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Application of Fuzzy Delphi Technique to Determine the Elements in Sketch Module for Design and Technology Students

[1]Nor Anisah Ahmad, [*]Ridzwan Che Ros, Arasinah Kamis, Raja Nazim Raja Abdullah, Norhafillah Abdullah

Abstract---*Sketching skills can enhance student's creativity. However, it should be guided by a well-planned and systematic methods. The sketch module is one of the methods that can help students to master the sketch skills in stages. This study aims to identify the elements required in developing the Sketch module for sketching topic in Design and technology subjects. In this study, quantitative method had been implemented by using Fuzzy Delphi Method (FDM). A questionnaire consist of 9 elements was given to the 13 experts selected by purposive sampling method. The findings showed that the expert agreement on all 9 items exceeds 75% and all defuzzification values for each item exceeds the value of α-cut = 0.5. This means that all of these elements are accepted by the experts. Through the instrumentality of the module, it is hoped to enhance the sketching skills among student and will help them to be more confident in creating new things. Further study of the findings will be continued in the development phase of the Sketch Module.*

Keywords---*Sketching skill, Fuzzy Delphi method, Design and technology.*

I. INTRODUCTION

Sketching is a process, or technique of drawing by hand without the aid if drafting tools or mechanical devices, in order to represent or visualize an idea (Serpil Özker, 2017). Sketching plays a big role in our cognitive development. It can help us learn to write and think creatively, develop hand-eye co-ordination, hone analytic skills, and conceptualize ideas (Chand A, 2016). Sketches help to convey ideas, demonstrate functionality, visualize, and illustrate an idea (Tufts, 2014). It also improves students' spatial skills, design capabilities and enhances students' creative problem-solving skills; so that students can turn into creative contributors in today's technological world. It is a powerful process to use because it always helps discover the best ideas and solutions to a design problem. It is difficult task to freestyle a complex design out of midair without hashing out the details. This is why sketching will remain an important step in the design and development process.

Freehand sketching is an implicit skill task of freehand sketching encourages and demands that learner actively construct their knowledge. The result of the literature review found that there's a strong connection between the hand and the neutral circuitry of the brain, where student who wrote by hand, were able to get more ideas as opposed to on keyboards, Brooke Mac Kenzie (2019). According to Fish & Scrivener, (1990) and Kavakli and Gero, (2002) whose carried out a study on sketch cognition suggested the interplay of sketching and mental imagery. Consequently,

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[1]*Faculty of Technical and Vocational, University Education of Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia*
e-mail: ridzwan@ftv.upsi.edu.my

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sketching skills have been identified as one of the most important tools for the development and enrichment of spatial skills. Research done by Charyton (2015) stated that sketching skills have also been identified as effective measures for the development and improvement of visual imagery and creative capacity.

Developing sketching expertise for student is important because it is not only acts as a sense-making tool for solving design problems, but also supports reflexive geometric problem solving. The task of freehand sketching encourages and demands that learners actively construct their knowledge. However, today's students often lack adequate experiences and skills in freehand sketching. Although sketching is typically considered a relatively simple skill, it cannot be assumed to be a natural ability. According to (Abidin , 2013), design is a creative process that translates ideas into physical products. Although students or designers have a great deal of knowledge in the process of design and technical understanding, but without good sketch skills, all conceptual ideas cannot be translated into two-dimensional and three-dimensional shapes.

Design and technology (D&T) were introduced in Malaysian Education System starting from 2017 replacing the Living skill subject. A study from Huei et al (2019) found that there is very poor competent skill of sketching among existing teacher who teach RBT. This is due to non optionist teacher, lack of training offered and only a small number of resources was provided. Resources such as teacher's guide and the existing module of RBT have not been offered a skill to enhance the sketching skill, whereas freehand sketching is an implicit skill. As stated by Abidin (2013) without good sketch skill, student will have problem in designing and transfer an idea. Moreover, research studies by Uzaik & Fang, (2017) indicated that most engineers received no formal training in sketching, despite the fact that sketching skills have proven to be important for concept generation and exploration and allow for engineers to quickly visualize and change ideas

Overall, there is a clear indication that students may be reluctant to sketch. The reluctance to freehand sketching may have different origins, from personal, intellectual, and social inhibitions, to technological ones. Whatever the reasons it was, the only solution is to require students to sketch and formally teach them the skill. The development of sketching module with the correct element and step will improve students' sketching skill and help teacher as well in teaching process. Normally, the elements of drawing are used in sketching to make it easier for other people to understand and follow, thus skills will be developing through practice. Although, sketching can be improved by incorporating elements of sketching in assignments, it is necessary to formally teach students the elements of sketching

There are a number of studies that define the element of sketching phase. According to Uzaik & Fang, (2017), teaching of sketching can be initiated with simple repetitiveness exercises of drawing straight lines, horizontal and vertical, curved lines: arcs and circles, shapes with some degree of accuracy and recognition of proportions. Other study conducted by Maughmer & Schmidt, (2007) explored that students can move from relatively simple elements (although still more complex than straight lines and circles) to more complex shapes, exercising the recognition and perception of edges, spaces, relationships, lights, and shadows. Goldschmidt (1991) explained how the visual thinking from the design perspective as the process and reasoning behind the creation of ideas or form in design. By a visual process, designers can appreciate shape, proportions and interrelations between items that made and object.

Nevertheless Alfonso (2016) found that the artistic sketching recognized several important elements of sketching skills, including recognition and identification of edges, cross contours, sizes–angles–proportions, shading, etc.

PURPOSE OF STUDY

The study aims to generate the elements of sketch module for D&T student of the secondary school in Malaysia. This study was conducted using Design Development Research (DDR) model in three (3) phases, namely the need analysis phase, design and development phase, and evaluation phase. Thus, this study aims to fulfill the research objective of identifying the element of sketch Module required by the students and their priorities based on expert agreement using FDM.

RESEARCH OBJECTIVE

To identify the element of sketch module to be implemented in Malaysian secondary schools based on an expert agreement.

II. METHODOLOGY

This study goal is to produce the elements of sketch module, using quantitative approaches involving a total of 13 respondents consisting of University lecturers, Ministry of Education (MOE), Curriculum Development Division (CDD), National Design Council (NDC) officers and senior teachers. Data were collected using a questionnaire that was been developed in the need analysis phase. Data was analyzed using Fuzzy Delphi Method (FDM) in order to designing domain creation and construction. The constructs and key elements of each indicator were using FDM too where it is through the consensus of an experts' group to verify, evaluate, reject, and add every indicator or element in the developed model. The selection of experts is very important, and it should be consistent with the context of the study.

FDM is a modified measurement method based on the Delphi method. This method was introduced by Kaufman and Gupta in 1988. FDM is a combination of the fuzzy numbering set and the Delphi method itself (Murray, Pipino, & Vangigch, 1985). Thus, it is best suited for the creation of a model or guidelines. This means that it is not a new approach because it is also based on the classic Delphi method in which the respondents involved must be among the experts in a field that is appropriate to the context of the study. These improvements indirectly make the FDM as a more effective measurement approach where it is able to solve problems that have uncertainties for an issue being studied. This fuzzy set theory was introduced by a mathematician in 1965, Lotfi Zadeh (Zadeh, 1965) and functions as an extension of the classic set of theory in which each element in a set is based on the binary set (Yes or No). The fuzzy set theory also allows gradual assessment of each element being studied. Ragin (2007) stated that the values for the fuzzy pagination are 0 to 1 or within the unit interval (0, 1). There are three (3) main factors in the analysis of FDM;

i. Threshold value (d)
ii. Percent of expert consensus> 75%
iii. Fuzzy A score = α-cut> 0.5

Procedures for Conducting a Study Using FDM

The findings obtained using the FDM approach, need to follow some procedures. Compliance to this procedure is an empirical finding.

a) Step 1

The first stage is the determination and selection of the experts involved as respondents. The selection of these experts is very important for make sure the selected experts are able to provide the right perspective with the context of the study being conducted. Jones and Twiss (1978) suggested that in the course of the Delphi method, the number of experts involved would be 10 to 50 experts. However, according to Adler and Zinglio (1996), in order to reach a high level of agreement among experts, the number of experts should be between 10 and 15 persons (Abdullah, 2018). For this study, 13 experts were selected using purposive sampling methods based on their expertise including 5 experts from university professors, 1 expert from MOE officers,1expert from NDC officers, 2 expert from Design Officer and 4 expert from D&T Principal Trainers.

b) Step 2

The questionnaire for this process was developed based on a combination of mapping analysis from in-depth interviews with experts, literature reviews and document analysis. As a result, a total of 24 items were developed for the sketch module questionnaire. In parallel to Powell (2003), the construction of expert questionnaires can be done through several methods: (1) interviews and (2) literary reviews.

Table 1: Questionnaire Element for sketching module Part

Part	Element	Item
A	Demography	3
B	Introduction of sketching	1
1	Element in Design	7
2	Principles in Design	1
3	Pictorial Sketching	3
4	Visual Effect	3
5	Digital Sketching	1
6	Orthographic sketching	1
7	Sketch of work	1
8	Sketch layout	1

c) Step 3

For data collection, the approaches that has been used was meeting with individual experts. Experts or respondent were asked to respond the questioner using seven point Likert scale indicating agreement on the items as 1 = very strong disagree, 2 = strong disagree, 3 = disagree, 4 = Less agree, 5 = agree, 6 = strong agree, 7 = very strong agree.

d) Step 4

All linguistic variables were converted into triangular fuzzy numbering. Assume that the fuzzy rij number is the variable for each criterion for expert K for i = 1, ..., m, j = 1, ...n, k = 1 ... .., k and rij = 1 / K (r1ij ± r2ij ± rKij). Table 2 shows the linguistic variables for seven (7) scales where it displays the measurement statement for an item and the fuzzy scale value it represents.

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Table 2: The 7-point Linguistic Variable Scale

Likert Scale	Linguistic Change Enable	Fuzzy Scale		
1	Very Strongly Disagree	0	0	0.1
2	Strongly Disagree	0	0.1	0.3
3	Disagree	0.1	0.3	0.5
4	Less Agree	0.3	0.5	0.7
5	Agree	0.5	0.7	0.9
6	Strongly Agree	0.7	0.9	1
7	Very Strongly Agree	0.9	1	1

e) Step 5

The data analysis is based on the triangular fuzzy number where it aims to get threshold value (d). Therefore, the first requirement to be followed is threshold value (d) must be less or equal to 0.2 (Cheng & Lin, 2002). The use of vertex method was carried out to calculate the distance between the average rij. The threshold value (d) of the two (2) fuzzy numbers m = (m1, m2, m3) and n = (m1, m2, m3) are calculated using the formula:

$$d(\tilde{m},\tilde{n}) = \sqrt{\frac{1}{3}\left[(m_1-n_1)^2+(m_2-n_2)^2+(m_3-n_3)^2\right]}.$$

Table 3 shows an example of the threshold value (d) produced for five (5) items reviewed based on the view of 13 experts. In this table, it shows that the threshold values for each item and the specialist value threshold (d) overall for each item. The threshold value (d) is the threshold value (d) which exceeds 0.2.

Table 3: Example of Threshold Value (d) Generated**.**

Expert	Element								
	1	2	4	8	9	14	18	20	21
1	0.066	0.058	0.063	0.206	0.432	0.277	0.047	0.047	0.029
2	0.306	0.195	0.298	0.105	0.182	0.055	0.047	0.047	0.328
3	0.088	0.195	0.298	0.322	0.129	0.055	0.047	0.047	0.652
4	0.088	0.195	0.094	0.322	0.182	0.404	0.047	0.106	0.029
5	0.066	0.058	0.094	0.206	0.129	0.274	0.106	0.047	0.328
13									
d Value Every Items (Threshold)	**0.096**	**0.122**	0.119	**0.255**	**0.287**	0.274	**0.065**	**0.065**	**0.227**

e) Step 6

In this process, the determination of the second condition is done where determining the percentage value of the expert agreement is executed. The second condition that needs to be observed is that the percentage of experts' agreement must be equal to or greater than 75.0% (Chu & Hwang, 2008; Murry & Hammons, 1995). Table 4 shows the percentage of expert consensus for the nine (9) items studied using the agreement of 13 experts in the study. Percentages show all items reach an agreement of experts exceeding 75.0%.

Table 4: Percentage of Experts' Agreement for Nine (9) Items

Items	1	2	3	4	5	6	7	8	9
Number of Items d $\leq$ 0.2	8	9	9	8	8	8	8	6	8
Percentage of Each Items d $\leq$ 0.2	**92.3**	**100.0**	**92.31**	**92.31**	**92.31**	**92.31**	**92.31**	**76.92**	**92.31**

f) Step 7

The data analysis used average of fuzzy numbers @ average response (Defuzzification Process). In this analysis, it is aimed to get the score of fuzzy score (A). To ensure the third condition is followed, the value of the fuzzy score (A) must be greater than or equal to the median value (α - cut value) of 0.5 (Bodjanova, 2006, Tang & Wu, 2010;). This indicates that the element is accepted by an expert agreement. Among other functions, the value of fuzzy scores (A) can be used as a determinant and a priority for an element according to experts' opinions. The formula involved in getting the score of fuzzy (A) is as follows:

A = (1/3) * (m1 + m2 + m3)

Table 5 shows an example of fuzzy scores (A) that is carried out using defuzzification process analysis based on FDM approach.

Table 5: The Score of Fuzzy Scores (A) Analysis of Defuzzification Process

Element / Expert	1			2			3			4			5		
1	0.7	0.9	1	0.7	0.9	1	0.7	0.9	1	0.7	0.9	1	0.7	0.9	1
2	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9
3	0.9	1	1	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9
4	0.9	1	1	0.5	0.7	0.9	0.9	1	1	0.9	1	1	0.9	1	1
5	0.7	0.9	1	0.7	0.9	1	0.9	1	1	0.9	1	1	0.9	1	1
Fuzzy Scale	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3	m1	m2	m3
Average Each Units	0.792	0.938	0.992	0.669	0.854	0.969	0.777	0.923	0.985	0.792	0.931	0.985	0.700	0.869	0.969

Fuzzy Score Value (Average)	0.908	0.831	0.895	0.903	0.846

FINDINGS TO FUZZY DELPHI STUDY

A total of 24 items were developed and sketch module questionnaire was tested through the content validity testing using FDM. Table 6 shows the findings for the analysis using a fuzzy numbering triangle. The findings from Fuzzy Delphi analysis, a total of 9 indicators representing the elements of Sketch module were accepted. Table 6 shows the findings for the analysis using a fuzzy numbering triangle.

Table 6: Summary of Fuzzy Delphi Findings

No	Item / Elemen	Requirements of Triangular Fuzzy Numbers		Defuzzification Terms			Process	Expert Consessuses
		***Thres hold Value,* d**	**Expert Consesuses %**	**m1**	**m2**	**m3**	**Skor *Fuzzy (A)***	
1	Introduction of sketching	0.096	92.3%	0.792	0.938	0.992	0.908	ACCEPT
2	Element in Design	0.122	100.0%	0.669	0.854	0.969	0.831	ACCEPT
3	Principles in Design	0.181	92.31%	0.638	0.815	0.938	0.797	ACCEPT
4	Pictorial Sketching	0.169	92.31%	0.685	0.854	0.954	0.831	ACCEPT
5	Visual Effect	0.095	92.31%	0.808	0.946	0.992	0.915	ACCEPT
6	Digital Sketching	0.169	92.31%	0.685	0.854	0.954	0.831	ACCEPT
7	Orthographic sketching	0.153	76.92%	0.546	0.738	0.900	0.728	ACCEPT
8	Sketch of work	0.189	92.31%	0.638	0.815	0.946	0.800	ACCEPT
9	Sketch layout	0.202	76.92%	0.623	0.823	0.962	0.803	ACCEPT

III. DISCUSSION

As indicated by Hsu and Brian (2007), FDM is a methodology that has been generally utilized and received gathering information dependent on the expert's group understanding of an issue being considered. There are various studies that applied FDM, for example, developing High –Performance Leadership standard For Malaysian School Leaders ((Abdullah et. Al , 2018) a model advancement SkiVes preparing educational plan (Mohd Ridhuan, 2016), Developing of Green Skills Elements in Secondary Schools (Bushra Limuna Ismail, 2018), etc.

The use of Fuzzy Delphi has resulted in a preliminary finding on the draft of Sketch module. A total of 13 experts were selected as respondents in this study in line with Adler and Zinnglo, (1996), which stated that to get a high level of agreement, the number of experts should be between 10 and 15. Initial findings of this study have high validity and reliability with a consensus percentage of >75% .Chu and Hwang (2008) and Murray, Pipino and Gigch (1985) showed that the agreement of the expert group was also observed.

The findings can also establish a predominant indicator and in this study, 9 elements have been accepted based on experts' consensuses .The result obtained were parallel with the numbers of study found in teaching of sketching started with drawing a straight line, curved lines, arcs, circle, recognition of properties, shapes, perception of edge, spaces, relationship, light and shadow. (Ullman et. al, 1990; E. S. Ferguson, 1994; Alfonso et. al 2016). Furthermore, Goldschmidt (1991) pointed out that design perspective is one of element behind the creation of ideas or form in design. Therefore, 9 elements which had been accepted will be used in sketch module development in Phase 11.

IV. CONCLUSION

The findings clearly indicate that there are 9 elements of sketching required to develop sketching module to enhance sketching skill among design and technology students based on the consensus of the experts' opinion. The module will help students to develop their skills in sketching step by step and increase the capability to create and explore new things as every student is blessed with a certain level of talent for sketching. Besides teaching the students how to sketch, it is crucial to apprise them the important role of sketching in particular interactive sketching and the design process. The knowledge and practice experienced through the sketching courses affirm that not only the end result of sketching is salient, but the whole process of sketching helps in structuring, developing and communicating the design process. By giving those lessons that are specifically developed for this goal, they will become better sketchers and designers as well.

REFERENCES

[1] Alfonso Martin-Erro, M. D. (2016). The Role of Sketching in Engineering Design and its Presence on Engineering Education. *Design Engineering Area - Universidad Nacional de Educación a Distancia (UNED), Madrid (SPAIN)*. doi:10.21125/inted.2016.1822

[2] Adler, M., & Ziglio, E. (1996). Gazing into the oracle: the Delphi method and its application to social policy and public health. London: Jessica Kingsley Publishers

[3] Bodjanova, S. (2006). Median alpha –level of a fuzzy number. Fuzzy Set And system, 157 (7), 879- 891

[4] Chand A, (2016). 'Breathing life into a character: conceptual tools for understanding the relationship between illustrator and character design', The International Journal of Arts Theory and History, 11 1-11 (2016)

[5] Charyton, Christine. (2015). Creative Engineering Design: The Meaning of Creativity and Innovation in Engineering. 10.1007/978-1-4471-6624-5_7.

[6] Chu, H.C., & Hwang, G.J. (2008). A Delphi-based approach to developing expert systems with the cooperation of multiple experts. Expert Systems with Applications, 34(8), 26-40.

[7] E. S. Ferguson, (1994). Engineering and the Mind’s Eye, 4th ed., 1 vol. The MIT Press.

[8] Fish, J and Scrivener, S. (1980). 'Amplifying the mind's eye: sketching and visual cognition' Leonardo Vo123. 117-126

[9] G. Goldschmidt. G (1994) “On visual design thinking: the vis kids of architecture,” Des. Stud., vol. 15, no. 2, pp. 158–174.

[10] Goldschmidt G. (1991), Dialectics of Sketching, Creative Research Journal, 4 (2), page 123–143

[11] Huei, O. K., Rus, R. C., & Kamis, A. (2019). Need Analysis: Competency Development Measurement Instrument in Mastering the Content of Design and Technology Subject in High School. International Journal of Academic Research in Business and Social Sciences, 9(6), 1043–1052

[12] Jamelaa Bibi Abdullah, S. I. (2018). A Fuzzy Delphi Method - Developing High - Performance Leardership Standard For Malaysia School Learders . *Journal Education and Social Sciences, Vol. 9, Issue 2, (February)*

[13] Kaufmann, A., & Gupta, M.M. (1988). Fuzzy mathematical models in engineering and management science. Newyork : Elsevier Science Inc.

[14] Murray, T. J., Pipino, L. L., & Gigch, J. P. (1985). A pilot study of fuzzy set modification of Delphi. Human System Management, 6–80

[15] Murry, J., & Hammons, J. (1995). Delphi: A versatile methodology for conducting qualitative research. Review of Higher Education, 18(4), 23-36.

[16] Mohd Ridhuan Bin Mohd Jamil. (2016). Pembangunan Model Kurikulum Latihan Skives Bagi Program Pengajian Kejuruteraan Pembelajaran Berasaskan Kerja, Tesis Institut Pengajian Siswazah Universiti Malaya Kuala Lumpur. Thesis Ph.D Fakulti Kejuruteraan, Universiti Malaya

[17] Shahriman Zainal Abidin, M. H. (2013). *Seni Reka Perindustrian: Daripada Idea kepada Lakaran*. Kuala Lumpur: Dewan Bahasa dan Pustaka.

[18] Serpil Özker, E. S. (2017). Important Of Sketching in The Design Process and Education. *The Online Journal of Science and Technology*, Volume 7, Issue 2.

[19] Tufts, K. (2014, 7 1). *Custom Demo.* Retrieved from DNNSoftware.com: http:www.dnnsoftware.com

[20] Uziak, Jacek & Fang, Ning. (2017). Improving students’ freehand sketching skills in mechanical engineering curriculum. International Journal of Mechanical Engineering Education. 46. 030641901774415. 10.1177/0306419017744156

[21] Powell, C. (2003). The Delphi technique: myths and realities. Journal of Advanced Nursing, 41(4), 376–382.

[22] W. Hsu and I. M. Y. Woon, “Current research in the conceptual design of mechanical products,” Comput.-Aided Des., vol. 30, no. 5, pp. 377–389, 1998

[23] Z. Bilda, J. S. Gero, and T. Purcell, (2006). “To sketch or not to sketch? That is the question,” Des. Stud., vol. 27, no. 5, p. 587; 587–613; 613.

[24] Zadeh L.A. (1965). Fuzzy sets and systems, System Theory (Fox J., ed.), Microwave Research Institute Symposia Series XV, Polytechnic Press,Brooklyn, NY, 29-37. Reprinted in Int. J. of General Systems, 17, 1990, 129-138