Finding "Appeal" Factors in Local Animation Character Design: Formalistic and Visual Semiotic Analysis (FVSA)

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ABSTRACT

This research aims to understand the 'appeal' factor in local animated character design. 'Appeal' is one of the 12 principles of animation design and is often considered ambiguous. To achieve 'appeal,' one of the methods used is Viewer's Impression Words (VIW), which is a modification of Kansei Words (KW). This method combines formalistic theory and visual semiotic to achieve Viewer's Impression Words (VIW), an essential part of Kansei Engineering. The results of this experiment, it can be concluded that this method is able to help the participants choose the appropriate VIW word and towards the next activity that is the process of loose principles. This method is suggested as a new technique to improve the process in obtaining VIW or Kansei Words to use in the measurement exercises to find the affect (emotion) in understanding 'appeal.' This is to achieve loose principles in local animated character design.

Keywords: Viewer' Impression Words, User-Centered Design, Character Design

ABSTRAK

Penelitian ini bertujuan untuk mengetahui faktor 'daya tarik' dalam desain karakter animasi lokal. 'Daya tarik' adalah salah satu dari 12 prinsip desain animasi dan sering dianggap ambigu. Untuk mencapai 'daya tarik', salah satu metode yang digunakan adalah Viewer's Impression Words (VIW) yang merupakan modifikasi dari Kansei Words (KW). Metode ini menggabungkan teori formalistik dan semiotik visual untuk mencapai Viewer's Impression Words (VIW), bagian penting dari Kansei Engineering. Hasil penelitian daripada ujikaji ini, dapat disimpulkan bahawa metod ini mampu untuk membantu peserta ujikaji memilih kata VIW yang sesuai seterusnya ke arah aktiviti selanjutnya iaitu proses prinsip longgar. Metode ini dilihat sebagai teknik baru untuk memperbaiki proses dalam memperoleh VIW atau Kansei Words untuk digunakan dalam latihan pengukuran untuk menemukan pengaruh (emosi) dalam memahami 'daya tarik.' Ini untuk mencapai prinsip longgar dalam desain karakter animasi lokal.

Kata kunci: Kata Impressi Penonton, Desain Berasaskan Pengguna, Desain Karakter

INTRODUCTION

The 'Kansei Engineering' method is referred to to achieve new loose principles in designing interesting local animated characters. Before this study began with a formalistic and visual semiotic approach,

the literature review referred to different areas other than the animation domain, such as user experience (UX) and User interface (UI). Different domains are referred because there are limited resources in User-Centered Design (UCD) and 'Kansei Engineering' methodologies on local animated character design (Soikun & Ibrahim, 2018).

In the field of UX / UI, the practice of combining both qualitative and quantitative methods is done to investigate human reactions, and quantitative data calculation is commonly used (Mozyrko, 2020). In this research, local animation character design investigation is done by adapting the UX / UI research style, which uses the Kansei Engineering approach. It is one of the methods used in 'User-Centered Design.'

LITERATURE REVIEW

The semiotic theory derives its name from the Greek word 'semeion,' which means sign. Much cultural development research uses semiotic theory in different ways. Semiotics uses a system called 'code' to read or translate statements from invisible units. Compared to verbal-linguistics, writing, audio, and voice, in semiotics, visual language can be better known and understood. Referring to Chandler (2007), semiotics is the study of signs. Reviews on signs can take place anywhere. In everyday life, signs can also be road signs, company signs, and so on.

Chandler also states that human beings are driven by a tendency to create meaning through the creation and interpretation of 'signs.' Signs are in the form of pictures, sounds, words, smells, tastes, actions, or objects. However, all these things have no intrinsic meaning, and they become a sign only if they are invested in purpose. Because animated images are produced by artists, it also can be interpreted as having intrinsic

meaning. Something that gives signs can be modified into loose principles to help artists and other designers understand or deepen the sense of the image (Soikun & Ibrahim 2018).

Two dominant models are today. It comes from linguist Ferdinand de Saussure and philosopher Charles Sanders Piers. Saussure defines a sign consisting of a 'Signifier' or a form taken from that mark and a 'signified' (marked) or concept and purpose it represents. Signs are the whole that stems from the relationship of the (Signifier) with the marked (Signified). The relationship between Signifier and signified is known as 'marker' or signification. The sign must have a Signifier and the 'signified.' It cannot have meaningless or shapeless markers. A sign is a combination that can be identified from a marker with a specific mark. Similar markers can sometimes show different signs. Charles Sanders Peirce formulated his model as a "semiotic and taxonomic sign."

Signs can be read as denotative and connotative. This is a term that connects between the Signifier and the signified. Two types of signified: Signified denotation and Signified connotative, are used for analysis, which differs from each other (Chandler 2007). Although different, when generating meaning, it will include denotation and connotation. Denotation is the literal meaning of a particular sign; for example, the word 'orchid' indicates a kind of flower. Denotation in photography can be seen through the digital reproduction of images. For example, cats are cats, while connotations are the result of human intervention, such as focus, lighting,

Table 1: Visual semiotic analysis: a reference from the De Saussure semiotic model (Soikun, T., & Ibrahim, A. A. 2018).

Drawing Features	Signifier	Signified			
Sea creatures	A group of colorful and big jellyfish	Peaceful and a very balanced ecosystem. The peaceful area normally resents a more tense future as in the "calm before the storm." Drawing, color, hue, and hapes suggest a mysterious yet tempting to know further about the drawing and the story.			

depth, special effects, and so on (Tomaselli, 1996). Fiske (1982) explains that denotation is what is drawn; the connotation is how it is drawn. The connotation is also the secondary meaning of a sign and is often motivated by culture. For example, blood pictures show violence in certain cultures.

Citing the study of the animation character in Makyung, it uses visual and formalistic analysis to identify general pattern attributes or semiotic shapes and proportions (Mohd Yusoff 2014). Visual analysis is used to determine the required animation character costumes. The costume images are analyzed in the form of a 'table,' which is placed in an instrument called the costume matrix (Tsukamoto, 2006). The costume matrix is further classified into bodywear, lids/footwear, ornaments, makeup, ties, and many more.

When examining visual analysis, there are no guidelines or rules that must be

followed. As stated by Mohd Yusoff (2014), in the study, no rules and guidelines are achieved. However, visual semiotics can personally provide an intuitive approach to gain a better and more reliable design. This is supported by other research on local animated character design that also uses semiotic theory by Khalis & Mustafa (2017). They show that animation contributes to the cultural industry through symbols and signs and is taken through different community lifestyles and various sources, including religion, belief politics, traditions, languages, systems, costume tools, buildings, and the arts. With reference to semiotic theory, these researchers have successfully identified the cultural influence on the artwork produced by their animation students studying art and design. This is through the use of content analysis in analyzing the complete final artwork. This analysis focuses on traditional culture and clothing, and visual semiotics look at the relevance of cultural elements influencing student design.

According to Tomos (2013), in anime, formalistic interpretation begins with the development of Japanese visual aesthetics in the twelfth century of the Heian Age. Traditional art forms using wood paintings and prints (Yamato-e) are characterized by thin lines to show facial expressions, wiki me-Kagihana, or straight lines for eye designs and hooks to illustrate nose designs. Formal analysis in anime opens up the direction of science, where the similarities found in the techniques of some animations have created a unique style of anime. The same technique is

used by limited cell animations such as 'Sega Eiga' or line drawing films. This technique draws attention to the behavior and facial expressions of individual characters, telling their stories. Another feature of Japanese animation determined from the formalistic analysis is known as 'Ma' or 'silent breath', where the actor pauses to reflect on time and space, a reflection on the space between events. Tomos (2013) has mentioned in his writing, 'Genji Monogatari,' which is described as the first novel in the world with more than 400 characters gradually increasing age consistently in the story. The main emphasis of the novel is on character characterization.

Saidi & Budiwaspada (2015) work entitled "Visualization and Transformation of the Body in Animated Films "Planes "looks into an animated film that uses inanimate objects as its characters. The animators of the animation transform the characters from 'dead' to something that holds life. By using structural and semiotic analysis methods, it was found that the transformation is carried out beyond the means of personification rhetoric the dead become alive). The research had use semiotic as a means to identify the character traits in the animation, which hold similarities in reaching 'appeal.' The goal of the research was achieved by at least two methods that are similar to each other, namely structural and semiotic. The two methods belong to the same family, which is language. The study used semiotic from the versions, namely Peirce, to solve the transformation of the body in animation through personification and metaphorization mechanisms. The study

founds that the concept of trichotomy (Peirce's Sign) is easier to use to disassemble the signs in the animation rather than Barthes's or Saussure's dichotomy. For example, in personification, certain parts on the Plane's elements (as sign) is similar to (iconic) to elements contained in the anatomy of human, or further, the elements are positioned as index and symbol.

The nature of this study, which experimental and multi-discipline nature, looks into different field domains to understand and incorporate ideas and knowledge. One such study was from Ramadin & Mulyana (2012), the research effort try to understand the meanings and signs in visual architecture objects of public spaces. One of the objectives is to compile ideas on visual signs through a relevant proxemic study approach to be processed into temporary conclusions as a reference to local authorities, entrepreneurs, academics, and also laypeople. A type of semiotic called proxemics was used in the study. Proxemics was popularized by anthropologist Edward T. Hall via his book The Silent Language and The Hidden Dimension. Proxemics is known as a non-verbal, temporary way of communication and is considered as 'space' semiotics. It is a study on how humans unconsciously building structures, namely the distance between humans in carrying out daily activities, organizing space in residence, and building up to urban zoning. The effort of this study in using semiotic or proxemic had indeed paved the way for other disciplines of study such as animation and graphic design in a multi-disciplinary approach to achieve understanding using the semiotic-related method.

Another study by Tinarbuko (2017) uses qualitative research to describe, interpret, and explain the meaning of public service advertisement connotations. Then, classified them based on the sociolinguistic theory, pragmatics, visual communication design theory, and semiotic theory. The study uses the semiotic visual communication method to analyze verbal and visual data as a method to read Public Service Advertising or PSA because of the tendency to view various data, such as arts, culture, visual communication design, and PSA as a language and phenomenon sign. The study also insists on the mastery of visual communication semiotic (Visual Semiotic) as it can be used as a verbal and visual reference for audiences to expand their imagination, insights, and knowledge on the importance of understanding the semiotic of visual communication both in the process of creating and designing PSA as well as the process of assessing public service advertising objects. The study also provides positive benefits for advertising practitioners and advertising agencies in general. The author looks inside the method of this paper, where it aims to examine verbal signs and visuals of PSA with a theoretical semiotics approach to acquire the meaning of the connotation contained behind the verbal and visual signs in PSA. It is also expected the through the visual semiotic method it is expected PSA can be classified based on signs, codes, and the meaning contained in it.

The formalistic analysis deals with formal properties of art and design, whereas semiotics deals with the meaning-making of signs and symbols. Semiotics analysis describes the specific operational rules by determining the sub-systems included in the field it examines. Considering that art is a form of visual communication language, the approach could be used to analyze animation drawings. In every animation drawing, there are meanings included, either intentional or subconscious - images transmitted to viewers of animation through drawings, either digital or traditional, unveiling sociocultural differences. Animation drawings can be analyzed based on what is shown on the screen. A synthesis called visual culture is used to determine the responses of viewers to the television, artworks, etc.

Visual culture, in contrast with formalistic analysis, lays weight in the meaning the visual conveys to the individual and society. Visuals or drawings are analyzed based on their meaning rather than their aesthetic values. The important thing to be analyzed is the cognitive content or representation in consciousness in which was formed with history and culture (Turkcan, 2013).

Semiotics deals with meaning, representing objects, language, and images in a wide sense. It is a process in which attributes meaning. A sign or images can, as something else. Often, semiotics study shows how the relationship of a sign and meaning results from experience and what we have been taught in our environment. In the visual images or culture, it is a research procedure

beyond the scope of symbolism studies. In this study, semiotics offers a different but useful perspective in the analysis of animation drawing as a formalism that rejected the relationship of meaning in its analysis. Semiotics analysis will provide a balance in finding the right keyword or Kansei words. Semiotics analysis acknowledges the variable relationship, and thus, images are look-into as dynamic. The images or drawing in this study, the animation drawing, are perceived as a complex inter-relationship between the individual (the viewer), the drawing, and factors such as society and culture.

The practice of semiotics in drawings and designs has been an ongoing effort and discussion on the importance of drawing in animation and another art field by professionals, practitioners, and educators. The article by Ashwin (1984) provided ground research and theory in analyzing drawings in the design field using a framework called semiotics (the science of signs) and has been further enhanced by a few different scholars. Drawing has always been associated with signs and has essential cultural origins that are indicated in Etymology. The German word Zeichen, meaning sign and Zeichen, for the verb to draw that is to make a sign. Similarly, the Italian word Segno, Disegno, meaning drawing, design, and Disegnafore, meaning design. The English word drawing has its roots in the action of pulling, which has a relation to the activity of drawing. He further adds that similarity in etymology is seen in the word sign and design.

Semiotics is a framework used to

categorize three types of imagery. However, these also depend on how these categories allow for understanding. The three categories in the semiotics framework are icons, indexes, and symbols. These semiotic frameworks prepared a method and provided a coordinated manner on the way meanings are interpreted on the signs or drawing by the interrelations of an object, representamen, and interpretant (M. Chapman, Ostwald, & Tucker, 2004). A sign or drawing, as it is posed in this study, can be seen as composed of two components, which are the Signifier and signified. The sign or drawing function to convey a message and communication. As such, this process involves two participants and can be called an emitter and the receiver. In this study, the animator who drew the animation drawing was the emitter, and the viewers were the receiver. The substance or messages is embedded in the drawing and exist in the set of codes. The drawings can be encoded by the emitter and decoded or interpreted by the receiver. The concept of trichotomy, the icon, indexes, and symbols, if applied to draw, the concept of iconicity is immediately obvious (Ashwin, 1984).

Animation character design, due to its nature-related design and animation, are more mimicking and resemblances of an existing occurrence — a representation of an event already familiar or experienced. The nature of drawing in animation provides a slightly different character as opposed to drawing for engineering or design; however, the application of semiotic analysis to the medium still applicable as in this study, it deals with

the final drawing of a character in animation and not immaterial form or sketches.

When it comes to animation, particularly Japanese animation or 'Anime' that is being investigated in this study, too many people, it is just animation aiming at entertaining and nothing more. However, too many more, it is much more at being only entertainment. There is much reason for such presumption, for example, the way it is presented, the style of drawing, selection of colors, characters, and the set up of the whole animation. Observation and analysis of the animation, particularly on its character drawing, using semiotics analysis will allow the understanding of its implicit values and thus authorize the Kansei Words intended for the study.

The article by Hoare (2017) points out how and where semiotics can be seen in animation. Take, for example, Anthropomorphism. This sign is understood as the representation of human characteristics used in animation characters or inanimate objects such as animals and stones. This sign assists artists and animators effectively to design traits such as happiness, love, jealousy, and so on. The understanding of these traits is possible, as these are the signs that humans can relate to. By referring to Ferdinand de Saussure, his signified and signifier theory plays a large role in the interpretations of animation character drawing. Saussure maintained that the sign was the basic unit of language. The Signifier is a statement or image that comes across our mind, such as "an animal with a very long nose." The signified statement would be very particular to the signifier statement, such as an 'elephant.' The signified statement is an image, sound that the signifier statement puts in our head. In this research, the semiotic theory by Saussure provides a procedure to acquire impressions from experts on animation characters, drawing intrinsic meaning by using Kansei Words adjectives.

There are more 'signs' that often be found in animation. These signs are based on techniques that artists used to make their work more lively. Signs such as Therianthmorphism can be seen in movies in which humans are combined with animals and beasts. Therianthmorphism, on the other hand, is a character that has the form of an animal or beast (Wells, 2002). The understanding of these animation signs may help animators to create an artwork with a precise creation of metaphors. This may help in channeling information through folktale-based animation.

Analysis of visual images, drawing, and design had used different theoretical approaches and methods; however, the most popular is Visual semiotics. Visual semiotic emphasizes the visuals to communicate to the viewers and the system dominating their usage. It also predominantly enquires into the ways through which the meaning is created rather than simply investigating what it is. The implicit meaning normally does not surface. An analysis and a process in reading it are needed in order for the meaning to appear. It also deconstructs the communicative visuals while in its attempt to attain the meaning and ideology (Parsa, n.d.). According to Kress & Leeuwen (2006), images are drawing, paintings, and photographs. He

further adds that images are the fundamental medium of information; the language role has become a medium of commentary. In this study, animation character drawings become the central focus. In support of animation, character drawing as a part of visual semiotics Barthes (1964) identifies that drawing relies on all sorts of conventions or code. He further called drawing 'rule-governed transpositions,' in which drawing establishes a code, and pen strokes can represent the signifieds. In the era of technology, some manual drawings in animation had been replaced by a digital pen, and digital drawing mostly adopted vector and bitmap drawings. However, the basic in the creation of the drawing, such as sketching and pencil strokes remains the same.

Communication using visuals has always been the predisposition of human beings since the cave paintings in Lascaux, France. Visuals are used in conveying between the emitter and receiver or viewers. Messages are embedded in visuals, which makes humans aware that they may be ignited by ideologies, experience, and myth. An analysis method or process called visual semiotics could form a hidden meaning. Semiotics has a long history and has been in use and taught in various fields of studies such as architecture, medicine, anthropology, linguistics, communication, and others. Throughout the development of semiotics, different ideas from other domains had been adopted, for example, the Prague school (1930s and early 1940s), where it developed the work of Russian formalists by adding a linguistic basis. Paris in the 1960s and 1970s adopted the idea of Ferdinand de Saussure, Roland Barthes, Metz, and so on. The development and combination of the different domains of semiotics have paved the way and created some unique new identities and criteria of semiotics called Visual Semiotics. Visual Semiotics has been first defined by Kress & Leeuwen (2006) book, Reading Image: the Grammar of Visual Design.

"We intend to provide inventories of the major compositional structures which have become established as conventions in the course of the history of Visual Semiotics, and to analyze how they are used to produce meaning by contemporary image-makers."

Moreover, they further add that "because meaning is not given, but constructed." given the explanation, it is possible to compose meaning from drawing through the visual semiotics analysis and process.

The effectiveness of Visual Semiotics had been supported, and it is by far less arbitrary. Visual semiotics hold their meaning compared to written and spoken language. As pointed out by Saussure, the concept in semiotics, Signifier, and Signified, the Signifier as sound, image, or word and the Signified, which is the 'meaning' raises the question of arbitrary when the relation between the two becomes random, where its meaning can become different from anything and anyone (Berger, 1990).

METHOD

This study combines and improves the way emotional keywords (Kansei) are collected and selected. Specimens that have been chosen through the Qualitative Content Analysis (QCA) method followed by visual and formalistic semiotic analysis (FVSA) to extract the audience's 'impression' keywords from each specimen. Participants of these FVSA activities were selected based on their expertise and experience, and this questionnaire activity was aimed at participants with appropriate qualifications and training in the field of arts and design.

The FVSA Questionnaire Form requires initial work from the researcher as the keywords for each design element need to be justified before being selected by the expert (FVSA Participant). There are many keywords collected related to semiotic and formalistic visual theory, principles and elements of art and design, character design principles, animation principles, and Kansei keywords from journals, books, magazines, research, and online sources.

RESULTS AND DISCUSSION

1.FVSA Questionnaire Design Based on Formalistic and Visual Semiotic For Kansei Engineering

Both theories from Saussure and Peirce correlate with the concept of this survey. This research labels the developed questionnaire as Visual and Formalistic Semiotic Analysis or FVSA because it was designed for this research to achieve the desired adjectives (Viewer's Impression Words) and coincide with the opinion of animation experts.

The design of this questionnaire practiced the use of signifiers and signified using semiotic and graphics included for experts to study their effects (refer to figure 5.1). Formalistic and Semiotic analysis in this study provides the adjectives needed for the selection of audience screening words (VIW). This FVSA questionnaire is an effort to improve Kansei Engineering, which is the primary approach used in this study. Formalistic and Semiotic analysis in this study is mainly related to pictures of animated characters. These designs may have intrinsic information embedded in it, and perhaps, the formalistic and visual semiotic theory could be the key to unlocking this information

Elements and principles of art and design are present in every work of art intended for formal analysis. These elements and principles exist either explicitly or implicitly. To begin the analysis, usually, the viewer will look closely and see how our eyes move around the object. Notice where the first sight is and why we are attracted to the picture and identify colors, textures, and shapes of images.

The artist's composition is to guide the vision to a particular part of the picture is just as important to note. All elements and principles, as well as composition, also need to be explained when using formalistic analysis. (Tate, n.d.). Figure 1 shows the relationship between the theories and the survey form.

2.Kansei Engineering Approach Related To FVSA and Viewer's Impression Words (VIW)

Kansei Keywords (Kansei Words) or (Viewer's Impression Words) VIW are collected after Kansei Engineers understand the planned strategy, and keyword collection (KW) is related to the product domain, i.e.,

Figure 2: Example of Formalistic and Visual Semiotics Analysis (FVSA) Questionnaire

Thank you for your participation in this survey. This form is part of the study to evaluate the impact of basic character design based on Japanese Anime Character Design and how its relationship on viewers impression. The result from the study will then formulate a design guideline to create characters on local folktales stories. This form is divided into three (3) sections.

- Section 1. Questions on respondents biographical information
- Section 2. Questions on which parts in an animution character appeal the most
- Section 3. Formalistic and Semiotics analysis to select the preliminary Kansei words on each selected minimition characters parts. These characters had gone through a few selection process such as the Character Selection Matrix and Quantitative Content Analysis (OCA). Similarly, the 40 preliminary Kansei words are identified in reference to the theories of the element and principles of art and the principles of animation as well as other design theories.

1	Nome	
1	Job Title:	
3	Place of work:	

2. Which of these animation character parts appeals the most to you. You may select more than one answer

1	Hair Style		7	Chart	- 0	13	Foot		19	Sheer	
2	Face Shape	[0]	8	Abdomen	10	14	Skin Coloar	13	20	Femings	100
1	Eyes		9	White	D	15	Head Ocur	0	21	Necklass	(1)
4	Nose	(0)	1.0	Shoulder/Arm	D	16	Shirt/Poolice		22	Cape	[0]
5	Mouth		11	Haced	- 0	17	Poets/Slant	10	23	Belt	
6	Node		12	Leg		18	Socks		24	Gloves	

3. In this section, we would like to select the preliminary Kansei words on each selected character part. These characters had gone through a few selection process such as the Character Selection Matrix and Quantitative Content Analysis (OCA). The Kansei Word Adjective can be selected more than one according to your own interpretation. Selection is based on the most suitable to impressions using Formalistic and Semiotics Analysis.

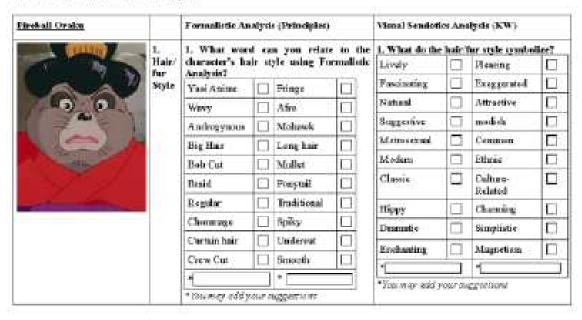
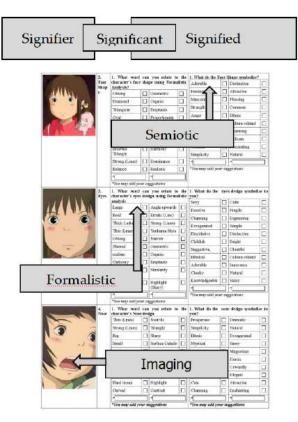


Figure 3: FVSA Survey Form with the visual and formalistic semiotic approach



local animated characters. These keywords are usually synthesized from relevant magazines, newspapers, or information from salespeople about emotions as well as customer opinions. Kansei keywords are adjectives, nouns, or verbs, and sometimes a sentence (Nagamachi, 1999).

This local animated character investigation uses keywords referenced from art theory and animation principles, character design principles and art and design principles, as well as art and design elements. These words may not describe the emotional keyword (Kansei) as required by Kansei Keyword. For example, impression keywords see 'appeal' keywords such as 'large,' 'long,' 'contrast,' 'round' (shape), 'soft', and so on. These keywords are used to determine 'appeal' by the designer (Snitkjær, 2019). Therefore, this study decided to use the word 'impression' instead of emotion (Kansei). The collection of 'impression' words in this study uses expert opinion from a set of questionnaires (FVSA) on specimens given to animators and artists to obtain their impressions on adjectives, nouns, and verbs related to 'appeal' in local animated characters. The viewer's impression words (VIW) collection is then reduced to a small number of more relevant keyword.

CONCLUSION

In conclusion, the FVSA presented in this article shows different ways to achieve Kansei Words, which are commonly used in Kansei Engineering approaches. The common practice in Kansei Engineering requires researchers to use their own logic in achieving KW (Kansei Words). These sentences can be obtained from relevant references such as books, magazines, journals, websites, and other sources (Kurosu, 2019). However, this research presents a more systematic approach to finding and understanding Kansei Words (Kansei Words) through FVSA activities.

The writing of this article also aims to show the direction towards the methodology used in the Kansei Approach to achieve 'interesting' local animated characters. An explanation of Semiotic and formalistic visual theory and its combination in the design of the FVSA questionnaire is expected to help or inspire future research in achieving local animated characters that contain the principle of 'appeal,' which is a very important principle in animated character design. It can also be

used in other animation domains and is not limited to Sabah local folklore animation. The use and approach of this theory are also used to achieve emotional words or in this writing; it is transformed into 'Viewer's Impression Words (VIW).' The combination of art theory and design is also capable of providing additional assistance in finding the right emotional words to be used in the design of a questionnaire commonly used in Kansei Engineering methods.

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