Emotion Expressor:

Communication system for children with ASD to explore their feelings and express their opinions.

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Abstract

Autistic Spectrum Disorders (ASD) in children is usually diagnosed by the age of 3. Affected children experience a number of difficulties with social interaction including communication and language problems. The children generally remain quiet and communicate less with other people, or may use alternative methods of communication such as sign language or the use of images. It can be hard to comprehend the speech of children with ASD and it is also difficult to get an indication of their emotions through their speech as their tone of voice fails to reflect this. They find it hard to ask for what they want and can get frustrated, as a result they will begin to scream or grab the desired item. As the children grow up, they become aware of how difficult it is to be understood and often become anxious and depressed.

The aim of the project was to develop a prototype system that will allow for children with Asperger syndrome, a type of autism, to explore their feelings and express their opinions. The interface to the system was developed and refined using a user-centred design approach. Children with ASD tend to be visual learners therefore pictures sets were used. The system focuses on the picture symbols that are the basis of communication as these can be easily selected and understood by the children. The system is computerised and allows for the selection of a variety of picture symbols on the interface using a mouse.

1. Introduction

The Dudhope Centre for Child Health provides therapy services for children with Autistic Spectrum Disorder (ASD). At present, the centre does not utilise any computerised system in order to facilitate the expression of feelings by the children. Verbal communication is currently the preferred method used by the therapist. However, it is possible that children with ASD may not like this method as they can find it hard to express themselves through talking. One of the difficulties people with ASD have is verbal communication. The system presently used in the centre includes the British Picture Visual Scale (BPVS), which comprises a series of questions designed to find out the level of autism in the child.

The objective of the project was to create a prototype system that will allow children with ASD to select a certain topic and enable them to express their feelings about the topic as easily as possible. As the users would be children with ASD it was important to keep the interface user-friendly and appealing to use.

2. Background

Autistic Spectrum Disorder (ASD), also known as autism or Asperger's syndrome, is a complex development disability that manifests within the first three years of life [18]. It is a neurological disorder that causes defective functioning of the brain, and affects the social and communication skills of each individual [1].

According to Wing (1971), around two-thirds of autistic children appear to be physically "normal" with abnormalities only found on close examination, while the remaining third suffer from an associated handicap of their brain or central nervous system function, for

example epilepsy, meningitis or spasticity [21].

The differences in manifestation of the disorder demonstrate that the degree of autism can range from very mild to severe. This range of severity differs from one individual to another. Studies show that 70% of people affected by autism have some form of mental retardation [22], while 10% are savants [7]. A savant is a person who has autism but is extremely talented in a particular area that most unaffected people are not, for example music, art, calculation and memory.

An estimated 535,000 people suffer from autism in the UK [8]. A review of autism research performed by the Medical Research Council indicated a prevalence rate of 1 in 166 in children younger than 8 [14]. Research has shown that boys are more commonly affected than girls, although there has been no explanation put forward as for why this is. Frith (2003) states that on average the ratio of boys to girls with autism is 4:1 [7].

As each individual may exhibit different characteristics or specific behaviours, Wing and Gould (1979) have found a cluster of features that provided diagnostic criteria for autism [12]. This is commonly referred to as Wing's Triad of Impairment:

- Social Interaction – difficulty in socialising with others, for example, being distant towards other people.
- Social Communication – difficulty with verbal and non-verbal communication. For example, the meanings of common gestures or facial expressions are not understood.
- Imagination & Social Understanding – difficulties with play (delay or absence of pretend play), poor imagination, ritualistic behaviours and reliance on routines. For example limited ranges of imagination for pretend play.

As stated previously, children with autism encounter difficulties with social interaction and communication, and another characteristic feature of the disorder in addition to this is problems with the expression of emotions.

2.1 Difficulties children with ASD Encountered

2.1.1 Social Interaction

There is a substantial difference in the manifestation of this feature among people with autism, making it is the most discernible area of individual variation [11]. The classical trait in some children with autism is their social withdrawal, and they do not enjoy the company of other people. This problem is commonly made evident when they start school, as they display a lack of interest in joining other children in school games or activities. Other children with autism can behave in a passive manner and are very dependent on familiar adults, like parents, and will join in with others such as siblings. However, problems in interacting with others and making friends still arise. The main cause of this is their inability to understand social signals and a difficulty in learning the skills of social interaction. They will only respond if their name is called.

2.1.2 Communication

Just as the level of severity of autism can vary between individuals, so can the range of their difficulties with spoken language. In severe cases, spoken language never develops. At the other extreme, mildly affected children exhibit highly developed language skills with exceptional grammar and pronunciation, and they may even have a have special talent for learning foreign languages [12]. However, communication does not have to be verbal, it can be all aspects of communication; understand and using facial expressions, expressive gestures, body postures and positioning. In spoken language there are problems with the meaning (semantic aspects) and pragmatic aspects of language. Without good communication, children often end up frustrated at not being understood or expressing their needs. This may lead to temper tantrums, aggression or destructiveness.

2.1.3 Emotion

Each autistic individual has a different level of recognition and expression of emotion. Their expressions are sometimes not understood by other people. Durig (2004) states that those with autism experience real and genuine emotion the same as everyone else, but they have difficulty in expressing their emotions and may require extra time and patience in recovering from emotions such as frustration. He also explains that the frustration displayed by autistic people may arise as a result of the repetitive ritualistic behaviour that is characteristic of the disorder [6]. Lack of understanding of emotions and being understood can also lead to frustration making them more vulnerable.

2.2 Visual learners

The National Autistic Society (NAS) states that people with autism tend to be visual learners. [19] They show a better understanding of what they see rather than what they hear. With 90% people with autism are visual learners and 10% auditory, visual strategies are commonly used to help with communication [1].

2.3 Computer Assistive Technologies

Studies have demonstrated that autistic children are attracted to the use of computers and can be taken in by off-the-shelf software [2]. It may be that computers have a calming effect on them and they find it easier to concentrate on using computers than interacting with people.

Currently various systems are used as aids to children with ASD. For example, there are technologies available which can be used as teaching devices in therapy of children with ASD. One example of this is the research study of 'Investigating a Robot as a Therapy Partner for Children with Autism' [20] using the AURORA Project. This project aims at teaching basic social interaction skills for the children with ASD with the use of a robotic platform. However this device does not help the child express how they feel.

Research by Blocher and Picard (2005) [2] reinforces the efficacy of technologies in the recognition of emotions. The application Affective Social Quest was developed and designed to teach emotion recognition to autistic children. It builds on the strength of the autistic child's visual system through the use of video. As a result of the use of this application, a three-year-old participant had an increased ability to identify a wider range of emotions after each session.

CompuThera [4] created by Robert Caron and his team, is another example of a teaching technology. Aimed at children with autism or receiving Applied Behaviour Analysis therapy, it teaches them the basic skills for reading and language. It uses the Discrete Trials methodology by way of seven steps to reading: matching, receptive skills, verbal imitation, expressive skills, spelling skills, sight reading and sentences reading. The application uses interactive read-along stories that are read out by the computer, and the words are highlighted in synchrony with the reading of the word. Flash cards are also available for printing.

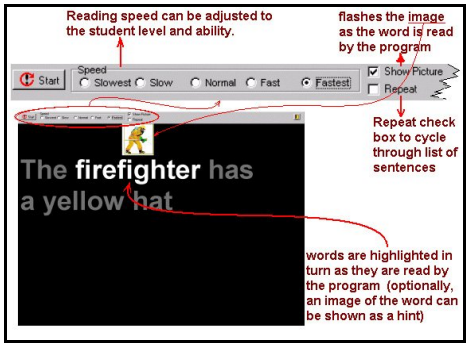

Figure 1. Screenshot of CompuThera reading application. Retrieved from http://www.computhera.com/manual/

2.4 Non-Computerised communication systems

There are many non-computerised methods in assisting children with ASD. For example, the Picture Exchange Communication System (PECS) developed 12 years ago by Bondy and Frost. This teaches young children how to communicate with others to initiate their requests and needs [3]. It requires the use of a set of picture cards which contain pictures, objects or symbols depending on the child's developmental level, as the less detailed the picture is, the easier it is to understand. The main idea is to teach the child to exchange a picture card for something he/she wants and likes. For example, if the child wants an apple, the child would use a picture card of an apple and give it to the adult. The adult in return would then take the picture card and give the child a real apple. This system has been successful and many young children later develop verbal language.

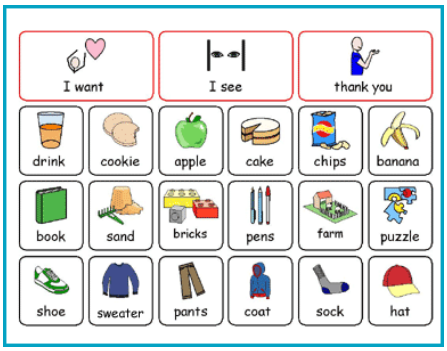

Figure 2. Example of PECS cards. Retrieved from http://www.teachgrid.com/in_print/books/pecs-cards/

Another example is Talking Mats [15], a non-electronic communication framework that consists of a set of picture symbols as the basis for communication. This is produced by a research team at the Augmentative and Alternative Communication (AAC) Research Unit at the University of Stirling. This is similar to the prototype system developed in

this project as it also allows children with ASD to express their opinions about certain topics using a visual approach. While PECS used only picture cards, this system uses a mat as well as picture cards. It was original designed for use by patients with cerebral palsy but it is now used for any disabilities disorders that have communication difficulties.

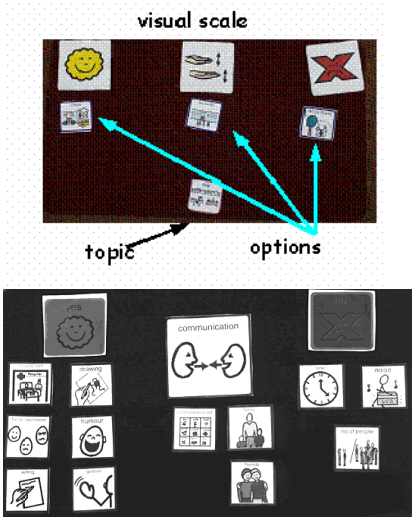

Figure 3. (Top and Bottom) Examples of Talking Mats. Retrieved from http://www.speechmag.com/archives/joanmurphy2.html

2.5 Current systems used at the Dudhope Centre for child Health

After the meeting with Dr. Sally Bonnar, it is found that the current technology systems being used at the centre included:

- 3Di
- Autism Diagnostic Observation Schedule (ADOS)
- British Picture Vocabulary Scale
- Other technologies

3Di - developed at The Institute of Child Health, University College London, and Great Ormond Street Hospital for Children, London. It is used by the parents to communicate with the therapist and not used by the child itself. The 3Di is a computerised dialogised tool for the diagnosis of autistic spectrum disorders in children. Its assessment of the child generates a comprehensive report for the parents. Dr Bonnar stated the 3Di is good and has the potential to be useful as they have just started using this system. Even though there is much information to be gathered and many questions to be answered, a positive feature is that it will not duplicate questions although it can be quite lengthy with the number of questions there are. It is also only used when there is uncertainty as to whether the child is autistic.

British Picture Visual Scale (BPVS) - This is used to measure the child's verbal IQ using a set of pictures. This consists of a set of pictures of which the child points to one that matches the word they hear and their answers will be recorded using score cards. Most of the pictures are for identifying items and some expressions. The child will need to match all pictures correct before moving on to the next set of pictures; otherwise they stay on the same set. It is easy to use for all ages from 2 onwards. Dr Bonnar states that this method is very good, it's useful and quick and there should be a computerised version. The nurse who uses this with children is not to give clues to the child as to whether they are wrong or right; only encouragement is given.

Autism Diagnostic Observation Schedule (ADOS) - This is a standardized protocol for the assessment of social and communicative behavior associated with autism, and provides a standardised method for assessing the level of autism. A series of structured and semi-structured tests is outlined by the protocol in order for the assessor to observe the interaction and responses of the subject.

Other methods used include the use of flashcards, and exercises with pen and paper. Children are also required to keep visual diaries which they discuss during the sessions.

A copy of the meeting minutes can be found in Appendix 2 (2.2).

2.6 Drawbacks of the systems discussed or current non-computerised systems

After research into the use of non-computerised systems, a number of disadvantages become evident due to the requirement for picture cards. Disadvantages are:

- Cards can get lost easily
- Time consuming in finding the correct card
- If not careful cards can be ruined easily e.g. tear or dirty
- Mats are boring, one colour only
- Mats can take up space and are not portable to carry around
- Cannot record which cards were used unless written down

The computerised systems are only there for teaching the child how to read, communicate and socialise with other people. It does not provide them with the ability of expressing themselves which is what the prototype system hopes to achieve.

2.7 Vision

The prototype system will overcome all of the drawbacks of the current systems stated. As children with autism tend to be visual learners it is important to offer them visual support as this minimises stress and anxiety. When designing the interface it is therefore important to provide the user with many visual supports. The prototype system will allow the child to express their emotions visually through the use of pictures. The interface will need to be designed using colours so that it looks attractive and appealing, and simple text so it will be suitable for the user to use. All the emotions that can be selected and topics to be discussed are stored in the system.

There are 2 different types of user profiles. These are student and therapist. The therapist has authorisation to maintain topics and students records. Topics can be added or deleted as appropriate. The therapist can make any changes to the student records that are necessary. Students can only access the system after their therapist has created a profile for them. The student user can create new emotions for specific topics available to them chosen by the therapist. Students can also obtain printouts of their work.

3. Project Management

3.1 Project Planning

There was a great emphasis placed on timekeeping; therefore a Gantt Chart was created using Microsoft Project. This allowed for effective management of the planning and progress of the project. It helped in maintaining the project up-to-date and meeting any deadlines required. The chart was created at the beginning of the project to give an estimated time limit for each stage. The chart was updated regularly after the completion of a stage, and following this the next stage of the project would be started, thus allowing the project to be completed efficiently. The Gantt Chart can be found in Appendix 1.1.

3.2 Supervisors

The supervisor in charge of the project was Dr. Annalu Waller. Regular meetings were held for reviewing the progress and development of the project. Annalu provided help and guidance during the completion of the project. Reports of these meetings can be found in Appendix 2 (2.1).

I received assistance with the interface design from Dr. Sally Bonnar, a Consultant Child and Adolescent Psychiatrist in the Centre for Child Health. Dr Bonnar is to be one of the main users of the system, which made her help invaluable. She was involved from the beginning and throughout the duration of the project. She provided detailed information about the problems that occur in children with ASD and how the computerised system should operate to help the children express themselves. To keep Dr Bonnar updated with the process of the project, regular contact was made through e-mails and meetings. Reports of these meetings can be found in Appendix 2 (2.2).

3.3 Users

There are 3 types of users for the project:

- Expert Users - the end users, expert computer users
- Domain Users - the staff or parents helping the children
- End Users - the children with ASD

The children are the main users of the system with the help of parents or staff to teach and communicate with them using the system.

3.4 Methodology

The system was to be developed for and evaluated by a group of children without ASD. Approaching children with AS at this stage was felt to be problematic due to their underlying difficulties. It was decided to elicit feedback from typically developing children in order to test out the user interface. These users must have the ability to recognise emotions / expressions and also read. They were asked to perform a task, expressing their emotions about a specific topic using the prototype system.

Dr Bonnar was informed of the progress of the project throughout its development, as she will be required for any inquiries of the interface design.

4. Specification

4.1 Requirements

When designing the system it is important to identify what the requirements are. This is necessary as requirements specify the objectives of the system. In order to do this, various techniques for the gathering of requirements are used. One of the methods includes interviewing the customer to gain their ideas on the type of system to be

developed. In the early stages of the project, even the user did not know what their requirements were therefore they sometimes changed during the course of the project.

The basic requirements shown here were formed from my background research into ASD and the currently existing system:

- Design of the interface must be clear and user friendly
- Text must have pictures or symbols alongside it
- Allow emotions to be selected using the mouse e.g. clicking on a button or dragging an image
- Allow for saving, opening and printing of previous work
- Create a therapist and student profile
  - Therapist user can gain access in order to maintain student details and add/delete topics
  - Student user can create new emotions about a topic
- Interface should be realistic i.e. does not use a monkey to represent the student or display a blackboard design as they are not in class
- Do not make it a game as they will know it isn't one, it is a task
- Different colours and interfaces for boy and girl users

Paper prototypes were also created to show and demonstrate to Dr Bonnar. This helps in gaining quick feedback using visual interfaces. These paper prototypes were rough sketches providing a visual design of the interface, i.e. what the system can look like, without having to start any implementation of coding. Adjustments could be made easily, and the user can suggest the addition of any details they desire. A copy of the paper prototypes can be found in Appendix 7 (7.1).

After the interview with Dr Bonnar, the full set of requirements was established based on her feedback on the paper prototypes. The feedback provided more information on the type of system sought and the original requirements were amended to adapt to these needs. The amended requirements were then divided up into functional requirements and non-functional requirements.

4.1.1 Functional and non functional requirements

The functional requirements encompass the tasks that the system must perform, and the non-functional requirements are the constraints on the system and users. Both categories of requirements will include the use of the words: shall, should and may to show the level of its importance. The full set of the requirements can be found in Appendix 5 (5.1).

A use case specification was also performed, which is a modern approach to the analysis and specification of requirements. Use cases are carried out to demonstrate what users can do with the system; these will be different for the therapist and student users. This can be found in Appendix 6.

4.2 Specification of the problem

A system is to be developed allowing children with ASD to express their emotions electronically. The centre currently uses flashcards, paper and pen exercises and children are to keep visual diaries. Any sessions done are recorded on paper or tapes. A computerised system for helping children express themselves would be an improvement for the centre.

The only users of the system are the therapist and the student. Users would log on to the system which displays different menu screens depending on their user profile. The therapist will not have the same menu as the student. It must be user friendly as a complicated system would cause frustration and anxiety if the user did not know how to use it.

The therapist user will be capable of maintaining student records and the topics that can be selected. New users can be added to the system but only the therapist has the authorisation to do this. New topics can also be added to the system and unwanted topics can be deleted. The system should have the capacity to store as many students or topics as required. Another option available would be the ability to change the therapist's password for security reasons. But the students' password would remain constant to avoid confusion.

For the student user, the interfaces will need to be designed with different colours and characters based on the gender of the user. The system will allow the users to express their emotions visually. The user will be asked to express their emotions on a specific topic. After their emotions are chosen, their reasons for these choices can be expressed as well. These will be saved onto the system when the user has finished. They can choose to open the work they had done or print out a copy of it to take home.

With the full set of requirements and use case specification, the implementation of the system can begin.

5. Design

The system uses the method, user-centred design. In the early stages of user-centred design [9], the project involved specifying and gaining an understanding of the situation and background, and identifying the user requirements. Based on the requirements gathered and the feedback from Dr. Bonnar on the interface design using the paper prototype, the initial development of the system was embarked upon. Rapid prototyping was also used in which Dr Bonnar was shown the user interface designs throughout the project and continuous feedback took place.

5.1 Technology used to develop the system

The software used for developing the system was Visual Basic (VB) using Microsoft Visual Studio .Net 2003. There are newer versions of Visual Studio in existence but these were not available. Visual Basic is an object-oriented language and this was used to implement the user interface and the technical aspect of coding. As the system was developed to be a prototype, it was not a priority to implement many lines of coding as the interface was the key aim. VB allowed any changes made to the graphic design of the interface to be updated easily and rapidly. The layout of the interface can be easily changed and moved around to meet the need of any of the design requirements.

A database was also needed to store and save any work that was done and Microsoft Access Database was used for this. Access Database is easy to use and can store as many records as desired. As the system is a prototype, it was not necessary to consider any client-server connections and so Access database was the suitable option for this requirement.

5.2 Design Overview

5.2.1 Database Design

The database was designed according to what was required. For example, it can store information about the student, and the work they did can be opened and accessed again. During the development of the database, the design changed in accordance with new ideas and requirements added throughout the process of the project. More fields and tables were needed to facilitate a more efficient performance of the system. In the end 6 tables were created, Student, Therapist, Topic, TopicFeeling, Feeling and StudentTopic. An E-R diagram was created showing these tables and the relationships with other tables. A design of the database can be found in Appendix 8.

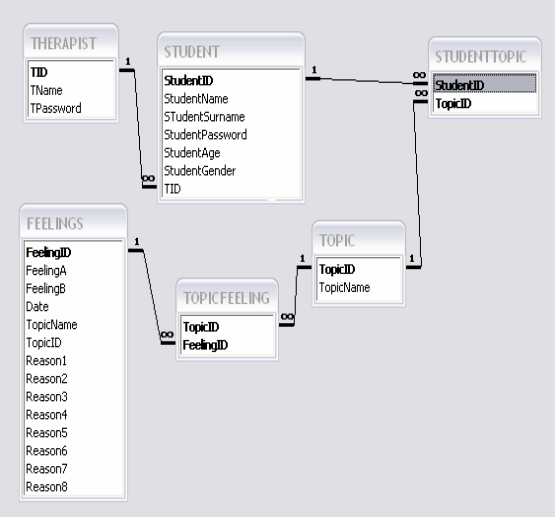

Figure 4. E-R diagram

5.2.2 Interface Design

The user interface was the essential aspect of the system. From the background research it was found that children with autism are visual learners, therefore it was important to design the interface with many visual/graphic supports. According to the ISO/IEC 9126-1 standards it was important to design the system with the quality of attractiveness, and the ease of understanding, learning and operation kept in mind [9].

The early designs were created based on the final set of requirements gathered from Dr Bonnar in which rough sketches and designs of the system were created using paper prototypes. This allowed the user to get a visual image of what type of interface was required. Changes can be easily made to the paper prototypes and allowed for quick feedback. It was necessary to consider the types of pictures, colours, positioning of buttons, text and other attributes that were to be used in the system. The pictures that were used had to be easy to understand as it would be useless if the children didn't know their meaning and what action the picture described.

Once Dr. Bonnar was satisfied with one of the designs, it was used as the basis for the development of the computerised design. The

paper prototype can be found in Appendix 7 (7.1) showing the alterations made from the original design to the current one.

As well as paper prototyping, the method of storyboarding was also used to show what options were available to the students when they use the system and what screens would appear. This technique was useful as it got rid of any unwanted options and screens that can be found in Appendix 7 (7.2). It gives the user a walkthrough of the system without having it implemented using PowerPoint. This way, the user gets a better feel of the system.

When the initial interface design of the prototype has been developed it was important to demonstrate it to Dr Bonnar and gain more feedback. Through an iterative process of evaluation and redesign, the final design of the system will have these following features:

- Two different profiles, therapist and student.
- A Menu screen for a student user instead of having all the available options on the expressing emotion screen.
- All the text displayed in the student screens in the same font, Comic-Sans.
- A scroll bar to display a variety of emotions instead of using a button to display all the selections in a different window screen. See Appendix 3 (3.2) for the emotions used.
- Pictures that is understandable by the users.
- A screen that allows student users to express their reasons, because after the student has chosen their emotion they need to understand why the student feels like that about the chosen topic.
- The student will be able to open and select a topic he/she has done before so they can discuss it with their therapist.
- Different options on the menu available to the therapist.
- Topics will be able to be deleted by the therapist if there are too many in the list or are not in use anymore.
- New topics can be added by the therapist
- The name of the user will be displayed on all screens so that the user knows the system is addressing him/her.
- The date will be displayed so that it can be recorded as the student may change their emotions over time.
- Warning messages will be displayed as necessary e.g. wrong login name/password
- New students can be added to the system by the therapist and their details allowed to be changed later on if necessary.
- Text incorporated along with pictures.

The following are some of the design changes made from the original to the current prototype of the system.

On the login screen, the colours of the background and the character used had been changed. The colours were thought to be 'too dark' and more attractive and clear colours were desired. The character was described as 'scary'. Figure 5 shows the differences made between the two characters and also the current one shows a lighter background.

Figure 5. (From left to right) Original and current character used on login screen.

The boy and girl characters used to represent the student on the screens are changed. More realistic characters were wanted, as the original characters were not in proportion when considering the size of their head and body.

It was important that the pictures on the buttons are easy to understand as they represent the function to be clicked on.

The original button for exiting the system was an X symbol but as Dr Bonnar said X can have double meanings. X can mean to close down the system, or exit but it could also represent 'wrong' to the children using it. To make this button clearer to understand, an open door has replaced the original picture.

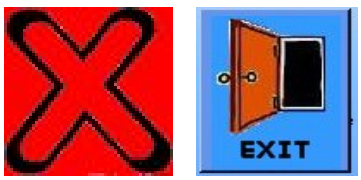

Figure 6. (From left to right) The original and current picture used for the exit button

The pictures that were used for the open and print button were stated as 'old' and 'unclear'. Simple pictures should be used for a clearer understanding and they should not be old otherwise they would seem dull and not

appealing on the interface. Therefore these were changed in order to make them more attractive and appealing, as well as easy to understand. Figure 7 shows the old picture used for opening a file had a cabinet, as the picture was small it seems unclear. Therefore the current picture shows an open file with a sheet of paper.

Figure 7. (From left to right) Original and current Open buttons.

Figure 8. (From left to right) Original and current Print buttons.

The button for creating a new emotion originally used a picture of a thought bubble. Dr Bonnar's opinions on it were that it looks like 'an ice-cream' so it was then replaced by a picture of a heart to represent their emotions, and not their thoughts as the thought bubble would have symbolized.

Figure 9. (From left to right) Original and current New Emotions buttons.

The original layout of the interface for choosing new emotions was documented as 'too cluttered' and it also needed to be 'evened out' as there were too many tasks on one side and not enough on the other. This gives the interface the appearance of many colours on one side as well. It was important that the interface was evened out so students will not just be focusing on one side of the interface. To even it out, the buttons were laid out along the bottom, having the thought bubble in the middle as it was the most important part on the screen. See Figure 10 and 11 for the differences in the interface design.

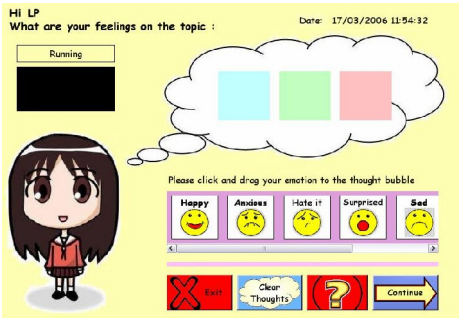

Figure 10. Original layout of the interface for the girl version.

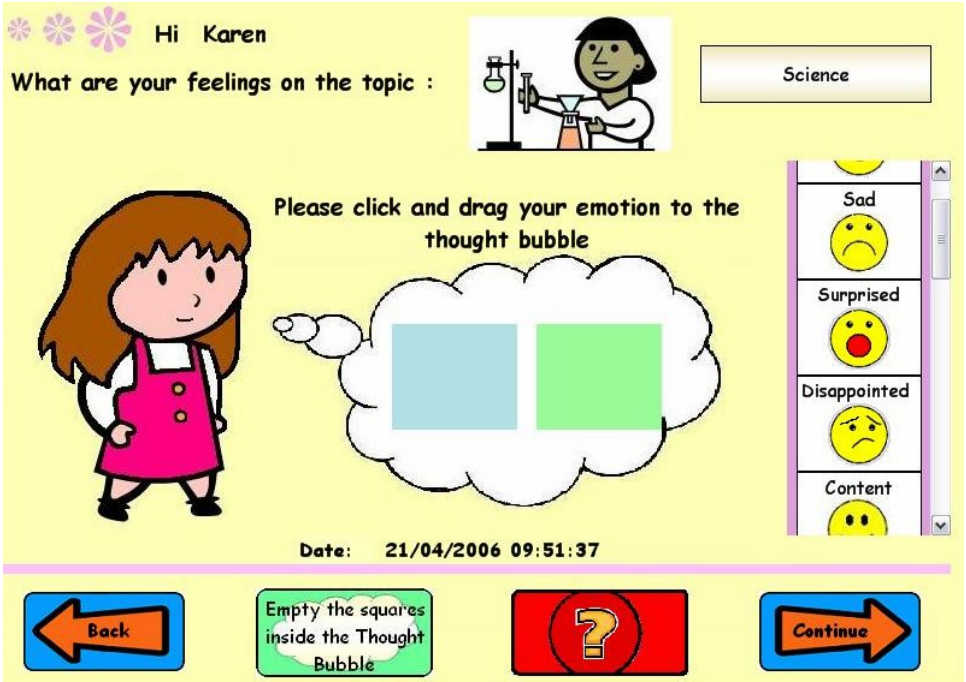

Figure 11. Current layout of the interface

A copy of the changes in the design of the interfaces between the original and current design can be found in Appendix 7 (7.3 & 7.4).

6. Implementation and Testing

The system was aimed to be used on a desktop computer where servers were not necessary as it was a prototype system to be developed. Other methods such as web-based applications did not need to be considered. The key was to allow the system to work on a computer and allow children with ASD to express their emotions using input devices, the mouse and keyboard. It was important to keep it simple and not complicated.

6.1 Software decisions

The languages considered for use in the development of the system were Visual Basic.Net (VB) and Java. It was decided that VB.Net would be used as it allows for greater control of the graphical user interface. It caters for quick changes to the interface design and allows for graphics to be uploaded and edited with ease.

Java and VB are both object-oriented languages, which are uncomplicated programming languages. Although Java has advantages over VB it was not believed to be appropriate for meeting the requirements necessary for this project. Some of the advantages of Java are:

- Portability – cross platform compatibility (once the program is written it can be run on any operating system, e.g. MAC, Windows, UNIX).
- Delivers web based application.
- Java is considered to be simpler and easier to use than other languages e.g. C++.

Even though Java holds many advantages over Visual Basic, there are certain disadvantages:

- Coding must be used for positioning, resizing and appearance of the items/objects on the interface.
- Too many layout managers (Border, Box, Flow, Grid, Card). The layout of the interface may not necessarily be in rows and columns, items could be placed anywhere on the screen.
- Using coding to design the interface and layout is too complicated and time-consuming for a prototype system where numerous changes can be made to the interface design.
- Slow when compiling, the programs in Java uses the language Java Virtual Machine that needs to be converted to a language that the computer understands, e.g. binary [10]. This is not required for VB.

As the system was to be a prototype, there would be numerous changes to be made to the user interface. To enable this, the interface must have the capability of being easily redesigned as often as needed. This meant that Java was not appropriate. Visual Basic, however, allows for simple coding and changes to be made to the interface as often as required.

Microsoft Visual Studio .Net 2003 was used for implementation of VB. The .Net Environment was designed for creating and working with graphical user interfaces (GUI). It contains many objects such as forms, listboxes, buttons and text boxes. Using the Object Properties, their appearance and size can be easily changed to suit the requirements for the system.

The .Net Environment provides different windows for various functions:

- Designing the user interface
- Writing and editing of any coding
- Compiling and debugging the program.

6.1.1 VB.Net

As stated before, VB .Net is an object-oriented language. It can be viewed as an evolution of Microsoft's Visual Basic (VB) implemented on the Microsoft .NET framework. Visual Basic allows graphical interfaces to be created easily using Windows Forms GUI library. With this, using VB.Net, technical coding can be written and the design of the interface can be done concurrently. The interface can be developed using the drop and drag function. When this is implemented it creates a section of skeleton code, the properties are then modified by the developer to meet the requirements. Several screens can be implemented and navigated through easily. The user would use the .exe file to run the program.

6.1.2 Access Database

A database was also needed to store all the data about the students and the work they will be doing therefore the use of Microsoft Access was employed. The databases that were considered included Microsoft Access and

MySQL, but after consideration Access was chosen because it is highly compatible with VB. The user must have the database installed on their computer so Access was a good option as it is the most common in circulation. MySQL can only be obtained if purchased or downloaded from the Internet. As this is a prototype program no Internet or server connection was required. This may mean that obtaining MySQL would be impossible, if the user did not have an Internet connection.

Access is a commonly used database designed by Microsoft for a graphical environment. It is used on desktop computers to create and manage computer-based databases. The tools available are powerful and sophisticated for professional developers. Access is also easy to learn for new users, enabling organisation, access and sharing of information to be performed with ease.

6.2 Implementation

As described above, the user interfaces and coding were developed using Visual Basic. The layout of the interface can be altered easily in order that the desired look for the interface is created. Next, a database was implemented for storing data and coding was developed for connecting the database to the system.

The coding was developed for the different functions stated in the requirements, some of them being, for example, to create profiles for the different users, allow the students to express their emotions and their reasons for it, or add / delete a topic.

The method of drag and drop was applied to perform the operations of the student creating new emotions and choosing their reasons. The student can select their emotion by clicking and holding down on the left button of the mouse, and dragging it across to the thought bubble box. The emotions and thought bubble box were created using the .Net object, Labels. There were problems in implementing this coding due to the developer being inexperienced in the use of coding drag and drop functions. To do this help from Internet resources was needed [5]. It was carried out by allowing the operation of drag on the label with emotions (copying its text of the selected emotion from the Label) and drop onto the corresponding label, the thought bubble boxes (pasting the text of the emotion onto the thought bubble boxes). The use of this method enables the students to have more interaction with the system rather than just clicking on buttons.

The coding of SQL queries, INSERT and DELETE, were used also for adding any data to the tables in the database [13]. This was necessary for adding new topics or students to the system by the therapist, while the student create new emotions to be added to the database.

For the implementation of the interface, the background of the screens and objects (buttons and labels) used JPG pictures. This was used as it was faster and took up less memory.

When implementing the coding, another issue that arose involving the coding written for the data source. This is the connection string between the database and the system. As a direct path was used (see figure 12), this will need to be changed to a relative path so that it is usable on other machines when installing it. The database and the system must be kept in the same folder otherwise the designated path name does not correspond to where the database is stored. The system will fail as a result.

```
strDataSource = "Data Source=
C:\Documents and
Settings\lpoon\Desktop\Emotion
Expressor.mdb"
```

Figure 12. Direct path coding used.

7. Testing

The program was tested to make sure it ran without any errors occurring. Although the system developed was a prototype, it was still important to test it for errors as users will be trying it as if in a real life environment.

Software testing used two techniques:

1. Blackbox testing – this is functional; tests the specification of which requirements were or were not met.
2. Whitebox testing – this tests the structure of the system; the technical coding

It was important to develop the functions of the system to be tested to ensure that it was working properly. Blackbox and Whitebox testing were done to guarantee that the main requirements such as creating a new emotion, adding or deleting a topic can be carried out.

Blackbox testing was used to find defects in the system based on the requirements without having to know how the coding executes. The technique of Blackbox testing utilised Equivalence partitioning and Boundary Analysis. These ensure that the outputs, in response to certain inputs that could be entered into the system, conform to the functional requirements specification of the program. Test cases were created according to the possible types of inputs the user can enter and the expected output.

White Box testing was used to check that the implementation of the coding executes its functionality correctly. The technique of Basis Path Analysis was used to give the minimal set of test cases as using full path coverage would be unrealistic. It was only necessary to test the areas where errors would occur.

A test plan was created stating the tests that had been done on the system and the methods used. Acceptance testing is another technique usually used in software testing but because of the time constraints on this project and as it is a prototype system this was not necessary. A copy of the test plans can be found in Appendix 9.

All the tests done used manual instead of automated testing because the tests were designed to confirm some unique behaviour and condition which need to be run once or a few times. The test also requires human manual interaction with the system. Automated testing is only required when the test needs to be run repeatedly, and this is not necessary for this project.

The most important feature to test was the user interface. This was modified throughout the project to meet all the user's requirements. The user interface was tested by Dr Bonnar on a regular basis when new interface screens and functions were added. After the interfaces were shown to her she expressed her opinions about them and provided feedback regarding any changes that were necessary.

Due to the time limit of the project not all of the specified requirements were met. Therefore it was important to implement the system with requirements of high priority. These were:

- Create profiles for different users to log on
- Create a new emotion for how the student user felt
- Add a new topic to the system by the therapist
- Delete an old topic from the system by the therapist
- Open / print work done by the student

The requirements with the lowest priority were not implemented. These were:

- Edit student details
- Change passwords
- View all students

7.1 Usability Testing

This involves measuring the performance of specific tasks by users. This was necessary as it tested whether users can use the system developed for its intended purpose and identified any difficulties encountered when using the system. This was done by observing the users whilst using it [17].

See Evaluation section for usability testing.

8. Evaluation

8.1 Ethical Approval

The original plan was to have the prototype system evaluated by children with ASD but because of the complications with ethics and the time scale of the project, this plan was discarded. Scotland Disclosure and Ethical Approval were obtained instead for working with developing children. See Appendix 4 (4.1 & 4.2) for Scotland Disclosure and Ethical Approval.

8.2 The users

Evaluation of the prototype system was done by a group of 8 developing children between the ages of 5 – 12. In this group there were 5 girls and 3 boys. The children are all attending primary school and at the time were on Easter holidays where they had spare time to help evaluate this system. The evaluations took place in the User Centre in Dundee University's Queen Mother Building from 10am – 1pm. The participants were recruited through contacts of Dr. Waller. Consent forms sent out to the parents and children are signed and can be found in Appendix 4 (4.4).

The children were all computer literate with experience in playing online games. They were all literature readers except for the youngest child who was in the process of learning to read at school. Any text on the system was then read out to her.

8.3 Procedure

Each child was asked to use the system on their own or in pairs while the rest of the children were kept occupied on other computers. The evaluation process was started by asking the child details of his/herself so that it can be added to the system. A demonstration of the program was then given to the child showing them how it worked. After this, the child was asked to use the program and choose a different topic expressing their emotions about the topic.

To test the usability of the system, the child's actions were observed paying attention to the following areas: the time taken for him/her to complete tasks; the number and nature of errors made; and if there were any pauses or areas where the users became stuck and any difficulties shown. [16, 17]

Feedback was received by asking each child questions after they had finished. The questions were focused on the interface design and the usability of the system. As the participants were all children under 12 years old it was important to keep the question simple using yes or no answers. The comments given by the child were used to analyse what they thought of the program. A copy of this questionnaire and the completed answers can be found in Appendix 10.

8.4 Evaluation of the Interface Design

The feedback received was all positive. All the children liked the system and thought it was easy to use. The pictures used on the buttons were understandable. Only the 5-year-old girl found problems as she has just started learning to read at school. The questions asked of her were mainly based on the interface.

The children liked the layout of the interfaces and could not think of any changes they would make towards it. They also liked the colours used and said it was 'colourful'. When asked about other colours that could be used they suggested the use of green, purple or red for the girl version. One boy stated how the other screens could have the different colours for the background instead of it mainly being blue.

For the screens of creating new emotions, there were differences in opinion on the number of emotions used; some children thought there were enough expressive emotions while others thought there could have been more. The general consensus was that the screen following it, asking them to provide the reasons for their choice of emotions, would be better with a bigger selection of words including 'easy', 'hard', 'exciting', and 'fun'.

The boys liked the boy character used, however some of the girls did not take a liking to the girl character. One comment was that the head of the girl character was 'too big' and the hands were 'too small'. Another comment from the child was that she would have preferred the girl character to have 'straight hair and not curly hair'.

8.5 Usability Performance

When choosing a topic, the topic box did not take up the full screen, so a large portion of the background screen was visible. This seemed to distract the users from focusing on choosing a topic and therefore the topic box will need to be made bigger so that the user chooses a topic first before performing other options on the system.

On the screen for expressing emotions, the drag and drop function was quickly understood by the children once it was demonstrated to them. They found it 'easy to use'. The entire user's performance shows that expressing their emotions and choosing their reasons was an easy task.

The function of opening work done by the user was not working properly therefore it was confusing for some of the children unless explained to them. The result for the print button was the same, as it requires the user to open the work done first before it can be printed out. This function will need to be fixed and corrected to make it easier to use.

With a clear understanding of the language used on the screens, the children were able to quickly and easily find the option for viewing their details.

See Appendix 10 (10.3) for ratings of the user's usability performance.

8.6 Suggestion for Improvements

Some of the children also made suggestions as to what they felt could improve the system.

- One boy suggested that it would be a good idea to have a textbox so that one or more different emotions can be entered instead of the standard ones provided.
- There was a comment that the system was 'rigid' and it was thought that instead of each screen popping up

quickly, it would be better if the screen faded in smoothly.
- When opening previous work, the suggestion of using pictures instead of text when selecting from a list was mentioned. This way the user would only need to look at pictures instead of a long list of words.

Overall the evaluation provided a positive feedback with good suggestions on improving it. The system was described as 'good' and 'interesting' and they all responded positively when asked if they would be happy to use it again. Some of the interfaces were redesigned after the evaluation stage based on the children's responses:

- Changing of the girl character
- More reasons added e.g. fun, interesting
- Colour of the background in the boy version of the interface for creating new emotions changed

9. Summary and Conclusions

The final product met the desired end result. Therapist and student users can login to the system. Only authorised users can have access, any usernames or passwords that are not recognised by the system will cause error messages to be displayed to the user, asking them to re-type their username/password.

As the therapist and student user each have a different set of menu options, the system will display the appropriate menu screens based on the profile of the user.

The student user has the following options: express new emotions about a topic, display their details, open and print out the emotions they have expressed previously.

When expressing new emotions, the user is faced with a selection of emotions (e.g. happy, sad, angry) to choose from using the drop and drag method. When their emotions are expressed, the following screen will allow them to express their reasons for these emotions (e.g. fun, boring and difficult). It is important that the user chooses at least one emotion and one reason. These will be discussed with their therapist, and it will also be easier for other people to understand their feelings towards the topic. If the user does not select anything from the screens, messages prompt them to make a selection. When they have finished, these details are stored on the system.

Students can view the expressed emotions again using the Open option where they can discuss it with their therapist. Printouts are also available for them to take home and show their parents.

The therapist user has the following options: view all the students, add new student to the system, edit the student details, maintain topics and also change their password. As the system was a prototype, the options of editing student details, viewing all students and changing passwords were not implemented because of the time limit and they are considered to be low priority.

There are no limits as to how many students or topics can be stored on the system. New topics and students can be added easily and quickly. There is a Delete function to delete any unwanted topics if they have not been in use for a while. This prevents the topic list from building up.

The system also displays the name of the user on all screens to make the student user feel it is addressing them directly and the system is there for them to use. The current date is also displayed on each screen and Help screens are available if the user is having any difficulties when using the system.

10. Appraisal

The project was successful at achieving its aim of developing a prototype system for expressing emotions and selecting reasons on a specific topic. This was one of the main features to be implemented.

Due to the time constraint not all the requirements and functions were implemented but the system performs the functions of high priority.

The users evaluating the system all provided positive feedback stating it was 'good' and 'interesting to use' and would be happy to use the system again.

11. Future Work

The Emotion Expressor still has many areas, which can be improved on.

11. 1 Adding of pictures.

When adding a new topic to the system, it does not implement the function of adding a picture along with it. This would be ideal as it was important to support graphical help along with any text necessary.

11.2 Enter own emotion using textbox

From the evaluation, a suggestion was given of implementing a textbox for the user to type in their own emotion. But this would depend on the child's level of autism as Dr Bonnar stated, as it might be hard enough to obtain even one emotion from them.

11.3 Choosing characters.

Allowing the child to choose their character for the system to represent him/her, i.e. for girls they can choose long or short hair, curly or straight and colour of dress. Boys can choose their hair colour, colour of top/trousers. This makes the system more personalised for the user as they are creating a character that is similar in physical appearance to them.

11.4 Registration for therapist user.

As the system is a prototype it was designed to be used by one therapist, Dr Bonnar. If more than one user was to use the system, the addition of allowing therapist users to register to the system would be necessary.

11.5 Permission for therapist.

The therapist could be given the option of viewing the student's work on their own main menu. This would provide the therapist access instead of having to ask the student to open it. But due to privacy and ethical reasons, the student would need to give permission first before any work can be accessed.

11.6 Logging in using first name.

Currently the user logs in to the system using their first name. Problems may occur if students with the same first name try to log in. This will need to be improved.

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