The Adaptation of Handwriting Recognition System User Interface in Preschool Literacy Learning Courseware

Mohd Nizam Bin Saad, Abd Hadi Abd Razak, and Azman Yasin

Abstract—**Currently, the education software or simply courseware has successfully become the heart of computer usage in classrooms. With varieties of courseware introduced, the discussion of which courseware assist students the most continues. This paper describes our experience on developing a literacy courseware named handwriting leaning number (HLN) for preschool children. HLN has adapted the handwriting recognition system interface where stylus pen becomes its input modality. By using the stylus pen, we believed that the children could perform better in writing exercise. In order to prove our assumption, we have conducted user satisfaction test using modified questionnaire for user interface satisfaction (QUIS) version 5.5. Result derived from the test indicated that the children tend to satisfy the user interface designed for HLN as the average mean score obtained was 3.864 with Standard Deviation of 0.6879. On the other hand, problems regarding precision and usability of HLN are also reported while solutions to the problems are recommended.**

Index Terms—**Handwriting recognition, literacy courseware user satisfaction test, user interface.**

I. Introduction

The ability to write is essential in a literate nation. Writing is a skill learned in childhood alongside with reading and it is widely practiced during the school years to assess knowledge, to store information, and to convey meaning [1]. The term writing can be used to describe processes (sometimes called the verb approach), or products (sometimes called the noun approach) [2]. Processes can be psychological (the construction of a piece of literature), or physical (the construction of letters), and products are the results of these processes. The end product of a writing activity may exist in a number of forms; it may be a handwritten or typed document, it may be hypertext or it could exceptionally exist as a sound recording.

Traditionally, children learn writing using pencils and papers so that they can practice this skill while their teachers monitor them alongside. With the current inventions, the same processes can be made easier and simpler. To date, learning via technology in classroom normally involves computer where it has been widely used throughout the globe. According to Gagne and Briggs in [3], the computer is suitable to be used as a learning media since it is interactive, repetitive, and responsive. In order to enable the computer to be operated successfully in classrooms, the education software must be excellent. Education software has been labeled with variety of names such as intelligent tutoring system, courseware, and e-learning applications. Even though they are different in named, they have common objective that is to educate students to succeed in their learning. In this paper, we are going to use courseware to refer to the education software.

Presently, literacy courseware that specifically developed for preschool children can be found almost everywhere. They include on-the-shelf courseware, web-based courseware, and research-based courseware. These courseware have been improved with respect to their pedagogical style and overall effectiveness over the year, however their interface have remained more or less the same; keyboard-and-mouse, or windows-icons-menu-pointing (WIMP) interface [4]. The study on the output modalities with respect to the children learning can be found a lot such as the use of voice pitch [5], sound, tactile and color [6], and animations [7]. Similarly, there are also studies on input modalities such as touch interaction [8] and gesture [9]. Yet, the literature has been silent on the effect of using pen-computing in children literacy learning especially for writing. We believed that the input modality of pen computing itself is irrelevant to the achievement of literacy learning, however if compared to WIMP interface, they can performed better in assisting the children to write. The pen-computing interface found in most of the handwriting recognition system can directly support the standard method of writing hence reducing the extraneous cognitive load and lead to increased learning.

Realizing the potential of handwriting recognition interface in the literacy learning courseware, this paper is outlined. The purpose of this paper is to share our experience on developing a literacy courseware for writing named Handwriting Learning Number (HLN) that adapted the handwriting recognition interface. The courseware is development for preschool children where the user-courseware interaction is done via stylus pen. The rest of the paper is organized as follow: Section II and III introduce the handwriting recognition system in brief and the relationship between our literacy courseware and the system. Section IV and V discuss the method to design the HLN interface and the interface design outcome. Section VI and IV reported our questionnaire and the user satisfaction test that we have undergone. Section VIII presents mmmmmm our discussion and finally, we conclude this paper in Section IX.

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II. Handwriting Recognition System

The pen based computing is a complementary input interface apart from the existing popular input devices such as mouse, keyboard, and touch screen. It is an interface where the input process is done via stylus pen movement on flat display which then record and displays the traces of the users [10]. It is not a new technology as [10] reported that this technology has already been used since 1968 through a device named Dynabook. As the technology growth, researchers have conceived techniques where the pen computing can be occupied in a wider usage such as recognizing human handwriting. Hence they start to develop a system named handwriting recognition system.

The handwriting recognition system is aimed at automating the process of turning handwriting work into a computer readable form [11]. By using the system, tiresome job such as typing mathematical formula and drawing can be done faster and easier. Apart from that, the handwriting recognition system also is used to identify hundred of old manuscripts from image documents as they are segmented into individual text lines and recognized with novel recognition algorithm [12]. There are also evidence that the adaptability of handwriting recognition system is also found in institutions such as financial as the signature identifier [13], postal industries as the address reader [14], and entertainment, as the music reader to recognize musical sheets [15].

Although there are many handwriting recognition systems have been developed until recent time, all of them however can be categorized into only two forms; either offline or online system. Offline handwriting recognition is based on scanned image data and online handwriting is pen-trajectory data which is recorded during the writing process [16]. In the offline system, the recognition process is done by analyzing a given text when it is completely entered. Normal offline HRS usage involves the automatic conversion of text in an image into letter codes which are usable within computer and text-processing applications [17]. Meanwhile in the online system will recognize the users handwritten while they are writing [10]. The recognizer works on small bits of information (characters or words) at a time and the result of the recognition is immediately presented. Signature verifiers system is an example of online handwriting recognition system where it compares a test signature with one or few specimens that have been collected as the users enroll in the system. The next section will elaborate on how we utilize online handwriting recognition system to develop our literacy courseware.

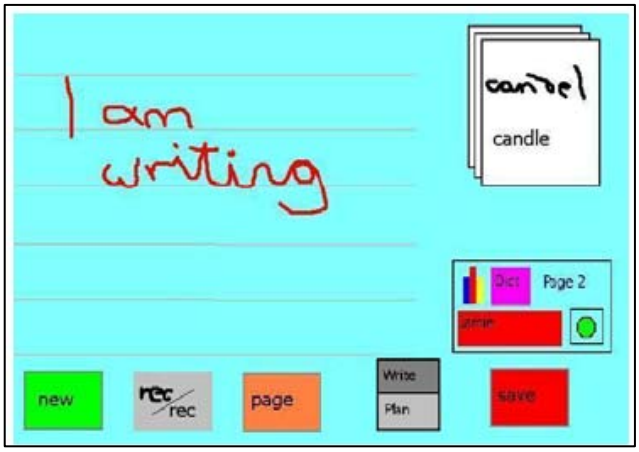
III. HLN and Handwriting Recognition System

As mention earlier in the Introduction section, in this paper, we would like to share our experience developing a literacy courseware for writing named HLN. The HLN is a prototype of an online handwriting recognition system which is developed during the system development phase in our research. The main aim of HLN is to assist children learning how to write properly (one at a time) so that their handwriting skill can be improved. It is also equipped with capabilities such as recognizing the handwriting number between 0 to 9 (it also can recognize character if programmed for such objective), embedding new handwriting pattern into its database, deleting the handwriting written as well as activities such as games and quizzes. HLN however has some limitation where allow only one number to be written at one time and it also cannot recognize cursive handwriting precisely. Later section will detail up the process that we have done to design and create the user interface of HLN.

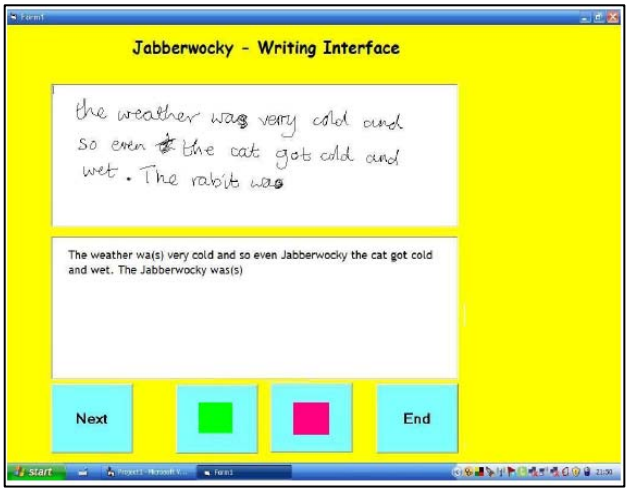
IV. Method for Designing the Courseware User Interface

There are three methods applied to design the HLN user interface. They are reviewing the existing courseware, finding guidelines via literature, and wireframing.

The first method lead us to review two existing handwriting courseware named CobWeb[18], and Jabberwocky [19]. The objective of performing the task is to visualize how a handwriting courseware interface for children should looks like and functioned. We identified interface features like page layout, button position, page sequence, instructions, and navigations so that it can give us fundamental idea to proceed with our own version of interface. Fig.1(a) show the CobWeb interface layout while Fig.1 (b) show the Jabberwocky.



(a)



(b)

Fig.1. (a) CobWeb interface (b) Jabberwocky interface.

Apart from identifying the interface features from both courseware, we also found good recommendations from both articles that represent the courseware, for instance [19] has highlighted eight requirements for Jabberwocky such as assist children in seeing where their handwriting was untidy, raise awareness of poor spellings to encourage children to take care, and be fun to use. These requirements have strengthen our understanding towards designing the user interface for HLN.

After we understood what are needed to design the user interface, we seek for further understanding by browsing recommended guidelines that can help us in designing the HLN interface. Based on our finding, research done by [1] has provides us with comprehensive guidelines on how to to design the HLN interface. She has outlined 40 guidelines that should be consider when 'enabling' software for children. These guidelines are listed in five categories which include interface for pen-based computing, interface for pen-based computing for writing, interface for output and training, interface for pen-based computing used by children, and interface for optional activities and games. Readers are advised to refer to her work for further understanding on all the guidelines. In our case, we considered only 27 guidelines. These interface guidelines are selected as they are very close to what we wanted for our courseware. Some selected guidelines include encouraging the user to look at the screen not at the tablet, advising the user what mode the pen is in, and providing rub up functions. Apart from the work done by [1], there are also similar guidelines to design and develop courseware for children such as written by [20] and [21].

The final method that we did to design the HLN interface is wireframing. In interface design, wireframe are paper-based sketches used to present another form of prototyping, focus on the look, content, and connections for an interface [22]. Wireframes are also referred to low fidelity prototype [23]. They are very easy to make and definitely low in cost. By sketching the wireframes, one can visualize the layout of the system where it will reveal the location of buttons, menu, textbox, etc [24].

The process to make wireframe is done by sketching and coloring the design layout using ordinary A4 size paper. The outcomes are then pasted on predefined size mounting board so that it looks more esthetic and stand stronger. Along the process, discussions among group members are made and modification is done immediately if flaws (such as link between pages is missing or broken, the layout is too messy, and the color scheme is not suitable for children) are detected on the wireframes. Later, the wireframes are brought to four preschool children whose kindergarten is located near to our university. We applied interview method to ask the children's opinion regarding the wireframe. Questions that are asked were adapted from [11]. Before the questions are asked, we create scenario in a form of stories regarding how children can write numbers on computer. When the children start to engage to the story they were then asked the following questions:

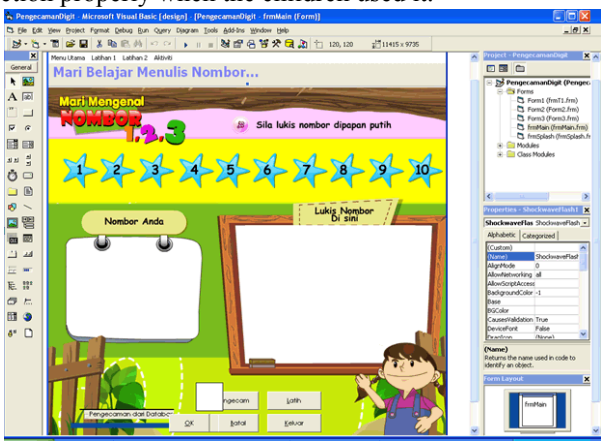
Question 1 – What should the courseware do?
Question 2 – How should the screen look?
Question 3 – What about help?
Question 4 – How can you change your story?
Question 5 - What about colors?

All questions are translated into Malay language as all the children are Malay. The children opinions were recorded using a hand phone, and the interviewer took notes during the interviews.

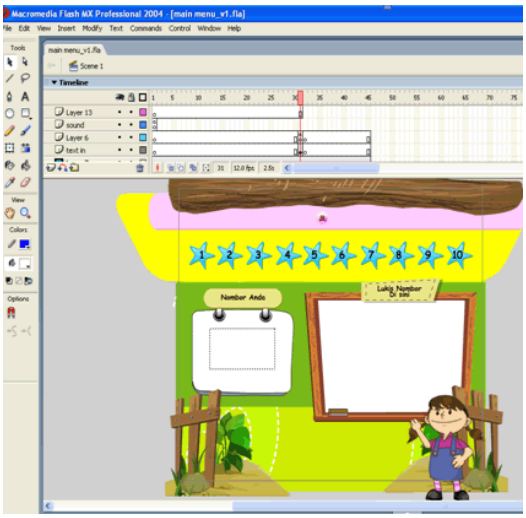
Wireframes that undergone the interview process are later modified so that it meet with the children preferences. Once the wireframes are refined, high fidelity prototype is made to present the HLN.

V. Interface Design Outcome

The actual development of HLN contains three main stages which include the system development, pattern derivation, and system refinement. In brief, system development stage aim to develop the prototype by using selected tools such as Microsoft Visual Basic 6.0 for system visualization and coding, Adobe Photoshop for interface design, and Adobe Flash to create the animation, games, and quizzes. Secondly, the pattern derivation stage is conducted to get a pattern that can represent a general pattern of handwriting for numbers between 0 to 9. Finally, the system refinement is performed to adjust the HLN so that it can function properly when the children used it.



(a)



(b)

Fig. 2. (a) Animation development in Adobe Flash (b) Main module interface in Microsoft Visual Basic.

In order to design HLN according to the children preferences, a tablet PC equipped with stylus pen is used as the hardware testbed. There are two modules in HLN namely main module and the activities module. The main module has three functions; writing, recognizing number, and handwriting training. On the other hand, in the activity module, we included three fun activities to strengthen the children knowledge on numbers. The activities are called matching number, drag and drop number, and guessing the correct number. The preliminary design of HLN's modules are done in Adobe Photoshop. Once the looks satisfied all group members, they are transferred into Adobe Flash to create animation and later into Microsoft Visual Basic to visualize the courseware with real image background, buttons, menu, other controls. Fig. 2(a) shows the snapshot of animation development in Adobe Flash while Fig. 2(b) shows the HLN's main module interface designed in Microsoft Visual Basic.

The final design of HLN that is brought to the children can be seen in Fig. 3. At this stage, all controls, layout, and functions of HLN has been tested and it is ready to be used.

Fig. 3. Final design of HLN.

As can be seen in Fig. 3, the writing interface is uncluttered, as work by [18] has indicated that when the pen is being use as a writing and selection tool, there is a propensity for mode errors. This has lead to the placing all the controls to the application at the bottom of the screen. Meanwhile for the writing area, CobWeb has lines to assist children writing, while Jabberwocky large writing space as both support cursive writing. However, in HLN, we minimize the writing area as it can accept only one number at one time. By using HLN, children can write number easily as it is similar to the way they use ordinary pencil.

VI. Questionnaire for User Interaction Satisfaction

In our study, testing the user interface design is an important stage to judge the outcome of the design process. It can guide the design or redesign of the system and potential areas for system improvement. This study used summative evaluation technique which occurs after the prototype development.

The test for user interface satisfaction was done using the Questionnaire for User Interaction Satisfaction (QUIS) version 5.5. QUIS is a standardized, general user test instrument for interactive computer systems [25]. The QUIS was designed to assess users' subjective satisfaction with specific aspects of the human-computer interface [26].

Before we use the questionnaire, we modified some of its features so that it fit with our study. Basically, the questionnaire was divided into two sections namely General Information for demographic information and User Interface Satisfaction for enquiring user satisfaction towards HLN. The later section was then divided again into five sub-sections containing between four to six questions for each sections. The five sections include *Overall Reactions to the Software, Screen Design and Layout, Terminology and System Messages, Learning,* and *System Capabilities*. In the original QUIS, scale are labeled from 0 until 10 meanwhile the leading question items are very short (Please refer to [26]). We found out that such questions and scale would not be appropriate for our study hence we rephrased the questions and limited its scale to five points only where 1 represents Strongly Dissatisfy and 5 represents Strongly Satisfy. We also present the scales in iconic form because we believed that it would be easy for the children to recognize them. The idea to design the iconic scale was based from [27]. Fig. 4 shows example of the iconic scale.

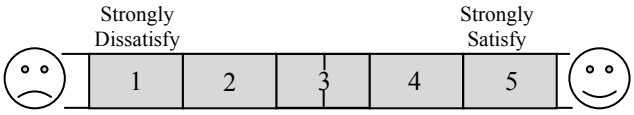


Fig. 4. Iconic scale.

TABLE I: Cronbach Alpha Values for All Dimensions

Section	Number of item included	Cronbach Alpha
Learning	6	0.842
Overall reaction to the software	6	0.810
Screen design and layout	4	0.778
System capabilities	5	0.756
Terminology and system message	6	0.731

The Cronbach Alpha values were calculated using SPSS version 13 to determine the data inter – item reliability which assesses the degree of internal consistency between multiple measurements of a dimension. Table I compares the Cronbach Alpha values for all dimensions in descending order. The all sections manage to gain Cronbach Alpha value of greater than 0.7. Learning has the highest Cronbach Alpha value of 0.842 while Terminology and System Information section has the lowest listed only 0.731. The average

Cronbach Alpha values for all sections are 0.78. With this value, it satisfy the internal reliability criterion for all section.

VII. User Interface Satisfaction Test Result

After the questionnaire has undergone the reliability test, they are brought to the test location which is located in two kindergartens. The HLN user interface satisfaction test was conducted on thirty children. Each of them was given brief explanation regarding the usage of HLN and its user interface. They also use the courseware to learn writing a number using Tablet PC and stylus pen. Once they were done, the children were given a questionnaire for user interface satisfaction test with guidance from fellow researchers. These questionnaires will be filled by us and our assistants based on the children satisfaction towards the courseware user interface. Asking the children to fill the questionnaire themselves would not be a good idea as they might not know exactly what to do with the questionnaire. After all questionnaires were collected, they are brought back and analyzed using SPSS version 13 in the university.

The result shows that the number of children who took part in the test is likely equal in gender. There are 16 (53.3%) girls and 14 (46.7%) boys involved. Out of the number, 16 (53.3%) children are six years old and 14 (46.7%) are five years old. There are no specific criteria applied to choose these children.

In our study, only simple descriptive statistical analysis was used to interpret the result which includes only Mean and Standard Deviation (SD). Based on the result, it is noted that the overall average mean score for all sections was 3.864 (SD = 0.6879). The average mean score indicated that all children tend to satisfy with the HLN interface. Detail mean and SD score for all sections can be seen in Table II displayed in descending order.

TABLE II: Mean and SD Score for All Sections

Measure	N	Mean	SD
System capabilities	30	3.9800	0.7493
Learning	30	3.9111	0.6263
Overall reaction to the software	30	3.8389	0.7029
Terminology and system message	30	3.8167	0.7066
Screen design and layout	30	3.775	0.6544

Overall, the mean score for each section as depicted in Table II are slightly high. The most striking result to emerge from the score was the HLN's System Capabilities section with mean score of 3.98. The mean score is obtained because HLN has the capabilities to enable the children to write the number naturally as what they experienced when doing the same task with pencils and papers. The foundation of HLN which is based on handwriting recognition system and the usage of Tablet PC as the hardware to run the courseware help the children to write easily.

When the system capable to help the children to write easily, this make the learning curve to adapt with all functionalities of HLN would also be very fast. This phenomenon can be seen by the mean score of Learning section (3.9111) which is almost similar to System Capabilities section. Equipped with functions like pen, eraser, writing pad etc., HLN helps children to recognize these ordinary writing functions easily therefore learning to write number is likely straightforward.

With only small margin of mean score between the Overall Reaction to the Software and Terminology and System Message section (3.8389 and 3.8167 respectively); we believe that the children tend to satisfy that HLN has provided them with wonderful experience during the writing process and it is also easy to use courseware to write. The courseware also is so flexible where the children can write as many numbers as they want and they can erase it immediately if they identify writing error. This is probably a new experience for them and it cannot be done as simple as that if they write in traditional way.

It contrast, we are quite shock to notice that the Screen Design and layout section mean score is the lowest (3.775). This contradicts to our early assumption as we believe that this section would score better. Since we have put a lot of effort to design the screen by fulfilling the children preference during the wireframe tasks, obtaining this score would be a bit frustrated. However, on the positive side, the mean score shows that the children still tend to satisfy with the HLN's screen looks.

VIII. Discussion

The result that we have reported in out initial user interface satisfaction test towards HLN suggested that the children was relatively satisfy with the courseware. The children like HLN because it is a new way of learning writing, yet it is similar to their ordinary writing exercise where they can write and rub the number. It also helps them in improving their handwriting. Moreover, HLN provides activities which is fun and entertaining as it is one of the prerequisite to develop courware for children.

On the other hand, we also discovered two difficulties that the children faced. First, they struggled when writing numbers like four, five, and nine. The HLN recognition engine cannot recognize the number correctly and sometime make them frustrated. This finding is almost similar to what have been reported by prior authors like [11] and [28] where recognition problems have cause the user to feel frustrated with handwriting recognition system. As we observed during the test process, we found out that the problem occurred because to write these numbers, the children have to lift up the stylus pen to complete the writing task. Apart from the recognition engine limited capability, we believed that this problem also occurred due to the usage of the stylus pen itself. [29] referred this problem as the recognition precision problem. According to them, apart from hardware problems like lag and parallax, the way user use the stylus pen also contributes to the problem. They might unintentionally performing movement like dragging and scrolling which yell precision errors. Furthermore, when they tapped the tablet surface too hard or too soft, precision problem will also come upon. [15] added that the problem can be minimized if

Windows Vista is used as platform for pen-computing applications. The operating system is equipped with functions like the tap-and-hold for right clicking, the ripple visualization for taps, and ‘‘pen flicks’’ to invoke common commands with gestures.

The second difficulty that we observed is the misconception of instruction by the children. This might be relates to the mean score of Terminology and System Message section which is rank second from last. Sometime we has to assist the children to perform the writing and playing activities correctly. Accoding to [30] such problem is called usability problem. When children are placed to control the recognition in the courseware while writing, different result behaviours can be noticed. The children might not know the sequence of performing the writing procedures which make them confused what to do after completing a task. Hence, the children cannot use HLN alone, they should be monitored by others like teachers and parents.

IX. Conclusion

We have presented our literacy courseware named HLN which its user interface is designed based on handwriting recognition system. HLN is designed and developed with the aim of assisting the preschool children to learn writing. Apart from that, we also discussed the processes that we have undergone to validate our questionnaire and the satisfaction test for HLN that we did. Outcome from the test suggested that we need to improve the screen looks of HLN and rephrase the word terminologies that we use in it. Additionally, the children tend to satisfy with the courseware and it has become a wonderful tool for them to learn writing. While HLN is still considered as a prototype and far beyond becoming a stable product, we encourage interested researchers to supply us with constructive comments to make the courseware better in the future.

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