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Applying the Fuzzy Delphi Method to Analyze the user Requirement for user Centred Design Process in Order to Create Learning Applications

Norhaslina Kamarulzaman[1*], Nazean Jomhari[1], NorakyaireeMohd Raus[2] and Mohd Zulkifli Mohd Yusoff[3]

[1]Department of Software Engineering, Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur, Malaysia; norlina_k@siswa.um.edu.my, nazean@um.edu.my
[2]Faculty of Quranic and Sunnah Studies, Universiti Sains Islam Malaysia, Bandar Baru Nilai, Negeri Sembilan, Malaysia; norakyairee@usim.edu.my
[3]Department of Al-Quran and Al-Hadith, Academy of Islamic Studies, University of Malaya, Kuala Lumpur, Malaysia; zulkifliy@um.edu.my

Abstract

Background/Objectives: This study aim to provide a clear user requirement for developing learning apps for Down syndrome children by using Fuzzy Delphi Method (FDM) method in User Centred Design (UCD) process. **Methods/ Statistical Analysis:** UCD is an approach that supports the entire development process with user-centred activities, in order to create applications which are easy to use and are of added value to the intended users. Whilst, the FDM is a technique to obtain the approval of experts in determining the item or sub-item in a study carried out. The targeted user in this study is students with Down syndrome. **Findings:** The first stage utilizes FDM to obtain the characteristics of the user, learning method and structure of learning technology that suit with user in designing the application. The empirical study show the list of user requirement that can be used in the developing the learning application. It is also used to obtain information about the extent to which the needs of technology in support of teaching and learning. **Application/ Improvements:** The findings of this study are expected capable of contributing to the needs of researcher and programmer to understand the basis of the basic learning needs of students with Down syndrome.

Keywords: Down Syndrome, Fuzzy Delphi Method, Learning Technology, User Centred Design, User Requirement

1. Introduction

One of the challenges in software development is to involve end user in the design and development stages in order to collect and analyze their behavior and feedback on the effectiveness and efficient of the method used and then to manage to proceed development accordingly. One way that can be achieved is by using the User-Centered Design (UCD) philosophy[1].

UCD is used in software projects with the aim to improve the usability of the product, reduce the risk of failure, reduce long-term costs, and improve overall quality. UCD integrate activities into the software development process combines the user experience with the development process, achieve a high degree of usability in the product[2]. UCD is also called human-centred design process[3] which is refer to the Human centred design processes for interactive systems, ISO 13407 (1999), states: "*Human-centred design is an approach to interactive system development that focuses specifically on making systems usable. It is a multi-disciplinary activity.*"

*Author for correspondence

According to Kraft[4], the success of a product, service, website, applications tool back to the one thing that successful user experience innovation. The user experience can seriously affect the accuracy of product usability[4]. No matter what the application at all, it should have the main thing that a matter is what user's experience. Therefore it must be taken seriously that the concept of user experience has a lot to do with the success and failure of any digital products.

Based on ISO 13407, Earthy[5] suggests that the activities in UCD include planning the human centred design process, identifying the user/organisational requirements, specifying the context of use, producing and evaluating the designs. It was supported by Rubin, J.[6] where they also depict the UCD Process as; 1) the users are in the center of a double circle, 2) the inner ring contains: Context; Objectives; Environment and Goals, and 3) the outer ring contains: Task Detail; Task Content; Task Organization and Task Flow.

According to Rogers[7], UCD is a user interface design process that focuses on usability goals, user characteristics, environment, tasks, and workflow in the design of an interface. UCD follows a series of well-defined methods and techniques for analysis, design, and evaluation of mainstream hardware, software, and web interfaces. The UCD process is an iterative process, where design and evaluation steps are built in from the first stage of projects, through implementation.

Therefore, practically UCD is an approach that supports the entire development process in which the activity is centred on the user and it creates an easy to use application that will add value to the consumer. The biggest advantage UCD in which it can provide or specify more precise user requirements.

There are four important principles UCD (have been captured in the standard ISO13407):

- A clear understanding of user and task requirements
- Incorporating user feedback to refine the requirements and design
- Active involvement of the users to evaluate design
- Integrating user-cantered design with other development activities

Various methods are used in UCD process to understand the user and task requirements to support the process of iterative design and evaluation. Methods such as focus groups, interviews and questionnaire are often used by the researcher to obtain data on the user requirements. Therefore, this study used the FDM technique to capture the user requirement because it was provide the weight for each item being studied and this weighting function can provide accuracy of the data produced.

2. Strength of Delphi Fuzzy as a Tool of Measurement of Experts

Delphi technique is a technique that has long been used in a study involving expert[8]. It is a method based on a group of experts to review and gather to form a consensus of opinion on such information. In short, it can also be considered a method to obtain structural data based on expert consensus[9]. However, Siraj, S.[10]asserts that there are three weaknesses Delphi technique, i.e. it can cause data reliability is doubtful if the researcher failed to elect a real expert. Boredom will happen to the expert for the study was repeated and the number of experts used was too small to evaluate something big. This argument is strengthened by the views of ~~Bojadive and Bojadive~~[11] which argues that the Delphi technique involves a study of the long and repetitive, while it could lead to a decision only subject to a small number of experts and highly subjective. This controversy would inviting to the question of the inability of experts to assess and evaluate a large, in other words it does not measure what is to be measured. To overcome this contentious, Fuzzy Delphi technique has been used as a tool to get a deal experts. The strength of this technique is that it can reduce the length of the study period by reducing Delphi rounds. The use of fuzzy elements are integrated into the Delphi technique capable of analyze the agreement specialize in only one round. Furthermore, Chang, P.L. et al.[12], holds that the strength of Fuzzy Delphi technique is that it is able to put the priorities and the elements of a consensual experts, the construction of questionnaires is based on literature highlights that have been approved by the appropriate experts and data obtained solid only one round.

There are two key points in FDM is triangular fuzzy number and defuzzyfication process. Triangular fuzzy number consists of three value, namely m_1 (smallest value), m_2 (the most plausible) and m_3 (largest value). The Figure 1 explains the position of these values.

Triangular fuzzy number used to generate the scale of linguistics (the same as the Likert scale) in which linguistic scale is used to translate linguistic variables to fuzzy number. The number of levels of the scale linguistic agreement must be in odd numbers (3, 5, 7 ....); higher scale linguistics

provided the data to be more accurate. In this study, we use seven point linguistic scales such as in Table 1.

Meanwhile, defuzzyfication implemented are intended to determine the ranking for each of the variables or sub-variables. The purpose of this process is to help researcher find the need for a variable level and the required sub-enablers. This raking process will help produce data as required on the basis of experts' consensus. There are three formulas that can be applied, namely;

i. $A_{max} = 1/3 * (a_1 + a_m + a_2)$
ii. $A_{max} = 1/4 * (a_1 + 2a_m + a_2)$
iii. $A_{max} = 1/6 * (a_1 + 4a_m + a_2)$

2.2 The FDM Process

When using the FDM method in a study, there is a sequence of steps to be followed:

Step 1: Interview the experts to determine the importance of the evaluation criteria of the variables that will be measured by using linguistic variables.

Step 2: Convert all linguistic variables (see Table 1) to fuzzy triangular numbering (triangular fuzzy number). Assume that the fuzzy numbers are r_{ij} variables for each of the criteria for specialist K for i=1,…, m, j=1,…n, k=1…k and $r_{ij} = \frac{1}{K}(\pm r_{1ij}\, r_{2ij} \pm r_{Kij})$.

Step 3: For the every expert, use the vertex method to calculate the average distance between r_{ij}[13]. The spacing between two fuzzy numbers m= (m_1, m_2, m_3) and n = (m_1, m_2, m_3) is calculated using the formula:

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

Step 4: According to Cheng and Lin[14], if the value is less than 0.2; d (d<0.2), the expert consensus has been reached. Furthermore, when the percentage of achieving group consensus among the experts is more than 75%, go to the step 5. If the data is found otherwise, the second of FDM needs to be done.

Step 5: Aggregate fuzzy assessment with:

$$\tilde{A} = \begin{bmatrix} \tilde{A}_1 \\ \tilde{A}_2 \\ \vdots \\ \tilde{A}_m \end{bmatrix}$$

i = 1, …, m

Step 6: For each alternative, fuzzy evaluation Ai = A_i = (a1, a_2, a_3) in defuzzication with $a_i = \frac{1}{4}(a_1 + 2a_2 + a_3)$.
Alternative ranking order of preference can be determined according to the value of a_i.

3. Data Analysis

Questionnaire survey was the main research tool in this study. The study has interviewed seven experts, with the experience of five years and above, to identify methods and strategy of learning for students with Down Syndrome (DS). Based on the results of interviews with experts, the set of questionnaire was designed with reference to the related literatures and interviews with experts. The questionnaire was divided into three sections (refer to Table 2). The first section was about the strengths of DS student in learning session and the second section was about methods of learning and the last section was about the structure of learning technology for DS student. A seven point scale linguistics scale was used and a higher point indicated a higher importance (refer to Table1).

The population is in the field of teaching and learning for children with Down syndrome. As the field of teaching and learning includes various parties, those who deal directly with students with Down syndrome have been selected, including teachers, parents and therapists. The subjects were teachers of special education, parent of the DS students and therapists of the department of special education under the Malaysian government. They were contacted and early informed of the intention to survey. The questionnaire was distributed after permission has been obtained. Researchers will ask them about characteristic, learning methods and the needs of learning technology. Finally, a total of 50 questionnaires were distributed, and more than 31 were returned valid. A valid response rate was 62%.

Table 1. 7 Point Linguistic Scale

Very strongly agree	0.90	1.00	1.00
Strongly agree	0.70	0.90	1.00
Agree	0.50	0.70	0.90
Medium agree/ Not sure	0.30	0.50	0.70
Disagree	0.10	0.30	0.50
Strongly disagree	0.00	0.10	0.30
Very strongly disagree	0.00	0.00	0.10

3.1 Validity and Reliability of Questionnaire Item

Validity testing is necessary to ensure the legality of the items that are built can help provide answers to the research questions. An item or instrument that has a high validity value if the items were built in the questionnaire can measure what should be measured[15]. In the opinion of others, Marican[16] argued the validity is used to measure the accuracy of a measurement used in the study. It aimed to determine whether the measures it contains all the features or ideas that should be present in the concept which is measured. The findings of the research would be meaningless if the measuring device used cannot measure what should be measured.

Testing reliability of the questionnaire also required to view that the relevance and understanding of the respondents to the items in the questionnaire. Terms of the questionnaire was based on the Alpha value obtained. This has been debated by Hair. J, et al.,[15] which states that the value of the Cronbach Alfa acceptable minimum was 0.7. However, Majid[17] opined that the Cronbach alpha reliability can be classified into three classes, namely if the Alpha value is worth 0.60, it shows that the reliability index is the minimum acceptable. Table 3 shows the value of Alpha Cronbach of elements if this study (refer to Table 3).

4. Result/Findings

Table 4, 5 and 6 shows the threshold value () for each item based on the expertise and overall percentage threshold for the consensus group of expert on the strength of DS student in learning, learning method and structure of learning technology for DS students. Overall, based on a percentage of the experts agreed to show all items agreed upon by experts.

Table 4 (refer to Table 4) shows that they were able to communicate with the people around them with defuzzification score 0.846is in the first ranking. This is followed by very gregarious and easy to learn through this relationship with deffuzzification score of 0.762; and the last, they are able to follow the routine of lessons so well with deffuzzification score of 0.703.

Table 5 (refer to Table 5) shows that learning by picture or model with defuzzification score 0.891is in the first ranking. This is followed by the best practice of learning is

Table 3. Number of items by domain and Alpha Cronbach

Elements	Total of Item	α-Cronbach
A	3 item	0.618
B	6 item	0.916
C	5 item	0.901

Table 2. Questionnaire

Sec	Elements	No	Item
A	The strengths of DS student in learning session	1	Although they cannot speak well, but they were able to communicate with the people around them
		2	They are able to follow the routine of lessons so well.
		3	Very gregarious and easy to learn through this relationship
B	Methods of learning	1	Learning by picture or model or form.
		2	The best practice of learning is imitate
		3	The best practice of learning is matching
		4	The best practice of learning is arranging
		5	Learning by singing or playing a musical instrument
		6	The use of learning aids that can be touched and seen
C	The structure of learning technology for DS student	1	Color is not too bright
		2	Sound of soft music or a gentle song
		3	Can be seen and touched
		4	Use of voice of cheerful child
		5	The movement of animation is not too fast

Table 4. Threshold Value and Percentage Consensus by Experts on Strengths of DS student in Learning

EXPERTS	The strengths of Down Syndrome student		
	A1	A2	A3
1	0.04	0.04	0.10
2	0.22	0.04	0.10
3	0.22	0.25	0.16
4	0.04	0.25	0.16
5	0.18	0.38	0.30
6	0.04	0.25	0.16
7	0.04	0.04	0.10
8	0.04	0.30	0.10
9	0.04	0.25	0.16
10	0.04	0.30	0.16
11	0.18	0.30	0.30
12	0.04	0.30	0.16
13	0.04	0.61	0.16
14	0.04	0.04	0.30
15	0.18	0.25	0.16
16	0.18	0.38	0.30
17	0.04	0.30	0.10
18	0.04	0.25	0.16
19	0.04	0.25	0.16
20	0.04	0.04	0.10
21	0.22	0.04	0.10
22	0.22	0.04	0.10
23	0.22	0.25	0.16
24	0.22	0.61	0.69
25	0.18	0.38	0.10
26	0.18	0.04	0.10
27	0.04	0.04	0.69
28	0.22	0.04	0.10
29	0.18	0.61	0.69
30	0.04	0.25	0.16
Defuzzification	0.846	0.703	0.762
Percentage consensus expert group to construct the strengths of Down syndrome students in learning: 80%			
Value ($d_{m,n}$) for each <=0.2 = 72, then (72/90) *100% = 80%			
Ranking	1	3	2

Table 5. Threshold Value and Percentage Consensus by Experts on Method of Learning

EXPERTS	Methods Of Learning					
	B1	B2	B3	B4	B5	B6
1	0.05	0.04	0.03	0.19	0.23	0.26
2	0.11	0.11	0.14	0.20	0.16	0.14
3	0.11	0.11	0.14	0.20	0.16	0.14
4	0.28	0.28	0.25	0.19	0.53	0.26
5	0.05	0.04	0.03	0.49	0.04	0.03
6	0.28	0.28	0.25	0.19	0.23	0.26
7	0.28	0.28	0.25	0.19	0.04	0.26
8	0.05	0.04	0.03	0.06	0.04	0.03
9	0.11	0.11	0.14	0.06	0.16	0.14
10	0.11	0.11	0.14	0.20	0.16	0.14
11	0.28	0.04	0.03	0.06	0.04	0.03
12	0.11	0.11	0.14	0.20	0.16	0.14
13	0.11	0.11	0.14	0.20	0.16	0.14
14	0.11	0.11	0.14	0.20	0.23	0.14
15	0.05	0.04	0.03	0.06	0.04	0.03
16	0.05	0.04	0.03	0.06	0.04	0.03
17	0.11	0.11	0.14	0.20	0.16	0.14
18	0.05	0.04	0.03	0.06	0.23	0.26
19	0.05	0.04	0.03	0.06	0.04	0.03
20	0.11	0.04	0.55	0.19	0.16	0.14
21	0.05	0.04	0.03	0.06	0.04	0.03
22	0.05	0.11	0.03	0.06	0.04	0.03
23	0.11	0.11	0.14	0.20	0.16	0.14
24	0.05	0.04	0.03	0.19	0.23	0.26
25	0.05	0.04	0.03	0.06	0.04	0.03
26	0.11	0.04	0.03	0.49	0.04	0.03
27	0.11	0.11	0.14	0.20	0.16	0.14
28	0.11	0.04	0.03	0.06	0.23	0.03
29	0.11	0.11	0.03	0.19	0.16	0.14
30	0.05	0.04	0.03	0.06	0.04	0.03
Defuzzification	0.891	0.890	0.871	0.830	0.858	0.873
Percentage consensus expert group to construct the method of learning: 88.9%						
Value ($d_{m,n}$) for each <=0.2 = 160, then (160/180) *100% = 88.9%						
Ranking	1	2	4	6	5	3

imitate with deffuzzification score of 0.890; next in rank is the use of learning aids that can be touched and seen with deffuzzification score of 0.873; this followed by the item the best practice of learning is matching with the score of 0.871; and followed by item learning by singing or playing a musical instrument with deffuzzification score of 0.858; and the last, the best practice of learning is arranging with deffuzzification score of 0.830.

Table 6 (refer to Table 6) shows that can be seen and touched with defuzzification score 0.890 is in the first ranking. This is followed by use of voice of cheerful child with deffuzzification score of 0.873; next in rank is The movement of animation is not too fast with deffuzzification score of 0.867; this followed by the item sound of soft music or a gentle song with the score of 0.863; and the last, color is not too bright with deffuzzification score of 0.824.

Table 6. Threshold Value and Percentage Consensus by Experts on Structure of Learning Technology

EXPERTS	Structure of learning technology				
	C1	C2	C3	C4	C5
1	0.21	0.15	0.11	0.14	0.15
2	0.21	0.15	0.11	0.14	0.15
3	0.07	0.03	0.04	0.03	0.03
4	0.19	0.24	0.04	0.26	0.03
5	0.07	0.03	0.04	0.03	0.03
6	0.07	0.03	0.04	0.14	0.03
7	0.07	0.15	0.11	0.14	0.15
8	0.07	0.15	0.11	0.14	0.15
9	0.48	0.24	0.04	0.03	0.25
10	0.21	0.15	0.11	0.14	0.15
11	0.48	0.15	0.04	0.14	0.03
12	0.07	0.03	0.11	0.14	0.15
13	0.07	0.03	0.04	0.03	0.03
14	0.21	0.15	0.11	0.14	0.15
15	0.21	0.15	0.11	0.14	0.15
16	0.07	0.03	0.04	0.03	0.03
17	0.07	0.03	0.04	0.03	0.03
18	0.07	0.03	0.11	0.03	0.15
19	0.07	0.03	0.04	0.03	0.03
20	0.07	0.24	0.04	0.03	0.15
21	0.19	0.24	0.28	0.26	0.25
22	0.19	0.24	0.28	0.26	0.25
23	0.07	0.03	0.04	0.03	0.03
24	0.07	0.03	0.04	0.03	0.03
25	0.07	0.03	0.11	0.14	0.15
26	0.07	0.15	0.11	0.14	0.15
27	0.19	0.03	0.28	0.26	0.54
28	0.07	0.03	0.04	0.26	0.25
29	0.48	0.24	0.11	0.26	0.25
30	0.07	0.03	0.04	0.03	0.03
Defuzzification	0.824	0.863	0.890	0.873	0.867
Percentage consensus expert group to construct the Structure of Learning Technology: 88%					
Value ($d_{m,n}$) for each <=0.2 = 132, then (132/150) *100% = 88%					
Ranking	5	4	1	2	3

5. Discussion and Conclusions

After the defuzzification score analysis was conducted, the researchers found that DS students are able to communicate well with the people around them even if they are physically unable to speak properly due to their short tongue[18]. In addition DS students are also easily to follow routines well if given effective instruction. This clearly shows that DS students they are capable to follow the learning procedure even if they are categorized either as they are learning difficulties. The argument of this study is in line with the argument Stoel-Gammon[19] and Kasari, et al.,[20] which they state that students with DS are able to learn how to read, write, and do simple arithmetic tasks after they have received proper education and good care.

For the second finding is a good factor for building an application with DS students for learning session is have a strong attraction with the image element and soft sounds. The image or photos used should also be clearly visible and can be touched well. This element consists of the ability to develop good learning apps for DS students which it's developing according to their needs. This was reinforced by the findings in learning method section which it's provides the characteristics of learning that are required by DS students. These elements are important for the DS student to learn better with the use of learning technology.

Based on the discussions and findings of the study, clearly shows that DS students were able to learn as other students. With learning technology which was built according to their requirements and needs precisely able to give help and motivate them to continue to seek better learning. The findings of this study are expected capable of contributing to the needs of researcher and programmer to understand the basis of the basic learning needs of students with **Down syndrome.**

6. References

1. Dix A, Finlay JE, Abowd GD, Beale R. Human Computer Interaction, 3rd Edition, Prentice Hall. Pearrow, M., Web usability handbook. Boston, Mass: Charles River Media, 2003.

2. Gulliksen J, Goransson B, Boivie I, Blomkvist S, Persson J, Cajander A. Key principles for user-centered systems design. Behaviour and Information Technology. 2003; 22(6):397–409.
3. Jokela T, Iivari N, Matero J, Karukka M. The standard of user-centered design and the standard definition of usability: analyzing ISO 13407 against ISO 9241-11. In Proceedings of the Latin American Conference on Human-Computer Interaction, ACM. 2003. p. 53–60.
4. Kraft C. User Experience Innovation: User Centered Design that Works. 2012; 228. Available from: http://proquest.safaribooksonline.com/book/software-engineering-and-development/9781430241492
5. Earthy J, Jones B, Bevan, N. The improvement of human centred processes – facing the challenge and reaping the benefit of ISO 13407. International Journal of Human-Computer Studies. 2001; 55:553–85.
6. Rubin J, Chisnell D. Handbook of usability testing: how to plan, design and conduct effective tests. John Wiley & Sons. 2008; 384.
7. Rogers Y, Sharp H, Preece J. Interaction Design – beyond human computer interaction (3rd ed). United Kingdom: John Wiley and Sons. 2012.
8. Winzenried A. Delphi studies: The value of expert opinion bridging the gap. Data to knowledge. ERIC Document Reproduction. ED412971(ed.). 1997.
9. Miller LE. Determining what could/should be: The Delphi technique and its application. In: Meeting of the 2006 annual meeting of the Mid-Western Educational Research Association, Columbus, Ohio. 2006.
10. Siraj S. Kurikulum Masa Depan. Universiti Malaya, Kuala Lumpur, 2008.
11. Bojadziev G, Bojadziev M. Fuzzy Set for Business, Finance and Management. World Scientific Publishing Co. Pte. Ltd. Singapore, 2007.
12. Chang PL, Hsu CW, Chang PC. Fuzzy Delphi method for evaluating hydrogen production technologies. International Journal of Hydrogen Energy. 2011; 14172–9.
13. Chen CT. Extensions of the TOPSIS for group decision making under fuzzy environment. Fuzzy Sets and Systems 2000. 2000; 114(1):1–9.
14. Cheng CH, Lin Y. Evaluating the best main battle tank using fuzzy decision theory with linguistic criteria evaluation. European Journal of Operational Research. 2002; 142:174e86.
15. Hair J, Black W, Babin B, Anderson R, Tatham R. Multivariate Data Analysis. 6th ed. Pearson Prentice Hall: Uppersaddle River, N.J. 2006.
16. Marican S. Kaedah Penyelidikan Sosial. 1th ed. Prentice Hall Pearson: Petaling Jaya, Malaysia, 2005.
17. Konting MM. Kaedah Penyelidikan Pendidikan. Dewan Bahasa dan Pustaka: Kuala Lumpur, 2004.
18. Nevid JS. Psychology: Concepts and applications. Wadsworth Publishing Company. 2012.
19. Stoel-Gammon C. Down syndrome phonology: Developmental patterns and intervention strategies. Down Syndrome Research and Practice. 2001; 7(3):93–100.
20. Kasari C, Freeman SF, Hughes MA. Emotion recognition by children with Down syndrome. American Journal on Mental Retardation. 2001; 106(1):59–72.