *Analyzing the effect of animated transitions on the user experience of mobile interfaces*.

Cohn, N. (2013). Visual narrative structure. *Cognitive science*. 37, 413-452. DOI: 10.1111/cogs.12016.

Cohn, N. (2014). The architecture of visual narrative comprehension: the interaction of narrative structure and page layout in understanding comics. *Frontiers of psychology*. Vol 5, July. 1-9. DOI: 10.3389/fpsyg.2014.00680.

Cohn, N. (2019). Being explicit about the implicit: inference generating techniques in visual narrative. *Language and Cognition*, 11(1), 66-97.

Cook, M. P., & Kirchoff, J. S. (2017). Teaching multimodal literacy through reading and writing graphic novels. *Language and literacy*, 19(4), 76-95.

Cooney, D. (2011). Writing and Illustrating the Graphic Novel. Barrons.

Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). *About face: the essentials of interaction design*. John Wiley & Sons.

Crucifix, B., & Dozo, B. O. (2018). *E-Graphic Novels*. The Cambridge History of the Graphic Novel, 574-590.

Darejeh, A., & Singh, D. (2013). A review on user interface design principles to

increase software usability for users with less computer literacy. *Journal of computer science*, 9(11), 1443.

Degott, C., Borges Jr, N. P., & Zeller, A. (2019, July). Learning user interface element interactions. In *Proceedings of the 28th ACM SIGSOFT International Symposium on Software Testing and Analysis* (pp. 296-306).

Derisma, D. (2020). The usability analysis online learning site for supporting computer programming course using system usability scale (SUS) in a university.

Dunst, A., & Hartel, R. (2021). *Computing Literary Surplus Value: Alan Moore and the Density of the Comic Book as Graphic Novel.* Anglia, 139(1), 195-223.

Dunst, A., Hartel, R., & Laubrock, J. (2017, November). The graphic narrative corpus (GNC): design, annotation, and analysis for the digital humanities. In 2017 14th *IAPR International Conference on Document Analysis and Recognition (ICDAR)* (Vol. 3, pp. 15-20). IEEE.

Eisner, W. (1996). *Graphic storytelling and visual narrative*. Paramus, NJ: Poorhouse Press

Farah Nadia, A., Syamsul Bahrin, Z. & Norshuhada, S. (2016). Comics in academia: a visual insight to its trends & innovation. *International Journal of Interactive Digital Media (IJIDM)*, 4(2), 7-12.

Fenty, N. S., & Brydon, M. (2020). Using Graphic Novels to Engage Students

Fernandez, A., Insfran, E., & Abrahao, S. (2011). Usability evaluation methods for the web: A systematic mapping study. *Information and software Technology*, 53(8), 789-817.

Fischer, D., Stanszus, L., Geiger, S., Grossman, P., & Schrader, U. (2017). Mindfulness and sustainable consumption: A systematic literature review of research approaches and findings. *Journal of Cleaner Production*, 162, 544-558.

Forsey, J. (2017). Aesthetic experience, aesthetic value. *Estetika: The Central European Journal of Aesthetics*, 54(2), 175-188.

Friesen, J., Van Stan, J. T., & Elleuche, S. (2018). Communicating science through comics: a method. *Publications*, 6(3), 38.

Gardner, H. (2006). *The development and education of the mind: The selected works of Howard Gardner*. Routledge.

Gaziulusoy, İ. (2021). Designing future experiences of the everyday: Pointers for methodical expansion of sustainability transitions research. *Futures*, 127, 102702.

Goffin, K. (2019). The affective experience of aesthetic properties. *Pacific Philosophical Quarterly*, 100(1), 283-300.

Golding, S., & Verrier, D. (2020). Teaching people to read comics: the impact of a visual literacy intervention on comprehension of educational comics. *Journal of Graphic Novels and Comics*, 1-13.

Gomes, C. C., & Preto, S. (2018, January). Artificial intelligence and interaction design for a positive emotional user experience. In *International Conference on Intelligent Human Systems Integration* (pp. 62-68). Springer, Cham.

Grimm, S., & Meeks, A. (2017). Break the stereotype! Critical visual literacy in art and design librarianship. Art Documentation: *Journal of the Art Libraries Society of North America*, 36(2), 173-190.

Hallowell, M. R., & Gambatese, J. A. (2010). Qualitative research: Application of the Delphi method to CEM research. *Journal of construction engineering and management*, 136(1), 99.

Hammond, H. K. (2009). *Graphic novels and multimodal literacy: a reader response study*.

Hargadon, E. E. (2019). Using Graphic Novels to Motivate Readers. *The Reading Teacher*, 72(4), 529-530.

Hefter, M. H., ten Hagen, I., Krense, C., Berthold, K., & Renkl, A. (2019). Effective and efficient acquisition of argumentation knowledge by self-explaining examples: Videos, texts, or graphic novels?. *Journal of Educational Psychology*, 111(8), 1396.

Hermann, A., Ferré, S., & Ducassé, M. (2012, October). Guided semantic annotation of comic panels with sewelis. In *International Conference on Knowledge Engineering and Knowledge Management* (pp. 430-433). Springer, Berlin, Heidelberg.

Hughes, J., & Morrison, L. (2014). *The evolution of teaching with graphic novels. Jeunesse: Young People, Texts, Cultures*, 6(2), 116-127.

Husni, H., Jamaludin, Z. & Alobaedy, M. M. (2021). An IxD-based model for digital graphic novels. *Technical Report*, Fundamental Research Grant Scheme (FRGS)1/2017/ICT04/UUM/01/1.

Jamaludin, Z. (2015). Digital graphic novels: Technology enhanced narrative for learning.

Jamaludin, Z. (2017, May). Modeling a digital graphic novel. In 2017 *8th International Conference on Information Technology (ICIT)* (pp. 344-350). IEEE.

Jiang, Z., Wang, W., Tan, B. C., & Yu, J. (2016). The determinants and impacts of aesthetics in users' first interaction with websites. *Journal of Management Information Systems*, 33(1), 229-259.

Joo, H. (2017). A study on understanding of UI and UX, and understanding of design according to user interface change. *International Journal of Applied Engineering*

Research, 12(20), 9931-9935.

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *Journal of advanced nursing*, 72(12), 2954-2965.

Khalighy, S. (2015). *Product design methodology supporting aesthetic evaluation* (Doctoral dissertation, University of Glasgow).

Kirchoff, J. S., & Cook, M. (2015). Overviewing Software Applications for Graphic Novel Creation in the Post-Secondary and Secondary Classroom. *SANE Journal: Sequential Art Narrative in Education*, 2(1), n1.

Kitchenham, B. (2004). *Procedures for performing systematic reviews*. Keele, UK, Keele Univer-sity, 33(2004), 1-26.

Kraus, S., Schiavone, F., Pluzhnikova, A., & Invernizzi, A. C. (2021). Digital transformation in healthcare: Analyzing the current state-of-research. *Journal of Business Research*, 123, 557-567.

Kucirkova, N., & Flewitt, R. (2020). The future-gazing potential of digital personalization in young children's reading: views from education professionals and app designers. *Early Child Development and Care*, 190(2), 135-149.

Kumar, R. (2018). Research methodology: A step-by-step guide for beginners. Sage.

Kurniawan, E., Nofriadi, N., & Nata, A. (2022). Penerapan System Usability Scale (Sus) Dalam Pengukuran Kebergunaan Website Program Studi Di Stmik Royal. *Journal of Science and Social Research, 5(1), 43-49.*

Kuttner, P. J., Weaver-Hightower, M. B., & Sousanis, N. (2021). Comics-based research: The affordances of comics for research across disciplines. *Qualitative Research*, 21(2), 195-214.

La Cour, E., Grennan, S., & Spanjers, R. (2022). Introduction: Key Terms in Comics

Studies. In *Key Terms in Comics Studies* (pp. 1-357). Palgrave Macmillan, Cham.

Lee, J., Kim, S., & Kim, H. (2021). *Interaction Design: Beyond Human-Computer Interaction*. Wiley.

Lee, T., Pham, K., Crosby, A., & Peterson, J. F. (2021). Digital collaboration in design education: how online collaborative software changes the practices and places of learning. *Pedagogy, Culture & Society*, 29(2), 231-245.

Leong, T. (2013). *Super graphic: A visual guide to the comic book universe*. Chronicle Books.

Li, N. (2024). *Analysing the interaction design of motion graphics in mobile UI.* Proceedings of the 3rd International Conference on Innovation Design and Digital Technology (ICIDDT 2023). https://eudl.eu/doi/10.4108/eai.3-11-2023.2342167.

Linnes, C., & Metcalf, B. (2017). iGeneration and their acceptance of technology. *International Journal of Management & Information Systems (IJMIS)*, 21(2), 11-26.

Mahamod, Z., & Noor, N. A. M. (2011). Persepsi guru tentang penggunaan aplikasi multimedia dalam pengajaran komponen sastera bahasa Melayu. *GEMA Online Journal of Language Studies*, 11(3).

Mamat, R., Abd Rahim, N., Affendi, N. R. N. M., & Rashid, R. A. (2019). Perkembangan Komik dan Animasi: Satu Kajian Perbandingan antara Melayu dan Jepun. *Jurnal Komunikasi: Malaysian Journal of Communication*, 35(2).

Marianthi, V., Boulodakis, M., & Retalis, S. (2016). *From digitised comic books to digital hypermedia comic books: their use in education.* Piraeus: University of Piraeus, 1.

Marlatt, R., & Dallacqua, A. K. (2019). Loud and Clear: Using the Graphic Novel to

Challenge the Status Quo in Content Area Literacy. *Journal of Language and Literacy Education*, 15(1), n1.

Matuk, C., Hurwich, T., Spiegel, A., & Diamond, J. (2021). How do teachers use comics to promote engagement, equity, and diversity in science classrooms?. *Research in Science Education*, 51(3), 685-732.

McClanahan, B. J., & Nottingham, M. (2019). A suite of strategies for navigating graphic novels: A dual coding approach. *The Reading Teacher*, 73(1), 39-50.

McKenney, S., & Reeves, T. C. (2018). *Conducting educational design research*. Routledge.

Meltzer, D., & Williams, M. H. (2018). *The apprehension of beauty: The role of aesthetic conflict in development, art and violence*. Harris Meltzer Trust.

Mohamad Khairi, H. O. (2016) Pembentukan Akhlak Pelajar Menerusi Aplikasi TeknikTeknik Penerapan Nilai dalam Pengajaran. *The online journal of Islamic education*. April 2016, Vol. 4 (1). 58-70.

Mohd Zulkifli A. G. (2010). Adab-adab islam dalam kehidupan. *Persekutuan Republik Arab Mesir*.

Moore, A. B., Nowostawski, M., Frantz, C., & Hulbe, C. (2018). Comic strip narratives in Time geography. *ISPRS International Journal of Geo-Information*, 7(7), 245.

Neuman, S. B., Wong, K. M., Flynn, R., & Kaefer, T. (2019). Learning vocabulary from educational media: The role of pedagogical supports for low-income preschoolers. *Journal of Educational Psychology*, 111(1), 32.

Newman, M., & Ogle, D. (2019). *Visual Literacy: Reading, Thinking, and Communicating with Visuals*. Rowman & Littlefield Publishers.

Ngo, D. C. L., Samsudin, A., & Abdullah, R. (2000). Aesthetic measures for assessing

graphic screens. *J. Inf. Sci. Eng*, 16(1), 97-116.

Nielsen, J. (1995). *How to conduct a heuristic evaluation*. Nielsen Norman Group, 1(1), 8.

Nielsen, J., & Molich, R. (1990). Heuristic Evaluation Of User Interfaces. *Proceedings Of The SIGCHI Conference On Human Factors In Computing Systems*, (April), 249–256. Https://Doi.Org/10.1145/97243.97281

Nikolajeva, M. (2005). *Aesthetic approaches to children's literature: An introduction*. Scarecrow Press.

Norman, D. (2013). *The design of everyday things: Revised and expanded edition*. Basic books.

Oliinyk, V. (2021). A graphic novel as a popular genre of book publishing in the context of modern design. *Linguistics and Culture Review*, 5(S4), 942-954.

Ortega, M. (2020). *Engaging English Language Learners Through the Use of Graphic Novels*.

Pagliaro, M. (2014). Is a picture worth a thousand words? Determining the criteria for graphic novels with literary merit. *English Journal*, 103(4), 31.

Pandey, R. (2022). Impact of Aesthetics in Innovative Product Development on Consumer Perception and Acceptance. *ECS Transactions*, 107(1), 9915.

Pantaleo, S. (2013). Paneling "matters" in elementary students' graphic narratives. *Literacy Research and Instruction*, 52, 150-171.

Pantaleo, S. (2014). Reading images in graphic novels: Taking students to a "greater thinking level." *English in Australia*, 49(1), 38-51.

Pantaleo, S. (2018). Elementary students' meaning-making of graphic novels. *Language and Education*, 32(3), 242-256.

Peng, C. (2020). Isu-isu Perkembangan Sastera Siber di Malaysia. *Jurnal Peradaban*

Melayu, 4, 93-110.

Ponsard, C., & Fries, V. (2008.). An Accessible Viewer for Digital Comic Books. *Computers Helping People with Special Needs*, 569–577.

Putri, A. (2019, July). Digital Graphic Novel as a Learning History Media in Digital Literacy Era. In *6th International Conference on Educational Research and Innovation (ICERI 2018)*. Atlantis Press.

Rajendra, T. R. (2018) . Multimodality in Malaysian Schools: The Case for the Graphic Novel. *MOJES: Malaysian Online Journal of Educational Sciences*, [S.l.], v. 3, n. 2, p. 11-20. ISSN 2289-3024. https://mojes.um.edu.my/article/view/12691.

Razak, R. A. (2013). Pembelajaran Berasaskan Penghasilan Penceritaan Digital Multimedia Bagi Menganalisis Novel Bahasa Melayu. *Jurnal Pendidikan Malaysia*, 38(1), 53-64.

Rigaud, C., & Burie, J. C. (2018). Computer vision applied to comic book images. In *Empirical Comics Research* (pp. 104-124). Routledge.

Rigaud, C., Guérin, C., Karatzas, D., Burie, J. C., & Ogier, J. M. (2015). Knowledge-driven understanding of images in comic books. International *Journal on Document Analysis and Recognition (IJDAR)*, 18(3), 199-221.

Rizvic, S., Boskovic, D., Okanovic, V., Sljivo, S., & Zukic, M. (2019). Interactive digital storytelling: bringing cultural heritage in a classroom. *Journal of Computers in Education*, 6(1), 143-166.

Roberts, R., Stair, K. S., & Granberry, T. (2020). Images from the Trenches: A Visual Narrative of the Concerns of Agricultural Education Majors. *Journal of Agricultural Education*, 61(2), 324-338.

Rogers, Y., Sharp, H., & Preece, J. (2011). *Interaction design: beyond human-*

computer interaction.

Rosenberg, B. (2018). A Case for the Inclusion of Graphic Novels in the Classroom

Rosly, N. S., Rahim, N. A., & Halim, H. A (2016). Interaksi Ujaran Kanak-kanak Menerusi Elemen Pendigitalan dalam Penceritaan. *GEMA Online Journal of Language Studies*, 16(1).

Roth, C., Vorderer, P., & Klimmt, C. (2009, December). The motivational appeal of interactive storytelling: Towards a dimensional model of the user experience. In *Joint International Conference on Interactive Digital Storytelling* (pp. 38-43). Springer, Berlin, Heidelberg.

Saffer, D. (2010). *Designing for interaction: creating innovative applications and devices*. New Riders.

Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. MIT Press.

Saputro, D. M. (2019). *Evaluasi Kualitas Estetika Fasade Bangunan Dengan Pendekatan Birkhoff Aesthetic Measure*. Studi Kasus: Seturan Boarding House, Yogyakarta (Doctoral dissertation, Universitas Islam Indonesia).

Sayılgan, O. (2023). Exploring Interactivity in Digital Comics: A Multifaceted Analysis of Sequential Storytelling. *Interactive Film & Media Journal*, 3(1), 97–105. https://doi.org/10.32920/ifmj.v3i1.1687

Serafini, F. (2017). Visual literacy. In Oxford Research Roth, C., Vorderer, P., & Klimmt, C. (2009, December). The motivational appeal of interactive storytelling: Towards a dimensional model of the user experience. In *Joint International Conference on Interactive Digital Storytelling* (pp. 38-43). Springer, Berlin, Heidelberg.

Short, J. C., & Reeves, T. C. (2009). The graphic novel: A "cool" format for

communicating to generation Y. *Business Communication Quarterly*, 72(4), 414-430.

Smith, G. C. (2007). What is interaction design. *Designing interactions*, 8-19.

Syamsul Bahrin, Z., Farah Nadia, A., & Norshuhada, S. (2019). Instrument for evaluating digital educational comic. *International Journal of Advanced Computer Research*, 9(44), 316-324.

Truong, T (2012). Exploring Secondary Students' use of a Web-based 2.0 Tool to Compose Digital Graphic Novels. The *3rd Annual International Conference on TESOL*, Danang, Vietnam.

Tseng, C. I., & Bateman, J. A. (2018). Cohesion in comics and graphic novels: An empirical comparative approach to transmedia adaptation in City of Glass. Adaptation, 11(2), 122-143.

Vakos, P. (2013). "Why the Blank Stare? Strategies for Visual Learners." New York:

Wallace, M. (2017). Graphic Novels: A Brief History, Their Use in *Business Education, and the Potential for Negotiation Pedagogy. Negotiation and Conflict Management Research*, 10(4), 324-335.

Winarti, A., Yuanita, L., & Nur, M. (2019). The Effectiveness of Multiple Intelligences Based Teaching Strategy in Enhancing the Multiple Intelligences and Science Process Skills of Junior High School Students. *Journal of Technology and Science Education*, 9(2), 122-135.

Wong, K. M., & Neuman, S. B. (2019). Learning vocabulary on screen: A content analysis of pedagogical supports in educational media programs for dual-language learners. *Bilingual Research Journal,* 42(1), 54-72.

Yu Siang, T. (2020, July 25). *What is Interaction Design? The Interaction Design Foundation*. https://www.interaction-design.org/literature/article/what-is-

interaction-design

Zaini, H., & Dewi, K. (2017). Pentingnya media pembelajaran untuk anak usia dini. *Raudhatul Athfal: Jurnal Pendidikan Islam Anak Usia Dini*, 1(1), 81-96.

Zhang, Z., & Hao, Y. (2021, July). Research on Emotional Design of Visual Interaction Based on Cognitive Psychology. In *International Conference on Human-Computer Interaction* (pp. 472-481). Springer, Cham.