# Requirements for the Design of a Handwriting Recognition Based Writing interface for Children.

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**ABSTRACT**
This paper describes how the design of a novel writing interface for children was informed by requirements gathering. The derivation of a set of system requirements from observations of children using early prototypes of the interface and from modelling the system is described, and then two methods of gathering further requirements by surveying children are outlined. The relative advantages and disadvantages of each method are discussed. The children were not able to contribute to the full range of requirements necessary for a complete system, but they contributed fun requirements that the observational work failed to identify. A model of the child's relationship to interactive systems is used to discuss why this is the case.

**Keywords**
Text Entry, Handwriting Recognition, Usability, Requirements, Children, Interaction, Design

**INTRODUCTION**
This work is part of a larger project that is determining the usability of handwriting recognition for children doing text entry.

Handwriting recognition is the automated process of turning handwritten work into a computer readable form. When it is used on-line, the user's writing is captured as it is made using a graphics tablet or tablet PC and a special stylus or pen. This writing is initially displayed on the screen as script and is stored in the system as an 'ink' file.

Using this file, a recognition algorithm interprets information about the position of each stroke and the time when the stroke was made and a stream of ASCII characters is produced that represents what the recogniser derived from the handwriting.

It is common for this stream of text to include errors, as the recognition algorithms generally have to make sense of incomplete or 'noisy' script.

Previous work by the authors on the use of handwriting recognition with children has established that the technology is usable, and a series of empirical studies has identified a number of usability problems. Solutions for some of these problems, in the form of design guidelines and system requirements, have been derived [1] [2] [3].

These guidelines relate to the use of the technology, and have been gathered by observing children using the hardware and software, noting comments from the children, and modelling the system behaviour.

This paper begins with a brief look at the research literature on involving children in the design process, and on designing for children. An overview of the research by the authors is then presented an initial list of the requirements for the final prototype is presented.

An experimental study is then described that was used to gather requirements for the system directly from the children using both questionnaires and interviews. The relative benefits and the results of these of two data gathering techniques are presented.

Discussion then follows about what it was that the children contributed and why this was the case. A model of the relationship between the child and the interactive system is presented, and this is used to suggest some general guidelines about requirements gathering for novel interfaces with children. The paper concludes with a brief description of the interface that was designed for the children as a result of the requirements gathering activity.

**THE SYSTEM DEVELOPMENT PROCESS**
The term 'design' can mean different things to different people. In a system lifecycle, 'design' is generally used to specifically refer to the activity that takes place after the initial analysis work and requirements gathering has been completed, but before any implementation takes place. It is acknowledged that in an iterative approach to systems



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development, evaluation of prototype designs might result in new or changed requirements.

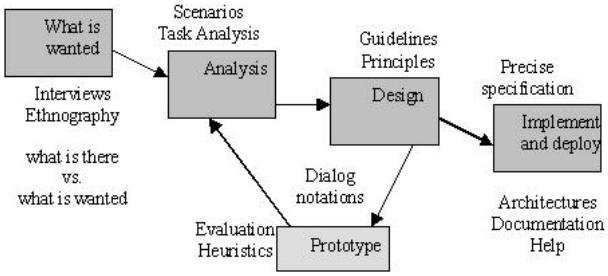


**Figure 1 - The System Lifecycle**

Some authors use the term 'design' in a wider sense, to include the analysis and requirements gathering process, and sometimes the implementation stage as well. In this paper, that 'bigger' activity is referred to as 'development' and 'design' is used in the former sense; thus the gathering of requirements is seen as a part of the development process but not as part of the design process.

### Involving Children in the Development Process

When children are involved in system development, it is likely that they will be doing something that includes analysis and requirements gathering, together with some design, and some testing or evaluation of products and ideas. For instance, in a paper that describes the usability research techniques that Microsoft have used in making products for children, the authors suggest that site visits can be useful to place the software in context; that children's opinions can be elicited by using card-sorting techniques and surveys, and that children can test designs using paper prototypes and lab tests [4].

Engaging children in the design process is often done in participatory design workshops [5]. There is a lot of enthusiasm for this kind of activity and a new vocabulary has built up comprising 'design teams', 'co-operative enquiry', 'informant design' etc. [6], [7]. Research has shown that for children to participate in the design process effectively, they have to have information about what constitutes good interface design [8].

### Designing for Children

General interface design rules, such as these by Schniederman [9] can be applied to products for children.

- Strive for consistency
- Enable frequent users to use shortcuts
- Offer informative feedback
- Design dialogues to yield closure
- Offer error prevention and simple error handling
- Permit easy reversal of actions
- Support internal locus of control
- Reduce short term memory load

When products are being designed for children, there are some guidelines that can be applied. Druin states that children notice '*what's cool, how easy things are to learn, what things look like*' and '*how much multimedia there is in a product*' [10]. From this, she concludes that children want interfaces that they can easily control; they want interfaces that '*respect*' them, those being interfaces that are not too simple. She also states that children want multi-sensory experiences.

Hanna *et al* [4] suggest that any computer based activity should be '*inherently interesting, have expanding complexity and should include reward structures*'; that the instructions should be '*age appropriate, easy to understand and remember, supportive rather than distracting and should allow the children to control the amount of information that they get*'. Guidelines that have been derived from this research include the use of 'visually meaningful icons', 'thoughtful cursor design', and the addition of features such as rollover, audio, animation, and highlighting [11].

There is some specific research on the selection of icons for children's interfaces. Uden and Dix [12] and Baecker et al [13] both suggest that children prefer animated icons, and it is the case that animated icons can offer more information.

### Designing Recognition based Interfaces

Recognition based interfaces are error-prone (they do not always interpret user input as the user intended) [14]. The user's task performance can be described as 'bumpy' [15], that is, there will be highs and lows. Due to the fragility of recognition-based interfaces, it is necessary to use a very carefully constructed user model [16]. There is little work specific to the design of handwriting recognition based systems, however speech recognition is a similar paradigm, and some of the work on designing for speech input can be applied here. It has been noted that users do not like to keep switching from speech to keyboard, and it is likely that this is also the case for pen input. Design guidelines include making error messages specific, allowing users to turn off the input device and indicating clearly when it is the user's turn to take part in the interaction [17].

### Recognition based Interfaces for Children

Druin describes some of the features that children want from a product as '*honesty, curiosity, repetition, and control*' [18]. Recognition-based interfaces struggle to supply these features. The ambiguous nature of the interface means that children will get conflicting feedback from the interface. They may write the same word twice, only for it to be recognised in two different ways. Children have however been observed satisfying their curiosity by testing out the interface [3]. However, due to the complexity of the algorithms that carry out the processing, and the invisibility of the recognition process, they are unable to derive any rational explanations for the results that they find when they test out the interface.

## ESTABLISHING REQUIREMENTS

The activity of understanding what a product should do is variously described as requirements gathering, requirements capture, requirements elicitation,

requirements analysis and requirements engineering [19]. Preece et al use the term '*establishing requirements*' and this seems to be a sensible description of the process of finding out what users may want or need in a system.

A requirement is a statement about what a product should do, or how it should behave. Preece et al [19] have identified five different types of requirement for systems that are being developed for adults:-

- Functional requirement - a statement of what the product should be able to do.
- Data requirement - a statement about the data within the product.
- Environmental requirement - specify the circumstances within which the product will operate; this will include the physical environment, the social environment, the organizational environment and the technical environment.
- User requirement - used to capture the characteristics of the user group; their skills, whether they are novices or experts, whether they will be casual or frequent users.
- Usability requirements - will be concerned with effectiveness and efficiency, accessibility and learnability.

In many situations, determining requirements is best done with the assistance of real or potential users. Observation and survey methods are often used.

## REQUIREMENTS FROM CLASSROOM OBSERVATIONS

The authors of this paper have carried out a series of empirical studies to inform the development of the handwriting recognition interface [20] [21] [3] [1]. The main studies are outlined here and some of the requirements that were elicited are gathered together below for ease of reference.

An early study compared handwriting with keyboard, mouse and speech input and this resulted in some environmental requirements and some user requirements being formulated.

Using the technology in a writing classroom assisted the researcher in the formulation of many of the functional requirements for the prototype.

A study that specifically looked at the interaction identified that there were problems with the position of the pen and the screen cursor and this lead to requirements for the physical interface being established.

Watching children make and recover from errors, both as they wrote, and as their work was recognised, identified some data and some usability requirements.

Observing children working through a training interface gave some indications of what some of the environmental and usability requirements are.

### Requirements that were Established

The requirements (and a few design implications that follow from them) are given below.

#### *Functional requirements*

The system should support the three stages of the writing process, these are planning, translation (writing), and review. Within these stages it should provide ideas for planning, allow for fast and accurate transcription, and allow for the easy movement, alteration and deletion of characters, words and phrases. It should include some spelling support and should incorporate file-handling facilities.

The recognition component should be able to work even when children write slowly, it should be able to deal with 'wobbly' writing, and should be able to recognise common misconstructions of characters.

#### *Data requirements*

The system needs to be able to cope with multiple users, each user may have multiple documents and each document may have many files associated with it. These may be text files as well as ink files, and the text and ink files will be related. Each text or ink file may have updated versions following an editing process.

#### *Environmental requirements*

For use in the classroom – the system needs to be robust, easy to learn and have on line help. It should not need an adult to make it work. It should be designed to work on a standard PC with a tablet and pen. The interface may be used in a noisy environment, or in a quiet environment – this implies that any sound output needs to be non-essential and easily turned off. Children are likely to be working collaboratively – so large font sizes on the screen are necessary.

#### *User requirements*

Users will be novices at the start but will quickly acquire competence. The primary users will be children of normal educational ability and without any motor dysfunction in their upper limbs. They will have reasonable vision and it is expected that the children will be able to read, but not with confidence. For this reason the words and language need to be kept simple and spoken output should be an option on the help screens. Children cannot be expected to be able to spell well, nor to be able to write cursively (although both will result in a better experience at the interface!). They can be expected to be able to hold and manipulate a pen, and to be able to construct even sized, legible alphabetic characters in upper and lower case.

Secondary users are adult helpers. These can be expected to be literate, and to be able to use a mouse driven GUI interface. They cannot be expected to be familiar with the handwriting recognition processes nor with the file handling of the application.

#### *Usability requirements*

Children should be able to use the interface within their first ten minutes of usage. They should be able to use the

controls without having to keep asking for help, and they should be able to access help from the system easily. The help should be presented to them in a suitable format for their age. Children should find the interface as easy to use and as quick to use as paper and pen.

## CHILDREN GIVING THEIR REQUIREMENTS

Having made a list of requirements from watching children using various prototype systems, it was decided to see if further requirements could be established; two methods were chosen; these being questionnaires and interviews. It was acknowledged that some more child-friendly techniques like co-operative enquiry [10] could have been used but these approaches were more ethnographic and to some extent, an ethnographic approach had already been used as many children had been observed using the prototypes over a significant length of time.

In addition to finding out any new requirements, it was decided to use the opportunity to find out how useful the two methods were and to see which the children preferred. There were two hypotheses, one was that there would be a significant difference in the number of needs elicited from each technique; the other was that the children's preferences for each technique would differ.

### The Children who took part

The requirements gathering activity was carried out with twenty-seven children aged 6 and 7 from a local state school. The children were divided into two groups. The 14 children in Group A were given a questionnaire and the 13 children in Group B were interviewed. The two groups were closely matched for gender composition and age.

### What the Children were asked

To make a reasonable comparison between the outputs from the two groups, it was important that the external input to the interview and questionnaire was as similar as possible. This was achieved by having two scripts; one for the interview and one for the questionnaire. Each script began with a statement of the problem domain:

> *In the next couple of weeks, Janet is going to make a computer program to let you write stories using the computer and a pen and graphics tablet* (equipment was shown). *The program will let you write in your own writing, and it will then put the writing into the computer and the words will show on the screen. The program will let you save your work, print it out and change it. Janet would like your help to make the program do the right things and look how you want it to look.*

Children were then asked the following questions:

Question 1 – What should the program 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 colours?

Each of these questions was expanded on by reading from the script; so for instance for Question 4, the script read

> *When you have written your story, you might like to change things in it.. It may be all about George and you want it to be about Shelley. How would you like to be able to do this? What things will you need in your program to help you change your stories?*

The questions were the same for both the interviews and the questionnaires. The interviews were held in the headteacher's office, as it was the only quiet place where they could take place. These were recorded using a visible microphone, and the interviewer took notes during the interviews. The interviewer had no experience of the previous work by the other authors and so she was able to remain neutral during the interviews with the children.

The questionnaires were administered to seven children at a time in an open plan workspace within the school. Children were asked to fill in a simple questionnaire that had spaces to fill in after each question. Any child that had problems with reading had the opportunity to ask, but most children understood the words on the sheet which had been deliberately chosen to be easy to read.

Before each interview, and prior to filling in the questionnaires, the children were asked to indicate how hard or easy the process was going to be. On the questionnaires there was a set of three boxes labelled Hard, Okay and Easy. The same three options were offered to the interviewees and the interviewer recorded their responses. At the end of the two processes, children were asked a similar question about how hard or easy they had actually found the process. From this data a score was calculated to measure the child's comfort with the process.

One child did not complete the activity as he felt it was too hard. He was going to complete the questionnaire, and so the results reported here are from 26 children, 13 using each method.

### What the Children Wanted

The children gave a lot of information. The most common requirement was for help with spellings with over half the children specifically mentioning spellings or help with words. This had not been mentioned in the questions or in the script.

Much of what the children wanted the program to do was influenced by their previous experiences with computers. The children in the study were from a middle class area and all had computers at home. The school had an ICT suite with networked Windows XP machines and the class had been using these weekly for two years. Children mentioned wanting help buttons, wanting wrong words to be underlined, they asked for font changes, bold, different sizes and other text formatting features. They referred to icons, delete keys, arrow keys, cursors and undo!

Some novel ideas were gleaned from the children, these included the idea that the computer would '*sound out*' the letters of words that were badly spelt. Another that the

program would un-mix mixed up words. One child wanted the program to put himself inside his stories at the click of a button.

Most of the children focussed on either spellings or system problems when they were thinking about the help that the program could provide but one child suggested that the program could give advice about how to make the story better. The same child wanted the spellings help to incorporate a box in which the child copied the word after it was presented to them.

One of the girls, when asked about screen designs, wanted the interface to look like a book, with pages that turned over and one boy wanted to be able to set the background of the writing screen to one of his own pictures.
The children seemed comfortable with '*computer speak*'. However, rather than 'delete' they mentioned 'rubbing out' and words like 'tell' and 'fix' were preferred to 'show' and 'repair'. When referring to something that would be a 'delete', many of the children used the phrase 'get rid' and one child had the idea of a 'demolish' button.

## MERGING THE REQUIREMENTS

When the requirements were put together there was very little conflict as the things that the children wanted were mainly to do with the look of the product and add-ons.

Once the requirements were put together, the system was designed.

## THE RESULTING DESIGNS

The design of the top-level navigation was based on the requirements from the classroom observations. For this, knowledge of the process of writing, and knowledge of the architecture of the handwriting recognition software was needed.

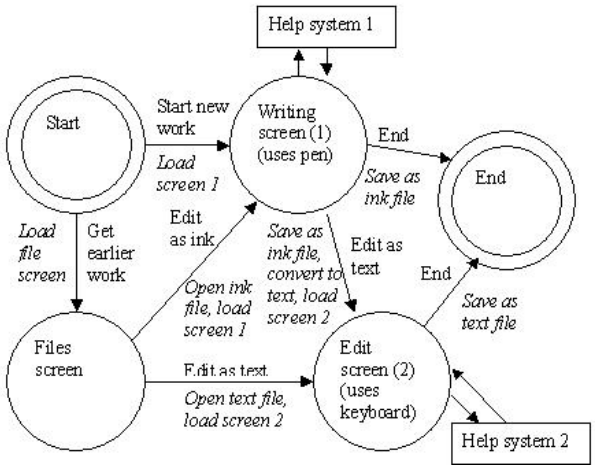


**Figure 2 - Top-level state diagram**

The Help system 1, which related to the handwriting interface, was designed to incorporate a games activity following responses from the children.

The screens for the application incorporated some of the children's ideas, as well as the functionality that was informed by the observational work. Children were able to change the colours of their writing. It was possible to draw pictures that could be pasted onto the finished work when it had been recognised into text. The words that were used on the interface were elicited from the children's language.

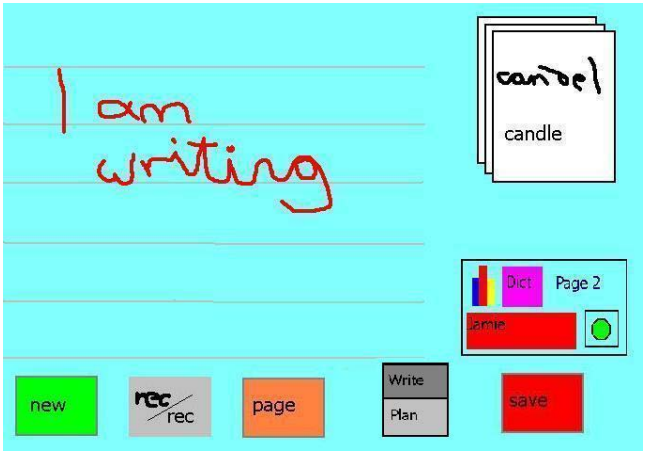


**Figure 3 - The Writing Screen**

## WHAT WAS LEARNT ABOUT THE CHILDREN'S CONTRIBUTION TO DESIGN

The system being developed was a novel one, and knowledge about the limitations and capabilities of the handwriting recognition software, as well as knowledge about the writing process, was needed for the design.

### The Relationship of children to interactive products

There are different ways to consider the child in relation to the product with which they are interacting. The work carried out in this paper has lead us to identify three different relationships:

Children as Players

In this relationship, the child sees the interactive product as a plaything. To satisfy its' purpose it must amuse or entertain the child.

Children as Users

Here, the child sees the interactive product as a tool. For the product to be useful it must enable the child and make things easier to do.

Children as Learners

In this relationship the interactive product is seen as a substitute school or a teacher. It is expected to instruct and challenge, reward and amuse.

When children are asked to identify what they need or require from a product, they are constrained by their lack of knowledge of areas such as learning and usability. They do not know how it is that products enable them or instruct them. They do not know how it is that products challenge them or make things easier.

However, children are able to inform developers about those things that amuse and entertain them; this knowledge

can result in the children being able to communicate requirements for fun.

Additionally, they know something about making things easier. They have a notion of consistency and visibility and they can relate to ideas like task conformance (like a book).

## WHAT WAS LEARNT ABOUT INTERVIEWS AND QUESTIONAIRRES

There was some variation between the two groups in the responses to some of the questions. In question 1 about what the program should do, six of the children who filled in the questionnaire suggested that the program should incorporate games or quizzes. A further three children wrote that it should let you '*quit school*!' In the group that were being interviewed the suggestions were far less controversial with children saying what was expected, for example "give you ideas for stories", "help you write better stories" and "makes computer writing".

Regarding screen design (Question 2), the ideas from the questionnaire were largely brief - "bubbles", "no lines", "full screen" - whereas with the interviewees the ideas were more expansive. The children who were interviewed all wanted pictures on their screens, but this did result from a prompt by the interviewer.

The other question where the two groups answered differently was with regard to colours. On the questionnaires nine of the thirteen children specified a colour scheme – e.g. red, white and blue or gold or blue. Only one interviewee stated a colour preference, with most of the children suggesting that the user should be able to change the colours or have multicoloured interfaces.

### Children's' Preferences for each Method

A preference score for each child was derived from the score for how easy the activity had been and a difference score that represented the shift from the expectation for how easy it was. Previous work has identified that children asked after an event how much fun it had been generally give the same score that they had given in advance when asked how much fun it was going to be [22]. The calculation of the preference score is demonstrated in the following two examples. For example; a child that gave a score of 3 before and 3 after would get a preference score of score of (3, +0). The 3 in this case is derived from the 3 after score and the +0 indicates that there was no change from the expected score. A child that said 3 before and 2 after would get a score of (2, –1). Here, the 2 is from a score of 2 after, and the –1 indicates that the child's experience was below what he expected. The average scores for the two different methods were;

Interview (2.1, 0.1)

Questionnaire (2.5, 0)

These figures indicate that the children were less happy with the interview than with the questionnaire but also that they generally got what they expected!

### Which is better, Interview or Questionnaire?

The two requirements elicitation methods that were used had drawbacks and advantages. The interviewing process was influenced by the input from the interviewer. Although she tried to avoid prompting the children, there were many silences that needed some input if only to make the children less uncomfortable. The children were unfamiliar with this sort of activity, it is highly likely that they had never before been interviewed by a stranger in this way. There appeared to be a general anxiety in some of the children who were worried that they might have given the 'wrong' answer.

The advantage with the interview method was that much more was elicited, and the vocabulary of the children was captured in a way that was not possible in the short questionnaire. Children were empowered by having only to speak and not write.

In the questionnaire, the children felt bolder and perhaps more able to say what they really felt. They appeared to be less concerned about 'right answers' and they put more of themselves into their answers. However, the way the questionnaires were administered (in a group) seemed to lead to some collusion – possibly as a result of children not knowing how to answer a question, or being anxious about their spelling ability.

Two children skipped questions in the questionnaire, and not all the children filled in the final '*How hard was it*' question. The questionnaire did little to inform the researcher of the children's preferred vocabulary for the interface.

## CONCLUSIONS

It appears from this study that children can contribute to the requirements for a novel interface, albeit in quite a superficial way. Most of the things that the children identified were functional and environmental requirements.

Both interviews and questionnaires can be used with quite young children and both can result in different outcomes. Interviews seem to be useful in the elicitation of language and vocabulary but they do appear to have caused more anxiety with the children than the questionnaires did. This may be in part due to the novelty of the experience and further work needs to be done to establish whether or not giving the children more chances to be interviewed can reduce anxiety. In this study, the questionnaires lead to some collusion and there were generally one-word answers given. It is possible that this was an effect of the age of the children as they were quite young and therefore not confident writers. It is possible that had the questionnaires been administered singly, there may have been different results.

Given that the two methods resulted in different requirements that had different emphases, it seems sensible to use a combination of these methods, as well as ethnographic observational data to determine the requirements for novel interfaces for children.

The model of the child's relationship to the interaction that has been presented goes some way to explaining why it is that children are unable to say very much about their own user needs and those features that support learning. However, they can comment about some aspects of usability and about fun. It was interesting to note that the children seemed to intuitively recognise the need for task conformance, for consistency and the use of metaphor.

The children that took part in this work have since been able to use the prototype that they helped design.

**Acknowledgements**

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