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Uncovering the Needs for a Hybridized Interaction Design Model for Sign Language Learning Through Experts' Feedback

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Abstract. Nielsen's and Molich's design guidelines have been famously adapted in studies related to the design of interactive products, including for learning environment, and for hearing-impaired learners. In current situation, the learning materials for hearing-impaired learners are lacking in terms of positive interactions that promote two-way communication, partly because they do not apply appropriate design principles appropriately for the users. This affects their stimulation in learning activities. Hence, this paper aims at uncovering the current design principles applied in learning materials for learning sign language for the hearing-impaired learners. Besides an elicitation of literature, a semi-structured interview with the experts in hearing-impaired curricula has been carried out. It reveals that a study needs to urgently be carried out in proposing a heuristics design model that is specifically able to evoke the positive learning experience.

Keywords: Interaction Design, Nielsen design guidelines, Molich Design Guidelines, User Experience, Hearing-impaired

1. Introduction

The number of people with disabilities (PWDs) has been increasing rapidly around the world. The statistics from [1] reveal that 15% of the world's population have some forms of disabilities; in which one-third of them are children below 15 years old [2]. It is estimated that over 1 million children with disabilities are born every year worldwide [3]. Many of them are not well-treated by their parents because it involves a long-term medical engagement, which they are not able to afford for, especially in developing countries [3]. They have different types of disabilities including physical, learning, hearing, and visual. Among those various types of disabilities, hearing-impaired including deaf is considered the serious one. [1] reports that 285 million people in the world are hearing-impaired and

deaf, in which 90% of them live in developing countries. Meanwhile, in Malaysia, the Malaysian Social Welfare Department reports that the officially registered disabled people as at December 2018 are 472, 228 people [4]. From that figure, 35,273 were hearing-impaired, increased 2,423 people from 32,850 in December 2008. Referring to the facts in Table 1, it could be deduced that from the year 2008 until 2018, the registered hearing-impaired people in Malaysia drastically increased to be double. Therefore, a study that focuses them as the main subject should be brought forward to ensure they are able to contribute to the nation building with the agenda of digital society 5.0 similarly with general people.

Table 1. Registered disabled people according to types of disability, 2008-2018.

Types of Disability	**Year**								
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2016**	**2018**
Visual Impairment	21,204	23,738	27,363	31,924	40,510	46,307	50,827	36,692	42,184
Hearing Impairment	**32,850**	**35,368**	**39,303**	**43,788**	**53,357**	**58,706**	**62,153**	**31,937**	**35,273**
Physical Impairment	78,036	86,485	106,252	123,346	148,461	162,215	174,795	142,600	167,077
Learning Problem	91,303	100,180	117,699	134,709	165,281	178,800	188,911	143,334	163,904
Others	10,546	13,147	15,023	25,436	20,673	24,455	27,025	54,706	63,790
Total	**233,939**	**258,918**	**305,640**	**359,203**	**445,006**	**470,483**	**531,962**	**409,269**	**472,228**

1.1. Digital society 5.0

Digital society 5.0 caters the current needs of society in various aspects of life. It focuses on human development that balances the economic advancement with the solutions of social issues by an application that highly integrates cyberspace and physical space [5]. Social innovation in digital society 5.0 is looking forward at a society that is able to break down the existing sense of stagnation, a society that respects others, a society that is able to go beyond the limit, and a society that its' every member is able to lead an active and enjoyable life. In digital society 5.0, new values are created through innovation [6]. The value of new innovation will bridge the gaps in various aspects like region, age, gender, as well as language to meet desired needs [6]. In such kind of aspiration, the hearing-impaired and deaf people is not an exemption. Therefore, this study is part of the digital society 5.0 agenda, particularly in enabling the hearing-impaired and deaf people have similar accessibilities with the general people. Language should not be the barrier for them to express their feelings, emotions, and thoughts. This could be achieved through innovation particularly in content development of Assistive Technology.

1.2. Advancement of Assistive Technology (AT) towards digital society 5.0

Initiatives in assisting the People with Disabilities (PWDs) including hearing-impaired and deaf learners in using Assistive Technologies (AT) have been growing in most developing countries. AT can be categorized into hardware (i.e. assistive listening devices (ALDs) and software (i.e. text captioning on a screen or monitor). The advancement of AT has triggered meaningful impacts on the various aspects of PWDs life, as seen in smartphones and tablets [7]. In line with that, the field of education has received large impacts by AT, including in formal and informal education. As an example, primary schools that offer special education equip their computer labs and classrooms with assistive listening devices, frequency modulation, and personal amplification. All these AT are utilized as part of the teaching devices to support and improve the disabled learners' learning activities in their educational setting. However, most of such technologies focus on the technical aspects, which is difficult for hearing-impaired and deaf learners (in primary schools) to operate on their own. This requires an assistant to play roles appropriately. In contrast, AT that focuses on digital content that stimulates hearing-impaired learners to have active learning experience similarly with general students

is highly scarce. For that reason, an Interaction Design Model that specifically caters the needs of hearing-impaired and deaf learners, in particular sign language, has to be systematically studied.

1.3. Hearing-impaired and deaf learners

Hearing-impaired, which is also known as hearing loss refers to partial or total inability to hear [1]. It may occur to one or both ear. Such disability can affect children's ability to learn and speak. This can lead to difficulties in social interaction as well as at work [8]. Normally, a deaf person has no ability to hear. Although in general hearing-impaired people are not able to speak, some cases show otherwise. Also, there are mute people who are able to hear [9]. With regard to the varying groups of hearing-impaired, this study focuses on hearing-impaired and deaf children, who have to learn sign language for the purpose of communication and expression of their feeling, emotion, and thought.

1.4. Sign Language

Sign language is a gesture-based body language that uses a manual correspondence of non-verbal communication to transmit meaning. It involves the body movement including movement of hand and facial expression to express information from one person to another [10]. It is also called as oral language, which is specifically developed for people with hearing-impaired and deaf problem. In this study, sign language is the main content of Hybrid Interaction Design Model. Prior to developing the intended model, an initial stage of investigation related to the needs and the availability of Hybrid Interaction Design Model has to be conducted. To achieve that, an elicitation of literatures and user-centered design approach has been utilized throughout the study as elaborated in the next section.

2. Materials and Method

There are two phases involved in this study which are (i) phase one – elicitation of literature and (ii) phase two – user centered design approach. In the first phase, 10 existing sign language design models and 10 existing applications of Nielsen's Design Guidelines have been reviewed through a systematic literature review approach. The credible online database which are Scopus, ScienceDirect, IEEE, WoS, Emerald, and EBSCO Host have been utilized for the searching process. Meanwhile in the second phase user-centered design approach has been adapted to complete the study. Qualitative is the appropriate approach as the main target users of this study is hearing-impaired and deaf learners.

In phase two, semi-structured interview has been conducted with experts in one Special Education Primary School (Hearing and Deaf Learners) located at Northern of Malaysia. Fig. 1 illustrates the summary of research activities involved in this study.

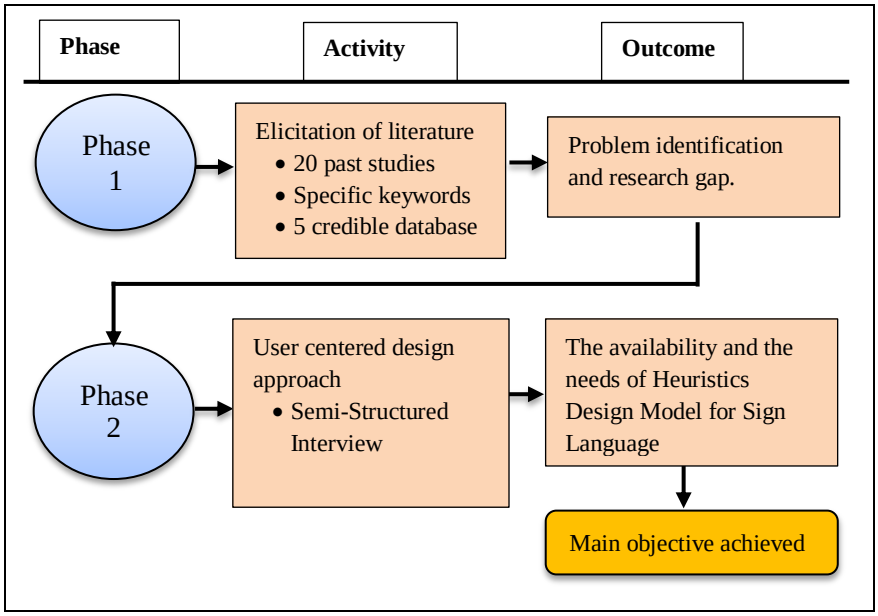

Figure 1. Summary of research activity

3. Result Analysis and Discussion

This section analyzes and discusses the results gathered throughout this study. They are discusses based on the research objective and research activities as highlighted in the previous section, which are divided into three (3) subsection; (i) analysis on the existing sign language design models, (ii) analysis on the applications of Nielsen's Design Guidelines, and (ii) analysis on the semi-structured interview.

3.1. Analysis on the existing Sign Languages design models

Sign Language is a core subject, compulsory for all hearing-impaired and deaf learners since they are in pre-school. In the era of digital society 5.0 sign language becomes more important for them as it is the only communication language among them. Learning Sign Language requires the hearing-impaired and deaf learners to have similar cognitive ability like general learners. However, their constraint to fully utilize their hearing organ making them difficult to understand and remember the contents [11]. These difficulties disrupts their stimulation and interaction process [12]. Accordingly, various models have been carried out to assist hearing-impaired and deaf learners in learning (listed in Table 2). Unfortunately, the interaction components in most of the existing Sign Language Models is treated with minimum focus and the features are insufficiently explored to make it sensible to the hearing-impaired and deaf learners. Also, it was found that most of the existing Sign Language design models fail to hybrid the Nielsen and Molich's Design models, which is highly potential in evoking the cognitive ability and positive interaction between the hearing-impaired and deaf learners with their teachers. Hence, it ought to be noted that this is the research gap that should be the focal point of this study.

Table 2. Existing Sign Language Design Model

No.	Provider	Name of the model	Drawbacks
1.	[13]	ASL for Kids	Has no menu button Users lost for the first-time use Too much graphics Lacks animation Lacks instruction Only provides American Sign Language
2.	[14]	The ASL App	The back button takes to the main menu

			Has no play and stop button Has no audio at all Too much content, which is not suitable for beginner Only provides American Sign Language Users need to purchase for the new function
3.	[15]	Sign Language Basics for Beginner	Only provides static graphics without appropriate animation to show the sign language Provides only British Sign Language Unattractive graphics
4.	[16]	Bahasa Isyarat Melayu	Non-functioning button Missing audio The video provides movement of a person Only provides two menu options, which are learn and practice
5.	[17]	25 Basic ASL Signs for Beginners	Only provides video Only provides American Sign Language
6.	[18]	My ABC and 123 Lite	Has no video Does not follow the standard text book module Lacks animation
7.	[19]	ASL Coach	Too little content Has no video Has no exercise Has no audio at all Does not follow the standard text book module Lacks animation
8.	[20]	Marlee Signs	Has no exercise Has no audio at all Does not follow the standard text book module Has no animation
9.	[21]	ASL: Fingerspelling	Has no exercise Has no audio at all Does not follow the standard text book module Has no animation
10	[22]	iMSL	Has no video Has no exercise Has no audio at all Does not follow the standard text book module Has no animation

3.2. Analysis on the existing applications of Nielsen's Design Guidelines

There are many heuristics for design model developed by researchers. Most of the sets of heuristics design model aim to enhance the interface object particularly to fulfil the user needs [23]. This is to ensure the positive and satisfying learning experience among the target users. There are eight design principles for heuristics design model which are (i) simple and natural dialogue, (ii) speak the users' language, (iii) minimize user's memory load, (iv) be consistent, (v) provide feedback, (vi) provide clearly marked exits, (vii) provide shortcuts, and (viii) deal with errors in a positive and helpful manner [24]. However, literatures show that most of the design model particularly in producing digital learning content utilizing the heuristics design principles at the evaluation phase [25] [26] [27] [28]. This means several iteration process is required at the evaluation phase, which is inappropriate for the design model particularly involving special-need users like hearing-impaired and deaf learners. Although iteration is still required at the evaluation phase, it has to begin at the initial phase of the study. Therefore, this study fills the gap by adapting the heuristics design principles at the initial stage of the study. All of this design principles will be adapted in the proposed model hybridizing with Nielsen and Molich's Design Guidelines.

Meanwhile, there are nine general principles of interaction design, which has been developed and refined by Nielsen's and Molich's since 1990s. These 10 general principles are (i) visibility of the application status, (ii) match between application and actual world, (iii) user control and freedom, (iv) consistency and standard, (v) error prevention, (vi) recognition rather than recall, (vii) flexibility and efficiency of use, (viii) help users recognize, diagnose, and recover from errors, and (xv) help and documentation [29]. They are also called heuristics as they cover the broad perspective that appropriate with the development of digital content application and are customizable appropriately for the target users [30]. Table 3 demonstrates the digital learning content that adopts Nielsen's and Molich Design Guidelines, carried out in various contexts of study.

Table 3. Existing applications of Nielsen's Design Guidelines

No.	Researcher	Guidelines	Context
1.	[31]	Nielsen's Design Guidelines and Usability Principles	Mobile e-Book
2.	[32]	Nielsen's Design Guidelines	Mobile Centralized Doctor Appointment System (CDAS) / Mobile e-Government Health Application
3.	[33]	Nielsen's Design Guidelines	Mobile Banking Application
4.	[34]	Nielsen's Heuristics Evaluation	Mobile Health Gamification
5.	[35]	Nielsen's Design Guidelines	mHealth Application
6.	[36]	Nielsen's Design Guidelines	Mobile Application
7.	[37]	Nielsen's Design Guidelines	Responsive Web System for Disabled Children
8.	[38]	Nielsen's Model	Cultural Conservation System
9.	[39]	Nielsen's Usability Design Principles and Heuristics Evaluation	Mobile Web
10.	[40]	Nielsen's Heuristics Evaluation	Mobile Learning

Referring to Table 3 it indicates that hybridizing Nielsen and Molich's Design Guidelines into the design and development of sign language digital content is still insufficiently explored. This indicates that, Interaction Design Model for Sign Language hybridizing Nielsen and Molich's Design Guidelines is needed in ensuring it enhances the cognitive ability as well as stimulate the positive interactions of hearing-impaired and deaf learners during their learning activities. To strengthen the results gathered from the elicitation of the literature, a semi-structured interview has been conducted. It is discussed in the next sub-section.

3.3. Analysis on semi-structured interview

The interview session has been conducted involving experts, who are the Coordinators of Special Education Department. The interview was held in one of the primary schools that offers curricula for hearing-impaired and deaf learners. A set of semi-structured interview questions were asked (Table 4). The types of questions were developed based on [41], which are classified into (i) knowledge, (ii) experience, (iii) opinion (iv) sensory, and (v) feeling.

Table 4. Sample of semi-structured interview questions

No.	Questions	Types of Questions
Q1.	Is there is any standard or design principles of Sign Language courseware specific for hearing-impaired and deaf learners provided by Ministry of Education?	Knowledge
Q2.	Currently how do the hearing-impaired and deaf learners learn?	Experience
Q3.	How do the teachers ensure that the hearing-impaired and deaf learners are able to grasp the knowledge delivered to them?	Experience
Q4.	Is the current teaching method appropriate for the hearing-impaired and deaf	Experience

	learners?	
Q5.	Is there any device provided by the MOE to assist the hearing-impaired and deaf learners in their learning activities?	Knowledge
Q6.	What are the most critical parts in teaching the hearing-impaired and deaf learners?	Experience
Q7.	To what extend the AT could assist the hearing-impaired and deaf learners in their learning activities?	Experience
Q8.	In your opinion, is the Sign Language courseware that integrates Nielsen's and Molich's Design Guidelines specific for hearing-impaired and deaf learners needed?	Opinion
Q9.	In your opinion, what are lack of existing coursewares?	Opinion
Q10.	How to attract the hearing-impaired and deaf learners to stay focus on their learning activities?	Sensory
Q11.	What are the appropriate elements of courseware for hearing-impaired and deaf learners?	Knowledge

Based on their answers, it was found that currently there is no standard Sign Language model specifically designed or proposed by Ministry of Education to stimulate the hearing-impaired and deaf learners' learning interest in Sign Language particularly one that hybridizes Nielsen and Molich's Design Guidelines [Q1]. Also, it is reported that hearing-impaired and deaf learners have to learn by using the similar learning materials designed for general students [Q2]. As they have the limited hearing function, it is too difficult for them to adapt the general students' learning styles [Q2]. This makes many of them feel that Sign Language is difficult to learn. In regards to that, the pedagogical approach depends on the teachers' existing knowledge and creativity to ensure the hearing-impaired and deaf learners are able to grasp the delivered knowledge [Q3]. According to those experts, the best method for teachers to teach Sign Language to hearing-impaired and deaf learners is visualizing the scanned-images on screen [Q3]. However, this technique is still hard for the hearing-impaired and deaf learners to stimulate their learning optimally, to have positive interactions with teachers or even with their peers since scanned-images do not show step-by-step gestures [Q4][Q9]. Another technique in current practice is one-way interaction, in which teachers have to speak more because of the limited learning materials particularly in the form of Interaction Design Model for Sign Language [Q3]. Again, this technique is hard to inspire the hearing-impaired and deaf learners to have a two-way interaction. O top of that, the experts also expressed that in Special Education Schools, Assistive Technology (AT) devices have been provided by Ministry of Higher Education to assist teachers in preparing the learning materials for hearing-impaired and deaf learners such as alerting devices [Q5]. However, the number of the AT devices is too limited. Besides, most of the time, the hearing-impaired and deaf learners still need teachers to assist them in using the AT devices. In fact, the situation becomes worse when the provided AT breaks down or needs maintenance. Learning Sign Language requires the students to understand, practice, and remember. However, as the hearing-impaired and deaf learners face limited hearing function, it is difficult for teachers to engage them in positive interactions in order to understand their problems as well as to measure their performance [42] [Q6]. This reflects that a comprehensive Interaction Design Model for Sign Language is necessary, to stimulate the interest of the hearing-impaired and deaf learners in learning Sign Language. The difficulties they face in their learning activities indicate that the need for the model is urgent [Q7]. In fact, it is expected that the model is able to ensure hearing-impaired and deaf learners are facilitated, enjoyed, and motivated to stay focus in the learning activities similarly with general students. Thus, the Interaction Design Model for Sign Language should conceptually address the main learning needs that are able to attract and sustain their attention in their learning activities [Q8]. The intended model should also be able to offer positive learning experience in supporting the hearing-impaired and deaf learners interactively and attractively with enjoyment and encouragement concept [43] [Q10]. In ensuring that the students are able to absorb the learning content, they should actively involve in class activities [42]. So, this could be supported by offering unique interaction experience specifically

designed for hearing-impaired and deaf learners [44] [Q11]. This is important to stimulate their learning interest by adapting comprehensive interaction concepts.

4. Conclusion

Based on the findings of the interview, this study aims at proposing an Interaction Design Model for Sign Language, particularly for hearing-impaired and deaf learners by emphasizing the aspects of positive interactions to stimulate their mind to trigger the cognitive ability. Therefore, prior to commencing the development of the proposed model, an initial stage of investigation (that this paper describes) has been carried out. Particularly, the study reveals that Interaction Design Model for Sign Language hybridizing Nielsen's and Molich's Design Guidelines is insufficiently explored whereas it is important to be adapted. The interview session also indicates that typical learning materials and AT provided for hearing-impaired and deaf learners is less helpful to them. Hence, this requires more steps to be investigated deeply in future.

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