

## DIGITAL GRAPHIC NOVELS: TECHNOLOGY ENHANCED NARRATIVE FOR LEARNING

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**ABSTRACT.** The effectiveness of digital graphic novels (DGN) has never been measured from the perspective of interaction design (IXD) although previous studies regarded DGN as having materiality and multisensoriality characteristics which were crucial for most purposes and territories, especially for students' learning. Teaching a dry graduate course with most of the traditional methods has been too dull to reinforce concepts taught in the classroom. This paper proposes DGN for learning difficult subjects such as 'research methods' and 'Islamic values'. The DGN however, must be of a well-crafted content based on abstractions of real life events. Methods of abstracting the content and enhancing the narratives in producing a DGN are provided. The DGN prototypes were developed and experimented with real graduate students. The results have proven a number of interesting facts about IXD in DGN and the desirability of DGN as one of the promising learning tools.

**Keywords:** digital graphic novels, interaction design, narrative for learning, pattern-based storyline

### INTRODUCTION

A graphic novel (GN) or a novel in a comic-strip format, uses sequential art to tell a story just like a comic book, but having complex plots with its beginning, middle and end as well as a main character that develops through conflicts and climax. Every part in a GN panel plays a role in the interpretation of the texts, and thus GN actually demands sophisticated readers (Petrovic, 2010; Hughes & Morrison, 2014; Cohn 2014). Major types of graphic novels, including Manga (the Japanese style comic), superhero stories, personal narratives or 'perzines', fiction and non-fiction. When digitized, a GN is considered as digital graphic novel or DGN.

In studying digital graphic novels, narratives for learning can be operationally defined as a series of respondents' real life experience, given in order and with established connections between them. The experiences must be filtered, abstracted, and enhanced to produce a solid learning content. As such, this study examines methods in abstracting the narratives and enhancing it with the help of technology to produce a DGN. The DGN is to be used as a tool to overcome one of the many problems in teaching and learning difficult courses at higher degree level. In order to do so, the contents of the narratives must first be analysed, converted into DGN, and then be evaluated for its effectiveness. So that in the end, we can prove that DGN is one of a legal and legitimate learning tool to be utilized in the form of teaching materials, assignments, or any other tangible learning objects such as the one adopted by The University of Colorado. In fact the university provides its own massive open online courses

(MOOCs) on comics and graphic novels via Coursera (<https://www.coursera.org/course/comics>).

### **The Paradox: DGN Benefit and the Reluctance to Accept**

GN has inspired generations of students and scientists. They are desirous science fiction readers that cause the GN to regain its popularity and make people realised its impact (Smetana, Odelson, Burns, & Grisham, 2009; Downey, 2009). GN with its visual characteristic can convey information that is sometimes difficult to articulate with words (Refer an example in **Figure 1**). Some students cannot invoke images from texts they read thus they are dependent on visual cues from GN. When digitized, digital graphic novels (DGN) can be equipped with interactive techniques and enhanced graphics features (such as morphing), which in turns help reduce ambiguity in understanding the subjects learned. Cohn (2013, 2014), who developed a visual language concept to the cognition of comics and GN, has claimed that DGN could establish parallels between how students comprehended sequential images and how they understood other modalities of communication. Such attributes would ultimately help them to engage and think out-of-the-box.



**Figure 1. An Example- GN Carries Meaning and Becomes a Supportive Way to Check if Students' Interpretation is Acceptable**

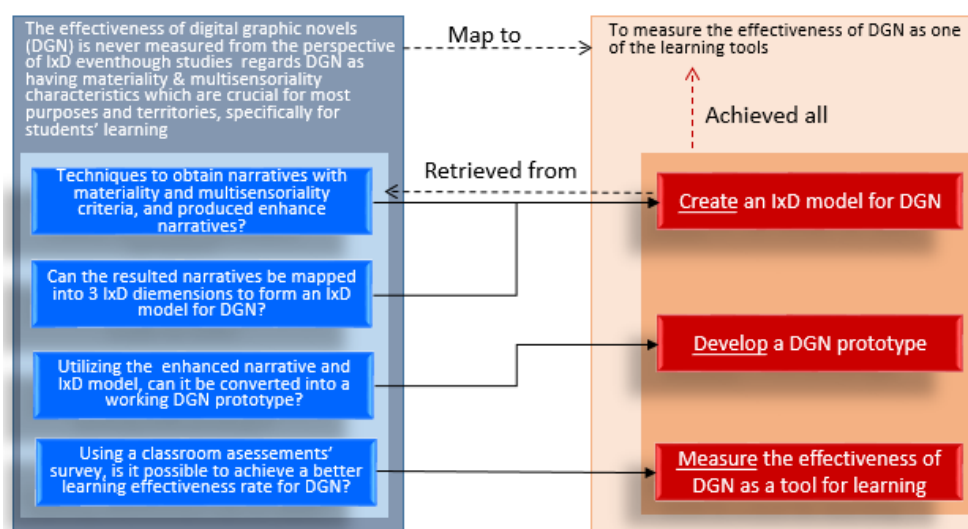
In spite of the obvious benefit of DGN, there is still some reluctance to accept DGN as a 'worthy' read, and that the students should read 'real' books (Hughes & Morrison, 2014). As a result of this reluctance, DGN has been largely an out-of-school endeavour. Although there is some progress where university libraries began to set up a corner in the library for GN and Manga collections, their inclusion in classes have been extremely slow, in the context of the world, and almost none in Malaysia. But the fact that it is progressing and thus increasing in educational market, it is a good sign for GN. But DGN, on the other hand, has never been measured in terms of its effectiveness of learning. DGN has been regarded as having materiality and multisensoriality characteristics which were crucial for most purposes and territories, especially for students' learning. Fail to measure the effectiveness will negatively impact students and struggling readers (Yang, 2008) in learning difficult and plain subjects. This is because DGN has potentials, but jumping into it without proper validation will lead to failure – both for DGN and students. Thus, measuring the effectiveness of DGN (both, its model and prototype), that was developed in compliance with IxD rules and using an abstraction method, could test the truth of the claim and remedy the situation.

### **Issues to Address**

With regards to measuring the effectiveness of DGN, this article addresses the question on techniques to obtain appealing narratives for DGN that can fulfil the 'materiality' criteria – i.e. being physical and consist of events/scenario that really matter. Then, are we able to en-

hance the narratives to invoke readers' senses, through DGN images that can 'say and tell' what words cannot accurately capture? Can we map All three IxD dimensions namely form, content and behaviour, to the enhanced narratives in order to produce an IxD model for DGN? Later, can the model be applied into a working DGN prototype? And finally, using the resulted prototype as a learning tool in a classroom assessment survey, is it possible to achieve a better learning effectiveness rate? By answering the questions we hope to be able to measure the effectiveness of DGN from the learning perspective, based on Kirkpatrick's evaluation model (Kirkpatrick & Kirkpatrick, 2006).

In specific, the sub-objectives of this study are to create an IxD model for DGN, develop the DGN prototype based on the model, and measure the effectiveness of the resulted DGN as a tool for learning. In a nutshell, **Figure 2** summarises the problem to be investigated, the research questions to be addressed, and the objective to be attained.



**Figure 2. The Mapping of the Problem, Questions and Objectives of this Study**

There are four deliverables of this study namely, a technique to obtain narratives with materiality criteria, an IxD model for DGN, the DGN prototype, and an effectiveness measure of DGN for learning.

### Why Graphic Novels?

There has been a presumption that students were often not motivated by simply seeing texts in the textbook. They preferred graphics before texts. GN is quicker to read than a prose novel, yet there is no shortage of literary worth in it (as in *Watchmen* by Alan Moore & Dave Gibbons and *Maus* by Art Spiegelman). GN and DGN have been claimed to be more attractive, appealing, motivating and less threatening due to the usage of the pictures. The picture and images given in a solidly build storyline can help students, not only reach an understanding of the content, but learn new vocabulary words, progress with the narrative, and support for text interpretation (Prensky, 2001; Hassett & Schieble, 2007; Thompson, 2007; Hughes & Morrison, 2014). For additional points, Downey (2009) asserted that the images in GN support students in denoting "particular thematic connotations, purposes or ideas". GN normally leaves the readers with many experience because those readers 'live several lives' while reading (Griffin, Homsy & Stelzig, 1985).

Smetana, Odelson, Burns & Grisham, (2009) also have discussed the use of GN in teaching English and concluded that the visual nature of GN provided a context-rich, high-interest environment for acquiring new vocabulary, contextual support and clues to the meaning of

the written narrative, help demystify the text, and increase comprehension. They also claimed that the use of GN in classrooms not only encouraging students to read, but also acquiring higher order thinking skills (analyse, interpret, and create). This is because the images in GN enable students to decode facial and body expressions, the symbolic meanings of certain images and postures, metaphors and similes, and other social and literacy nuances (even a subtle difference in meaning/opinion /attitude) (Simmons, as cited in Bucher & Manning, 2004). This is why today, many universities have extensive collections of original comic art for scholarly studies. One example is the Ohio State University's Billy Ireland Cartoon Library & Museum (<http://cartoons.osu.edu>).

With regards to intelligence, GN's benefit has been acknowledged by Howard Gardner, a Harvard psychologist. He asserted that three out of seven human intelligences can benefit from the use of GN. The three are linguist, spatial, and interpersonal intelligences (Lytga & Lyga as cited in Downey, 2009). The use of colours, lights, shadows and lines in the images also influence the tone and mood of the story (Smetana et al 2009). All these are the elements taken into account in designing interaction, and such is why IxD plays an important role in DGN.

The effect of DGN, however, depends much on engaging content in a logical, sequential order (Cary as cited in Smetana, Odelson, Burns & Grisham, 2009). Such is the reason why content generation has been handled separately in this study, through which real life experiences were compiled to create a representative, compelling narrative.

## **THEORIES: VISUAL NARRATIVE GRAMMAR AND INTERACTION DESIGN (IxD)**

Cohn (2014) measured reaction times and brain activities, then finalized his 'visual narrative grammar' theory, to show the relationship between the system that has been used by the readers and meanings of sequential images comprehended. The theory contended that the creation of meaning across sequential images have relied on a "narrative grammar" that packaged conceptual information into categorical roles organized in hierarchic constituents. These images were encapsulated into panels arranged in the layout of a page (physical/screen). Believing that narratives allow students to establish emotional connection with the events/phenomena depicted in the DGN, we combine this theory with IxD in order to enhance the 'digital' qualities of a DGN.

IxD is the art of facilitating interactions between human through products and services. By definition, IxD is 'the practice of designing interactive digital products, environments, systems and services' (Cooper, Reinmann & Cronin, 2007). IxD is contextual in which it serves its purpose for its time and context. IxD solves specific problems under a particular set of circumstances. For example, every second in a day, people interact via e-mails,Whatsapps, and smart phones. All these are made possible by good engineering but, it is IxD that makes them usable, useful, and fun. Poor IxD can make people suffer, like poor phone interface make us struggle to synchronise our phone to our computer. IxD theory stated that in designing a new interaction in a product (in our case, the DGN), is to note which other agents will be local to the new interaction and then to examine the likely effects any existing interactions might have on the new interaction. By doing so, we enhance the chance that new interactions will succeed when they are eventually introduced into the interaction space (Coiera, 2003).

When we decided to apply the IxD theory in DGN, our focus has been on all three dimensions of IxD. First, on how images could be enhanced with a variety of digital multimedia elements such as audio, animation, sound effect, user control and interactivity. Those were towards the representation of the senses in DGN, or better known as the form of IxD. Second we were interested in studying the actual engagement of DGN with human senses during the

learning. This was because we anticipated that each enhancement on any DGN element might effect existing ‘interaction’ in DGN. The engagement level has been a result of all dimensions of IxD -- the form, content and behavior of the product.

### THE METHOD TO OBTAIN NARRATIVE PATTERN & THE IxD MODEL

To achieve the first sub-objective, i.e. obtaining narratives that are appealing enough for the target students (university students). One of the criteria of an appealing narrative was the story contains events/scenario that really matters to them. This event could be best obtained from real teenagers’ experience (Zulikha, 2011 & Farthing, 2014). Twenty four respondents from Kedah (6), Perlis (6), Selangor (6), and Kelantan (6), aged between 17-24, have been interviewed in very informal sessions. The tabulation of the respondents is shown in Table 1. The respondents willingly agreed to participate in the study and showed keen interest in telling their life stories. Total time taken for the interview has been about 112 hours, averaging at 4.5 hours per respondent. The actual duration spent was about 2 years due to difficulty in getting respondents, available time (for both, the researcher and the respondents), missing respondents (incomplete experience shared), and cases where parents did not allow us to continue further.

**Table 1. The Respondent Tabulation – Narrative Providers**

AGE	HOW MANY OF THEM?
17	2
18	3
19	4
20	4
21	4
22	4
23	2
24	1
TOTAL	24

The stories were written and some recorded (for those who allowed) and then transcribed as narrative. The narratives, treated as data from now on, were tabled according to themes. It was found out that all narratives contain 31 themes altogether, with a story having 5-11 themes. This finding implied that each user story/experience was made up of 7 themes, on average.

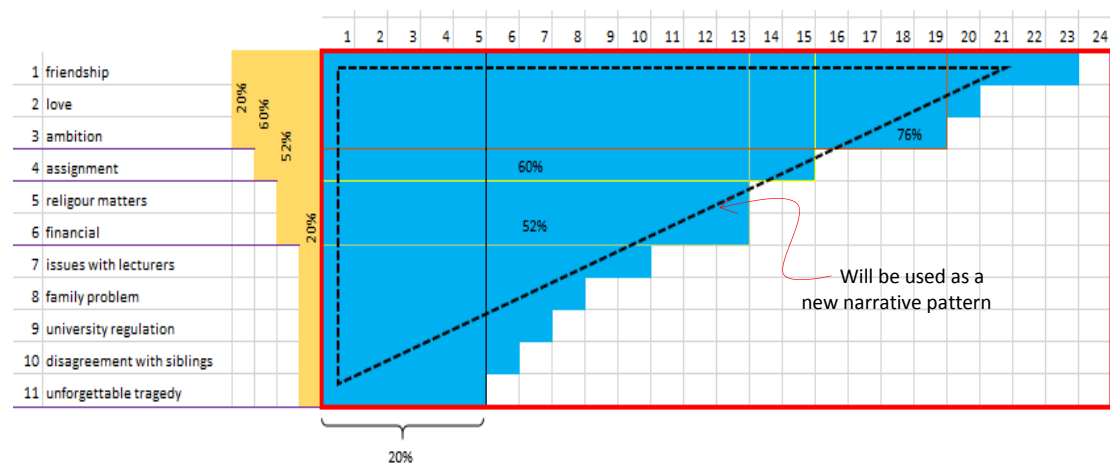
The data, when analysed, have fallen under eleven major categories namely, friendship (23 respondents), love (20), ambition (19), assignments (15), religious matters (13), financial (13), issues with lecturers (10), family problems (8), university’s regulation (7), disagreement with siblings (6), and unforgettable tragedy (5). There were a few other isolated issues like drug, fame, husband-wife, and travelling. **Figure 3** is a snippet of the raw data tabulated.

Rspdt	Locat	age	area	Real story	theme extracted											total theme per respondent
					1	2	3	4	5	6	7	8	9	10	11	
1 M	22	Kelantan	St1	1	2	19	20	9	12							6
2 M	20	Kelantan	St2	2	19	21	22	5	12							6
3 M	23	Kelantan	St3	1	2	19	20	21	14							6
4 M	18	Kelantan	St4	1	2	19	22	9								5
5 M	22	Kelantan	St5	1	2	20	22	9	5							6
6 M	19	Kelantan	St6	1	2	19	22	9	26	16						7
7 B	22	Selangor	St7	1	19	21	22	9	4	25						7
8 B	21	Selangor	St8	1	19	20	21	5	4	6	15					8
9 K	21	Selangor	St9	1	2	19	20	21	5	26						7
10 K	24	Selangor	St10	1	2	19	21	9	5	26						7
11 K	20	Selangor	St11	1	2	19	20	12	25							6
12 K	21	Selangor	St12	1	2	19	22	12	24							6
13 K	22	Kedah	St13	1	2	22	5	9	4	10						7
14 K	17	Kedah	St14	1	2	19	20	21	22	4	10	6	31	24		11
15 K	18	Kedah	St15	1	2	19	22	5	14	26						7
16 K	19	Kedah	St16	1	2	19	20	21	4	17						7
17 K	18	Kedah	St17	1	2	20	21	4	18	25						7
18 M	18	Kedah	St18	1	2	21	22	9	26							6

**Figure 3. The Themes per Respondent, in the Narrative**

**Figure 4** shows 20% of the stories covers all categories, while 76% covers 3 categories namely friendship, love and ambition. The pattern provides adequate input for the comic content. The pattern indicates that a system of shared patterned exists within the user experience.

Using the finding, a direct-mapping tabulation was done to create a single storyline touching all the 12 categories, but given proportionate weight as shown by the triangle inside **Figure 4**.



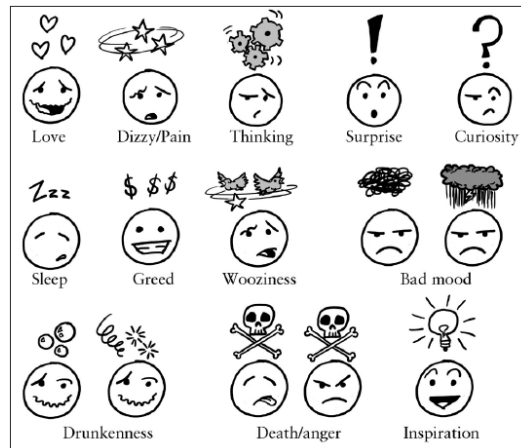
**Figure 4. A Narrative Pattern Produced from the Frequency Matrix of Respondents (24) and Themes (11)**

The structure of the storyline in our DGN has been based on the new narrative pattern (**Figure 4**) and the IxD dimensions, as justified in the previous section. The structure of the narrative could be articulated further with the support of IxD principles. The DGN too, would benefit by employing the principles in its form (the visuals), content (the storyline and the newly crafted story) and behavior (how the user interface of the DGN behaved upon user interactions).



## IxD Model for DGN

The look and feel of a digital product is one of the three dimensions of IxD. The look and feel of DGN are commonly represented in comic-like panels. The idea of embedding ‘upfixes’ (Cohn, 2014) too, has been becoming common in delivering more meaning with less texts. *Upfixes* are the floating objects over the head and it was claimed that they helped in speeding up the process of comprehending the desired meaning. **Figure 5** shows samples of *upfixes* proposed by Cohn (2013).





**Figure 5. Examples of *Upfixes* Suggested by Cohn (2013:42)**

Panels, *upfixes*, layout, buttons, and other interface objects are among the ‘form’ dimension of IxD which need to be gathered for requirement establishment. The storyline and narrative described in the previous section are the requirements for ‘content’ dimension of IxD. The DGN behavior is the third dimension to be included as part of the requirements.

The IxD form, relies heavily on visual language. For the kind of DGN we intended to obtain, this visual language is a choice of a three-manifestation of visual language, namely the American (Superhero, Comic strips), Japanese (Manga), and Central Australian Visual Languages (other graphic representations and signs to augment spoken conversation). All kinds of visual variations should be grouped under the ‘form’ dimension of IxD. **Table 2** lists common features in a GN that falls under the category of ‘form’.

**Table 2. Common Features in a GN**

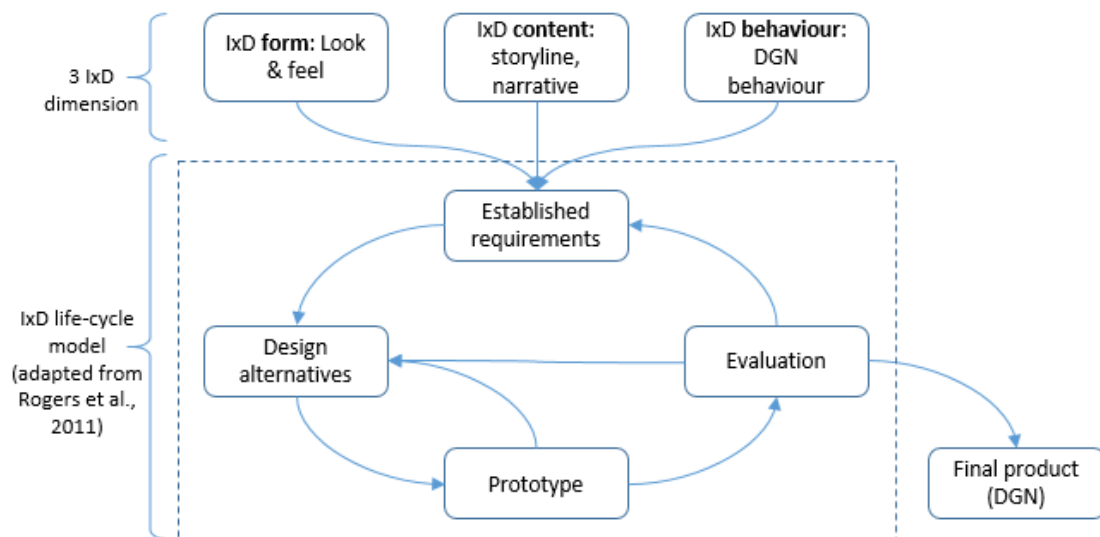
Feature		Meaning/use
Pictures or illustrations		To provide context and help reader visualize what is happening; to provide visual meaning to the story.
Words and texts		To show talking, thinking, sound effects and narrations.

Captions		To describe the situation, context, and none of the characters is talking.
Panels and gutters		<p>Panels: To guide reader to read in sequence and to provide the order of the story.</p> <p>Gutters: To show transition to a new scene or setting.</p>
Speech bubbles		To show a character is talking.
Thought balloons		To show a character is thinking.
Upfixes		To help in speeding up the process of comprehending the desired meaning without using texts.

The IxD content is the narrative obtained from the newly crafted storyline based on the themes' pattern in **Figure 4**. The content development process involves translating the new storyline narrative into drawings to produce the intended GN. Actors are created with resemblance of the real respondents' characteristics in terms of age, gender, social status, and attitudes. This method of producing content has some similarity to the use of persona in IxD (Cooper, Reinmann, & Cronin; 2007) whereby it model the self that is informed by complexity theory to the user/reader. The 'crafted' content can then be compiled into the storyline with addition of planned knowledge, skill, moral, ethical and cultural values. This way, the character's strength of the model of the self can be preserved, extended, and reinforced to be operationalised as virtuous behavior in the GN. Teaching material can be included (as part of the planned knowledge and skill) within the context of the story, guided by the new storyline.

The behavior dimension of IxD refers to the panel transmission, panel closure, voice on demand, and other user controls via the user interface to be provided in DGN. These components serve as the established requirements for the DGN prototype. **Figure 6** illustrates the model, which incorporates the IxD life-cycle model adapted from Rogers, Sharp and Preece (2011).



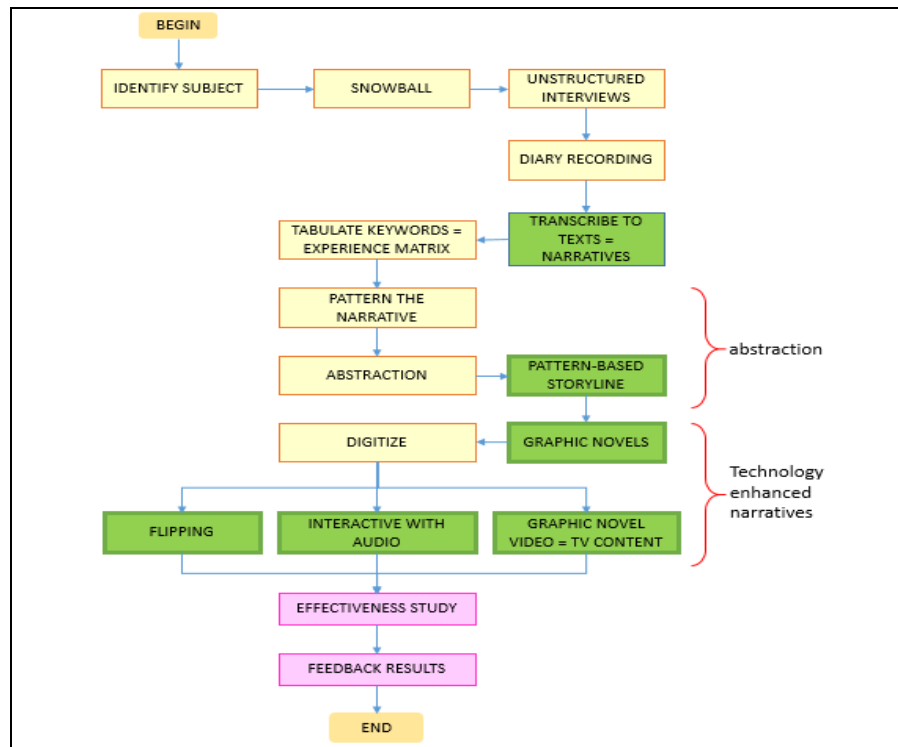


**Figure 6. IxD Life-Cycle Model for Digital Graphic Novel**

By proposing the model, we addressed the second question posed in this study, i.e. to utilize the resulted narrative in mapping it to all three IxD dimensions. As such, we have achieved the first sub-objective of the study.

## THE PROTOTYPE DEVELOPMENT

The question posed earlier was to find out if we could convert the model, by utilizing the enhanced narrative into a working DGN prototype. The model in **Figure 6** is promising enough, but we need to prove it with a working prototype. The DGN components, categorized into all 3 IxD dimensions have served as the established requirements for the DGN prototype. We came out with three kinds of design alternative for DGN namely a flipping GN, a video-based GN with speech narration and an interactive GN. The overall process of the development is simplified in **Figure 7**.



**Figure 7. The Development Process and the Evaluation of DGN**

The low fidelity prototype was first designed in the form of paper prototype. We produced a paper-based GN, which has been manually drawn and coloured. The drawing posed another challenge because it requires us to create and select appropriate images to convey a range of meanings from concrete information to concepts and abstract expression. The completed physical GN was then scanned (digitised) to produce the high fidelity prototype, in three design alternatives. The first one, a flipping GN, was developed using flipsnack ([www.flipsnack.com](http://www.flipsnack.com)). This prototype had a look and feel similar to physical GN where users could flip the pages and choose pages to read via page thumbnails. An extra feature of the digitized version was that the pages could be enlarged. **Figure 8** is a snippet of the flipping version of the GN.



**Figure 8. A Snippet of the Flipping Version of the GN**

The second prototype, video-based GN with speech narration, has been developed using Jing and published via YouTube. This prototype had a common look and feel of any YouTube videos. Additional features were the speech narration and voice-over for the texts in the bubbles. **Figure 9** and **Figure 10** are snippets of the video-based version and an interactive version of the GN, respectively. Three alternative designs were not the throwaway prototype. All were used in the evaluation with real users (students).



**Figure 9. The Video-Based GN with Narration and Voice Over**

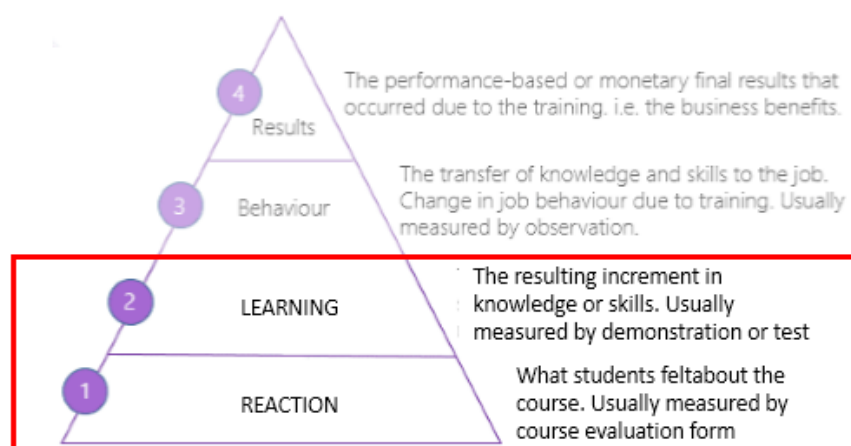


**Figure 10. The Interactive Version of the GN**

This section shows how we have achieved our second sub-objective, i.e. to develop a DGN prototype using the enhanced narrative and the proposed DGN's IxD model.

## EVALUATING THE EFFECTIVENESS OF DGN

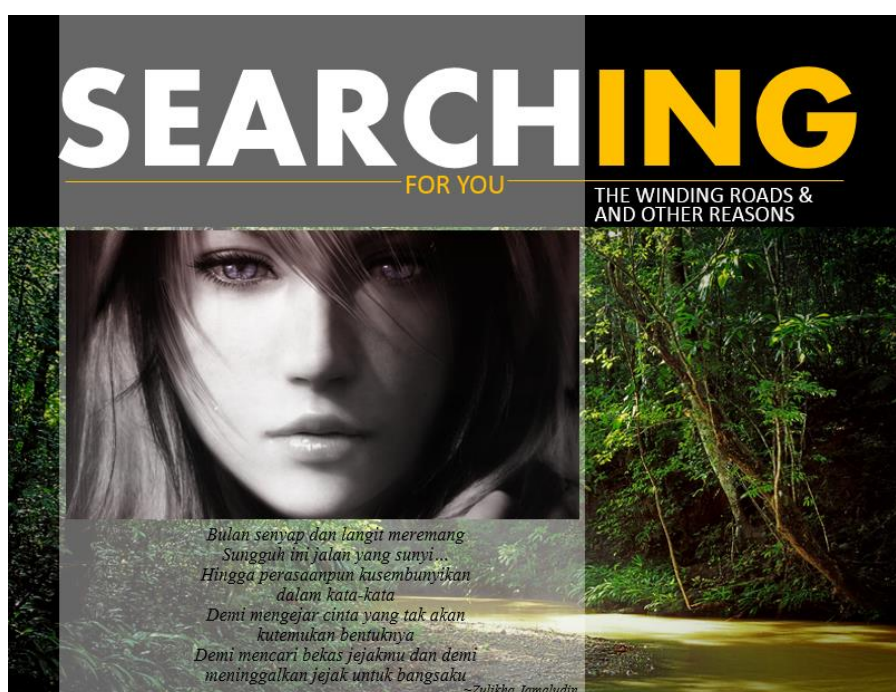
Kirkpatrick's model (Kirkpatrick & Kirkpatrick, 2006) has been adopted in evaluating the effect of students' learning via DGN. The model strived on four dimensions in evaluating the impact of a learning program, i.e. reaction, learning, behavioural change, and results. This study has specifically utilised the first and second dimension of the model since the purpose was to conclude on (1) what students felt about the course when DGN was used as a tool for learning and (2) whether there has been any increment in their tests results. These were the purpose of the 2 dimensions of Kirkpatrick's model, as summarised in **Figure 11**.



**Figure 11: Level 1 (Reaction) and 2 (Learning) of Kirkpatric Evaluation Model (Kirkpatric & Kirkpatric, 2006)**

## DGN for Teaching a University Course

For the purpose of evaluation, the resulted prototype has been used in teaching a Masters' degree course, i.e. Research Methodology course. Why this course? This was one of the courses that has many new terms and difficult concepts. Webster (2005), Cohn (2013) and Cohn (2014) claimed that students gain a better understanding of concepts when comics are used to teach the concepts. The understanding mostly came through the connections they made to the illusion, satire, irony, and parody in the stories. Also, this course requires students to be equipped with writing skill and DGN has been an effective way to teach outlining skills. Using a DGN, the students were able to understand that each panel represents a paragraph. The caption represents the topic sentence, and other details could be found in the visuals and dialogue. The sophistication of DGN to be utilized in the Research Methodology course is thus justified. **Figure 12** is the cover page of the DGN used in the course. The title is "Searching for you: The winding roads and other reasons" (*Jalan berliku menuju rintang ranting pencarian*).



**Figure 12. The Flipping Version of the DGN--its Cover Page**

Students have been given the opportunity to download and go through the flipping version of DGN. The first time DGN was introduced to the class, the students were taught how to read all the 'codes' in a DGN. Researchers (Dallacqua, 2012; Gallo & Weiner, 2004; Pantaleo, 2011) urged that the students needed to "see", not merely looked at, the illustrations, the words, and the events in the story. The story has been embedded with significant research methods content.

A total of 42 students have involved in the study that spanned through 3 semesters. 15 students were from intake 1, 13 from intake 2 and 14 from intake 3. The instructional procedure involves students explaining the content of the DGN to class members, which have been divided into 4 islands, in the form of discussions, writing, drawing—their choice. On top of the normal lectures they have to attend, they have been given the DGN and are left to explore the DGN without any push, at their own free time.

## The Assignments and Results

For this course, students had to complete 6 assignments namely a proposal critique, teaching module, creating a DGN (for a given research concept), preparing a poster for their kind of research, a quiz and a research proposal. The assessment accounts for 15%, 15%, 15%, 10%, 15%, and 30% respectively.

The evaluation has been done on the (1) *reaction*, i.e. what students felt about the course when DGN was used as a tool for learning, and (2) *learning*, i.e. whether there has been any increment in their test results. *Polleverywhere* has been used ([www.polleverywhere.com](http://www.polleverywhere.com)) to gather data from 42 students on the two levels of effectiveness measures. On reaction, the result is shown in **Table 3**, whereas on learning, the result is shown in **Table 4**.

**Table 3. Students' Reaction (3 Intakes)**

Scores	Level of understanding % (rated by students)		
	80-100%	50-79%	Less than 50%
Proposal critiques	25	40	35
Teaching assignment	20	60	20
Graphic novel (teaching research concepts)	<b>78</b>	22	0
Poster	<b>65</b>	25	5
Quiz	20	55	25
Research Proposal	30	55	15

**Table 4. Students' Learning**

Assessment type	% distribution	Average score intake 1-3
Proposal critiques	15	68
Teaching assignment	15	69
Graphic novel (teaching research concepts)	15	<b>89</b>
Poster	10	<b>80</b>
Quiz	15	54
Research Proposal	30	72

For assessment type: GN, they had to produce their own version of DGN to explain a certain research concept, such as *thesis statement*, given to them. These terms were those that have never been covered in lectures, only included in the DGN they had downloaded. Tools used by the students were mostly free tools include *storyboardthat*, *videoscribe*, *makebeliefscomix*, *writecomix*, *pixton*, *chogger*, *creaza*, *toondoo*, *xtranormal*, *bitstips* and many others of their own choice and favour.

Graphic novels and posters have been rated highest in the category of 80-100% understanding. These two types of assessments produced the highest score too. This result for both reaction and learning has indicated *obvious* positive results for DGN specifically. On average, 78% of the students chose/rate 80-100% understanding level for DGN, and none think of it as less than 50% understandable. On top of that, the average score for assessment where they were required to prepare the DGN for explaining particular research concepts, is 89%. This score has been by far the highest of all other assessments' score.

In summarizing the result of measuring the effectiveness of DGN, we could say that most students (78%) believed they understand more content by learning from DGN and they also proved it by obtaining the highest score (average 89 per 100 points) score better rate for assignments requiring them to explain research concepts using DGN. Thus, it was not just making them understand the subject matter better, but making them familiar with DGN and able to produce their own version of DGN. The data have revealed that postgraduate students too



can benefit from DGN, and learning from it affected not only their response, but also their score.

## CONCLUSION AND FUTURE WORK

While we, Malaysian, still view DGN as a reading that can never make the leap, people in Europe and Japan view DGN extremely useful for teaching and learning. This study was carried out because we perceived DGN as having educational potential. They can help at least, as shown in this study, with understanding and scoring better. The results somewhat prove that DGN lends itself to useful learning and is uniquely suited to modern students (Gen-Y) even at postgraduates level. DGN is indeed a powerful attractor for students of all ages. For educators, bringing it to classroom will also bring new ideas and new perspective in teaching method.

In retrospective, this paper has addressed the issues on techniques to obtain appealing narratives for DGN, to enhance the narratives in order to produce an IxD model for DGN, to apply the model into a working DGN prototype, and finally, to measure the effectiveness of the prototype (and thus approving the model) in terms of its reaction and learning level according to Kirkpatrick's evaluation model. We have had a positive results for both levels. Even so, we realise that the result of this study is unlikely to change the minds of those deeply entrenched in opposition to the potential of DGN, but at least we have shown that DGN can be used as another tools to bridge what students have already known with what they have yet to learn.

However, more research need to be done before rushing to include DGN in the curriculum because what we have proven is that DGN can bridge the understanding. Our experiment coverage is not yet adequate to prove that DGN can be one of the top selected instructional material. This is because of the challenge in producing suitable DGN content. A large section of this study has concentrated on methods in producing the appealing content for target audience. We believe that content appeal can be generated based on compiling real life experience. Such is a big challenge to bring DGN to the mainstream.

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