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Digitally Augmented Labels and Worksheets

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Abstract

Modern digital pens provide potentially useful features that allow enriched user interaction in a variety of scenarios. These features have not been exploited to realise the potential of the technology. Two application areas using the pen were identified: (1) managing medication and health symptoms. (2) Educational visits to museums. This project explored the development of digitally augmented worksheets and labels through user centred design. Similarities in these 2 application areas in the necessary functionality supported the development of a generic toolkit of code to allow for development of further systems utilising the worksheet and label features using digital pen technology.

A full implementation of a museum system was created including: a digitally augmented tour, two digitally augmented worksheet implementations and a desktop application to retrieve data from the pen. An initial design for a medication management system was also created. User centred evaluations throughout the project offered evidence that the applications were usable, appealing and potentially useful.

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Chapter 1

Introduction

1.1 Motivation

As digital pen technology has advanced in recent years, the potential uses of this in ubiquitous computing are increasing. However, no greatly successful applications have been deployed that utilise the full functionality and potential of digital pen technology. An interesting area is how to successfully create the bridge between paper and digital media. In many cases, paper cannot simply be replaced by a piece of software to represent the same data. Several of these scenarios were discussed and two interesting application areas for new interaction techniques that address the physical/ digital divide were identified early in the project. These are: (1) the communication of information and interaction in museums and (2) home care system to increase medication compliance.

The first application area is an interactive museum application that can offer an alternative to traditional museum guides that are both expensive and can restrict users movements to a particular route. This application also involves using an augmented worksheet, meaning users could answer questions, draw pictures and get information via the Smartpen. Using a separate desktop application, museum staff can receive a digital copy of worksheets and store information from the visitor's answers.

The second application area is a medication management tool, which would help users manage their own prescribed medicine with the aid of a Smartpen and a specially created augmented worksheet, allowing them to maintain their independence but still have their health monitored. A worksheet could allow users to receive information via the pen audio messages related to their medication. Labels can be used to augment medication containers with messages for the user; data can also be saved on the time and frequency of use by the user, based on the user "ticking" the label. When the pen is docked with a conventional computer, medication usage data, as well as any symptoms or problems written by the patient on their worksheet, would be communicated to carers or clinicians.

In the beginning of this project, the original application area was medication management. However, an opportunity to explore the use of digital pens in a museum context became available. It was decided to investigate and gather requirements for both applications and to explore the common features of both case studies. Although the contexts of these application areas are very different, the functionality needed is similar. As a result of analysing these case studies, it is clear that they would need similar implementations and it would thus be useful to create a programming toolkit that could

be used to produce either or both of these pen applications. In many systems, common interfaces can be created that allow developers to use code created by others in their own code. This is clearly beneficial as it saves time when developing code but it is also useful as this code has been tested by others. No such toolkits exist for developing pen applications despite the common segments of code that would be needed to allow for the main functionality of the pen. Currently, development development of digital pen based systems is ad hoc and uses SDKs from a pen supplier. These development kits provide functionality to control the pen but do not contain specialised common pen functions that could be re used in many scenarios. An intended outcome of this project was to provide a toolkit of code suitable to many applications other than those defined previously.

1.2 Aims

Based on the above, the aims of the project fall in to two main areas:

- Develop one or more applications to exploit worksheets and labels for use in museum and medication scenarios.
- Develop a toolkit of generic code for use in digital pen applications.

1.3 Objectives

Based on the aims the following objectives were identified:

- Research existing ubicomp and smartpen systems in museums.
- Research existing medication management systems supported by technology.
- Create usecases based in the two application areas to find the common features of digital pen applications.
- Conduct surveys, interviews and focus groups to gather requirements for creating digital pen applications.
- Create a generic software tool kit for use in digital pen
- Deliver a piece of software that uses digital labels and worksheets to give audio messages to the user.
- Investigate the amount of code reuse between pen applications.

1.4 Approach

The approach followed in this project is somewhat unusual. The original context of the pen interaction was medication management, but the opportunity to explore the use of the pen in the museum

occurred early in the planning stages of the project. Therefore it was decided to continue with both these applications and to explore the amount of similarity in pen applications to be used in different contexts. This would allow the development of a generic toolkit for pen interaction.
As this project consists of two case studies, each section will discuss the relevance to each of these with main focus on the museum interaction and less focus on medication management.
The requirements gathering and design of the prototypes and toolkit was completed in an iterative cycle, allowing improvements from user feedback each time, therefore creating applications that are suitable for the context they are intended. There were 3 major iterations, phase one consisted of a prototype created from research and an expert interview, this was tested on a focus group to gain feedback to inform phase 2. Phase 2 developed the prototypes based on the feedback received. This version of the pen applications was tested with possible end users in a design validation study. Phase 3 was the final iteration of the implementation and the desktop application of the system was developed.

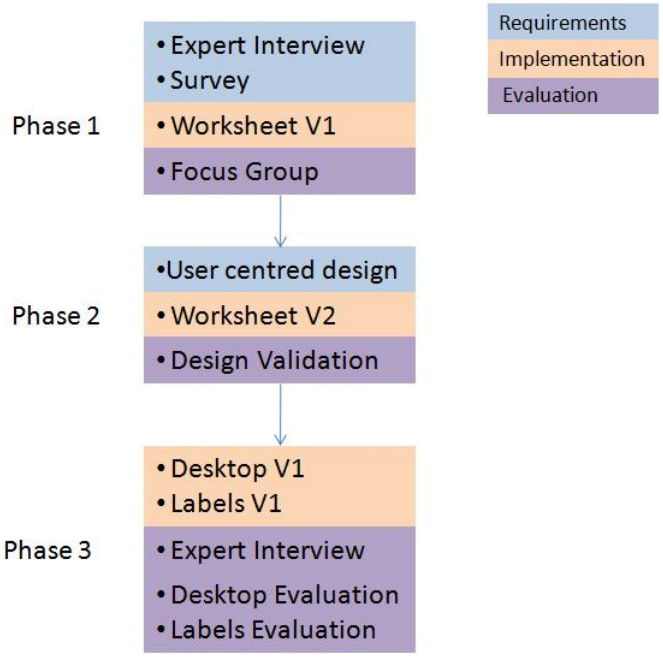


Figure 1.1: Phases of project

1.5 Definitions

This sections provides definitions of terms that will be used throughout this report.

- **Worksheet**: Augmented paper that acts as an input and output device.
- **Labels**: Augmented paper that provides output to users when selected.
- **Penlet**: A digital pen application.

- **Desktop application**: Software that runs on a PC.
- **System**: Entire museum system including labels, worksheets, penlets and desktop application.
- **Prototype**: one or more of the system elements being used in an evaluation.
- **Activity**: Task performed during the project to further develop the system (for example, interviews).
- **Output**: A prototype or document that was produced as a result of an activity.

1.6 Overview

An overview of sections in this project:

- **Chapter 2** discusses the background research conducted in to digital pen technology, museum interaction and medication compliance.
- **Chapter 3** describes the final museum labels, worksheets and desktop application. This will be explained via scenarios and a walk through of how the system could be used.
- **Chapter 4** outlines the procedures followed to gather requirements for the project. As the project has 3 phases this chapter explains the iterative cycle of prototyping and gaining user feedback.
- **Chapter 5** provides information on interesting and challenging implementation tasks encountered throughout the project.
- **Chapter 6** discusses the evaluation of the system, showing both the evaluation techniques and results.
- **Chapter 7** reflects on achievements, limitations and possible future work to continue this project. This chapter discusses how successful the project was in reaching the aims and objectives set out in 1.2.

Chapter 2

Background

To gather information on the main issues for each case study and existing technologies used, background reading was conducted. This was in 3 main sections:

- Pen and Paper Interaction
- Augmented Museums
- Medication Management

2.1 Pen and Paper Interaction

Bridging the gap between paper and digital media is a topic that has had much research and investigation. With the use of digital pens, paper can be used as an interactive device [11]. Therefore, using digital pens can give users the advantages of using traditional pen and paper with the added benefits of multimedia playback.

Paper is often used along side technology in cases where collaboration or communication with others is involved [19]. These communications are often ad hoc additions to documents that may not always be transferable to a digital system. The need for this link between the physical and digital world was shown in the well known study involving the creation on a system for air traffic control. In the existing system paper strips were used by the air traffic controllers to keep track of the plane landings and departures. The ethnographers had to understand the significance of the paper and how it is used to communicate between workers rather than just try to replace it as it was critical to the work and collaboration [6].

Tangible interaction is the use of physical items to represent digital information [15]. This is a useful method of user interaction as it is mobile, the user is not restricted to movement in one area on a screen, and it allows for collaboration as the tangible item can be distributed between groups of users. This is relevant to the use of digital pen technology as the paper and pen can be taken around the museum easily and shared between groups of visitors.

As discussed, the portability of paper and collaboration between users is an advantage to using digital pen and paper systems. This was investigated further in this project by conducting continuous

user evaluations where participants were observed to view how the pen was used in the context of museum interation (see section 6).

2.1.1 Existing Digital Pen Technology

Anoto [4] technology is used to allow digital data to be attached to a piece of paper using a digital pen. The pen works by recognizing a special non-repeating dot pattern that is printed on the paper with the use of an infrared camera. The use of the pattern means that the pen is able to associate pen strokes with a specific point on the page, and determine which page is being written on.

There are several digital pens using Anoto technology on the market that allow users to digitise their hand written notes, annotate paper documents and integrate pen technology with mobile phones. One digital pen links user's written notes with audio recordings, the Livescribe smartpen, discussed in section 2.1.2.

2.1.2 Livescribe Smartpen

Figure 2.1: LiveScribe Pulse smartpen

The digital pen used in this project is the Livescribe Pulse Smartpen [18], that allows the user to attach recorded audio to written or drawn notes on the paper. Notes must be written on livescribe paper which can be bought or printed by the user. These notes can be transferred to the Livescribe desktop software by docking the pen via USB.
The pen consists of input and output components, as shown in Figure 2.2:

- **Infrared camera:** Recognises the Anoto dot pattern to associate pen strokes and audio with.
- **Microphone:** Captures user input and stores as a .wav file.
- **Speaker:** Plays audio to the user, both integrated into applications and recorded by the user.
- **Headphone Attachment:** Same as speaker, yet allows this audio to only be heard by one user via headphones.

- **Screen Display:** Outputs text and very simple graphics to the user. Used when navigating through menus.

This pen is designed to attach audio to handwriting when note taking. When the pen is used with Livescribe notepads the user's notes are saved on in the pen's internal memory. As shown in figure 2.1, paper controls are used to control the pen's functions such as record, stop, volume control etc. Navigation arrows allow the user to navigate between menus and launch applications. When the pen is docked via USB to the user's PC, Livescribe desktop software is launched and retrieves all new pen data. Users can view a digital version of their physical notepads, save or send these pages and hear audio while reading what was written while it was recorded.

Figure 2.2: Annotated Pulse Pen

A SDK to develop applications for the pen using Java has been provided by Livescribe. These applications, called Penlets, can be used to store information about the pen actions and give output via the pen such as audio and visual (on screen). Livescribe penlets are written in Java using the Livescribe Platform SDK and eclipse plug-ins. Penlets are accessed via a menu widget on paper controls on the default Livescribe paper. Custom Livescribe compatible paper can also be created in eclipse and penlet methods associated to particular regions are run when the region is selected with the pen. This has advantages as it means the application can be run automatically when selected rather than through the menu.

Figure 2.3: Pen Communication

Desktop applications can be created using the Livescribe Desktop SDK, allowing developers to create software that can retrieve data from the pen. This is developed using C#. This allows applications to be created to retrieve data and images from the pen and display this to the user. Applications created using the desktop SDK can provide similar functionality to the Livescribe Desktop software that is used by all users of the pen to upload their notes and audio. This also allows developers to define what information should be saved at retrieved. The communication between paper, penlets and desktop applications is shown in figure 2.3.

2.2 Augmented Museums

To aid in the design and creation of an augmented museum system, existing practices and technology were investigated. This section will discuss this process and how this relates to future design decisions made within the project.

In museums, the most common tour technology used are audio guides to give information to the visitors about attractions and screens to display information. Currently there are two main companies for audio museum guides: Acoustiguide [3] and Antennaaudio [5]. These are usually expensive and cannot be maintained by the museum. For example, if a painting is moved and the tour has to be moved, they will need to get the company to do it.This is a problem for smaller museums that cannot afford such a system.

Although many museums provide tour guides for visiting schools, museums are also trying to become more effective in providing informal education to families and non-guided school visits [2]. Using digital systems to provide information to visitors is increasing the user enjoyment and therefore encouraging learning . In education, deeper learning is achieved when people are involved in active participation and interaction rather than reading or listening. Studies show that when senses such as sight, hearing touch and emotions are used the experience is more memorable to users [25]. Although the scope of the project is museum interaction, it is important to design with education in mind. This allows systems to be flexible and would provide a possible use in schools as well as museums.

Most museums have text displays to give accompanying information for an artifact. Traditionally, museum staff develop displays and write non digital labels to give information about the items [16]. Labels usually contain data such as: what the object is, what it is made of, where it came from and where it was made [26]. Museum staff can create information labels for exhibits that can be associated with a particular artifact. However, they can not alter the tour in many existing systems. Therefore, this removes their control over the layout and order of exhibits. This problem in existing tour guide systems was taken in to consideration when designing the pen based museum guide in this project. The ability for museum staff to adapt the tour easily is also addressed in section 5.4.

There has been many projects to explore new forms of interaction for visitors to a museum. This is possibly due to museums being keen to allow researchers develop new systems for better museum interaction [7]. An example is The City project that was aimed at aiding users visiting of a museum or city centre using both old and new media [1]. A study was conducted in a museum context aimed at investigating how users communicated when exploring the museum. It was found that although there was various technologies being used by visitors, this did not restrict conversation throughout their visit. Although this example was involving visitors collaborating remotely with others in the museum the findings are also relevant to investigating museum visiting in this project.

2.2.1 Existing Augmented Museum Technology

Livescribe vs Dataton

An alternative device to traditional audio tours is on the market at a lower cost and is therefore more accessible for smaller museums or those with a limited budget. The Dataton Pickup [10] is similar to Livescribe technology and works via infrared camera communicating with hot-spots (shown in figure 2.4), allowing the tagging of audio to particular labels. The device is currently used in museums to allow audio on the tour to be given to visitors via a device that allows each visitor to hear the message corresponding with their location in the museum.

The Livescribe Pulse Smartpen has similar features to the Pickup. Both of these devices use infrared technology to associate a particular area with an audio message. However, the Smartpen allows users to write on specialised paper and to attach audio. This is an advantage over the Dataton as it can be used to both capture audio as well as play. A technical comparison 2.2.1 was conducted as part of this project to ensure the use of the prototype system was useful in a museum context, as the Dataton is currently use in museums.

Figure 2.4: Dataton Pickup

2.2.2 Digital Pen Technology in Museums

As discussed in section 1 digital pens and augmented worksheets could be used in a museum context to allow visitors to answer questions and retrieve feedback. A similar paper worksheet was created in the paper++ project [20], where the objective was to exploit connection between digital content and paper. The technology used in the study was different to the Livescribe digital pen used in this project as it was based on the pen writing using conductive inks to recognise active areas on the worksheet. When the user selects the worksheet they are then shown related images or information on a nearby computer system in the museum. The major difference between this project and the paper++ example is that the pen used is multi-modal and provides immediate information to the user via audio and visual display. This is an advantage as users can hear information related to a specific area immediately and can move around the museum more naturally as they must not be near the computer screen displaying information. Positive feedback from this study was how comfortable users were using the pen and how they understood what they were expected to do to use the technology.

Feature	Dataton	LiveScribe
Storage	up to 8GB	Two versions 2GB and 4GB. New version of pen,Echo, can store 8GB.
Development	No SDK. But audio can be set up via standard software such as iTunes.	An SDK is available to allow developers to create penlets and specialised paper. Can also use the Livescribe Desktop SDK to retrieve data from pen and view/hear messages.
Multi-Users	Two sets of headphones can be attached to one Dataton.	Only one set of headphones can be added, but can also be used to play aloud without headphones.

Figure 2.5: Technical Comparison of Livescribe vs Dataton

2.3 Medication Compliance

The population of over 65 year olds is rising and within 20 years, it is expected 25% of population will be in this age bracket [22]. As people live longer, they develop health issues associated with old age [9] and often must adhere to prescribed medication to maintain their health. One solution to increase medication compliance that has been suggested and investigated is assistive technologies to assist users in remembering their medication regime.

Studies show that only 75% of elders managing their own medication complied [23]. This means a quarter of all people did not take all medicine necessary. Additionally many people, particularly older, do not know the names of their medications or what they are for.

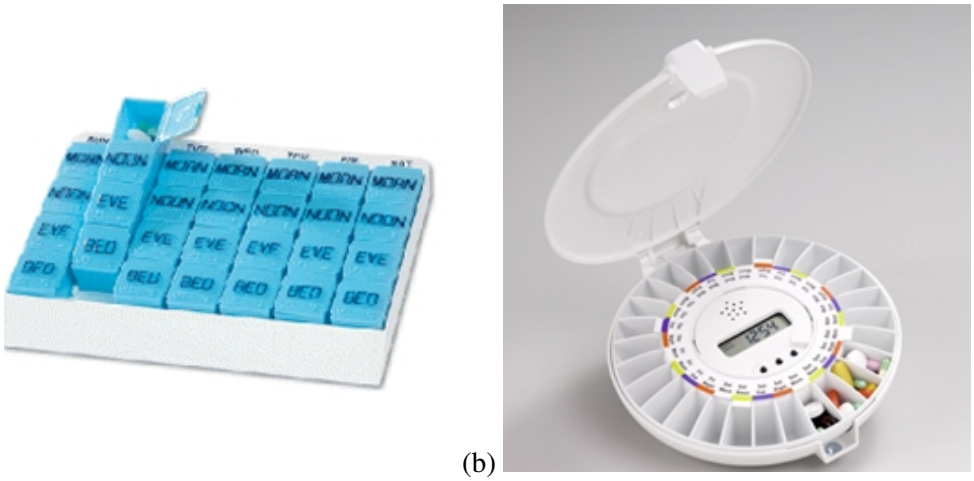
As medication is personal and individual to each person, the way they manage this can vary. A user's home is a special environment and regular design conventions cannot be transferred in to use in home care technologies [23]. Therefore any system to help manage a user's medication routine will be personalised and one common system for all users will not be successful. As such a system would be in use within the user's home, the technology must be welcomed by them or it will not be used successfully.

2.3.1 Technology in Medication Management

Management of medication can vary for each patient as it is personalised to their conditions and home care scenario. Patients managing their own medication use methods unique to their own routine, including low tech methods such as post its, pillboxes and storing in a specific location in their home.

Pill boxes are frequently used to manage medications. With compartments to hold pills for a particular day or time as shown in Figure 2.6 (a). To remind patients to take their medication at the correct time alarmed pill boxes can be used [24]. An example is shown in Figure 2.6 (b). The boxes are set up with pills for a specified time, if the time is missed the alarm continues to play at intervals

for an hour. If this dose is skipped and the box moves on to the next day. Therefore, when the pillbox is re-filled, he patient or carer can realise if any doses were missed.



(a) (b)

Figure 2.6: (a) Basic Pill Box (b) Alarm Pill Box

Technology can also be used to aid in patient based symptom reporting and management [14] to allow patients to record their medical issue and symptoms with receiving outpatient care. A study into pen based technology in symptom management has shown that patients reported the pen based systems easy to use and they were often preferred to traditional pen and paper [8]. Although this is not a digital pen system as used in this project, it shows how patients are willing to use alternative technology in symptom management and reporting.

2.3.2 Digital Pen Technology in Medication

As discussed in 1.1, digital pen technology has not been utilised to meet it's potential. However, the possibility of use in medication is clearly an application area where the technology would be of use as there has been several attempts to implement a digital pen system in a variety of medical scenarios.

An example of this is using a pen to transfer patient symptoms. Usually, symptoms are reported to a doctor, however symptom questionnaires can be used to gather this information and compare symptoms in the same patient during different time periods [14]. This is relevant to the project and is important to take into consideration as there are few examples of pen use in home care. Digital pens have been integrated with technology in a variety of scenarios, mainly clinical [17] and rarely in home care.

In health care, electronic health records (EHRs) and other technology are being implemented frequently. However, some staff use pen and paper either instead of or as well as the digital versions [12] often duplicating information in both 'worlds' . This use of paper can be for a variety of reasons including efficiency, ease of use, memory and to communicate between different members of staff. These issues should be taken into consideration when designing a system to replace physical

forms with a digital equivalent. Perhaps there is a benefit to having a physical copy that a digital version cannot replicate.

Several studies have attempted to utilize the use of handwriting recognition in health care to allow staff to continue using pen and paper. However, although handwriting recognition is possible to use with digital pens, it is often noted that this is not accurate, in particular in the medical setting where the OCR cannot recognise medical terms [21].In an example study, the pen was part of a system to digitise the medical system in an Emergency Room (ER) that also included RFID tags, sensors, smart desks and headsets to create digital versions of the medical records. The study has similarities to this project as it is creating a bridge between physical and digital documents using Anoto technology, however the use of additional technologies such as RFID are where the main difference is, as in this project the main technology is a digital pen. Taking these OCR issues in the ER study and initial feasibility tests on the Livescribe pen, it was decided not to use handwriting recognition within the project.

2.4 Summary

In the two case studies examined in this project there are examples of successful existing technologies and also scenarios that are lacking a solution. These scenarios where chosen as there is a clear advantage to using augmented paper in each. The next stage in the project was gathering requirements in these contexts.

Chapter 3

System Overview

As the system contains several stages to a work flow of tasks , this section will discuss the final system in terms of a work flow of a typical museum scenario. The final system supports:

- The creation of augmented worksheets and labels.
- Interaction between a digital pen and augmented worksheets and labels.
- Uploading of digital pen data on a desktop application.

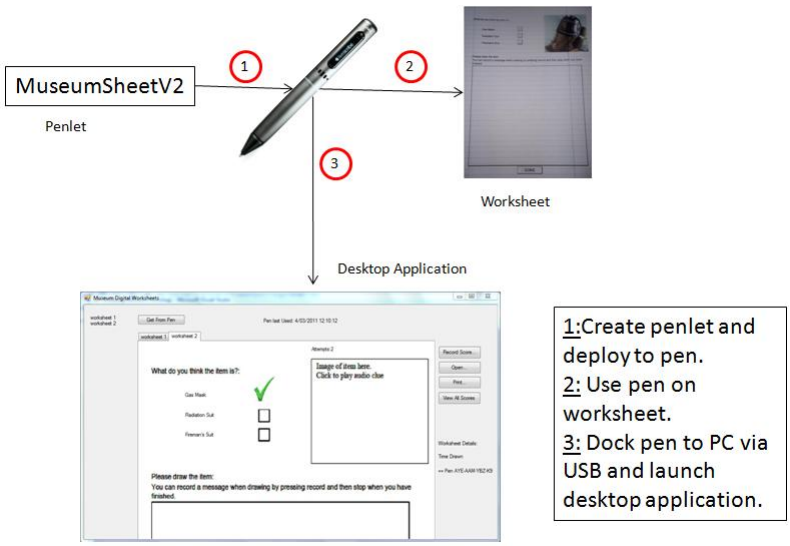


Figure 3.1: Workflow Diagram

Designs were created for augmented worksheets to allow the user to store and retrieve information from the pen, penlets to define what should be stored and output given to the user and a desktop application was created to upload data from the pen and display to the user on their PC. An overview of these processes is given in this chapter, further information and justification for decisions are discussed in chapters 4 and 5.

3.1 Pen and Paper Applications

Pen applications were developed in two forms: (1) Labels and (2) Worksheets. Augmented labels contain information on a particular object or artifact. Worksheets are designed to meet a specific scenario, augmented to contain information. They also store data related to user interactions with the paper. As museum staff must be able to create augmented paper to contain information for any artifact, it was decided to create a set of generic paper applications that allow scenario specific data to be added with no software development experience needed. The final designs are shown in this chapter, the iterative process that informed these designs are discussed in chapter 4.

3.1.1 Labels

To create labels to provide a digitally augmented tour museum staff must follow this process:

1. Record the audio messages for each artifact in .wav file format.
2. Copy these files into the eclipse workspace for the tour.
3. Enter the names/ text descriptions of items in to eclipse.
4. Deploy penlet to digital pen(s).
5. Print labels (Figure 3.2 (b)) and place each on the relevant artifact.

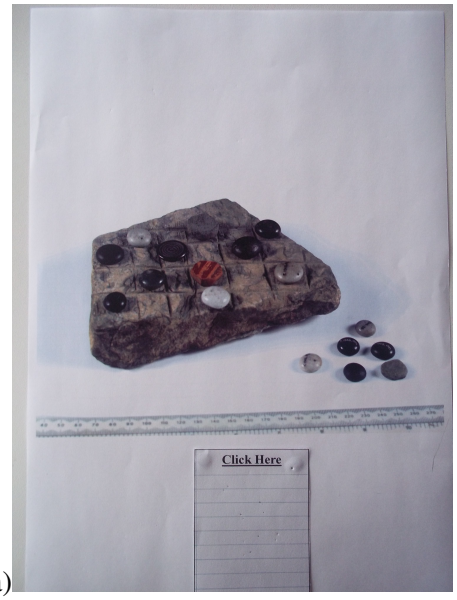
When the penlet has been created and labels printed, they are placed on the artifact description panel within the museum.
A family of visitors will each be given a pen to use as they progress through the museum. When they find an interesting artifact they can tap the augmented label (Figure3.2 (a)) with the pen and hear an audio message giving information on the item. Artifacts can be visited in any order and a message can be heard multiple times.

3.1.2 Worksheets

To create digitally augmented worksheets for use in the museum museum staff must follow the following process:

1. Record the audio messages for each option and clue in .wav file format.
2. Copy these files into the eclipse workspace for the worksheet.
3. Enter the names/ text descriptions of multiple choice answers in to eclipse.
4. Deploy penlet to digital pen(s).
5. Print worksheets for use by visitors.

(a)



(b)

Area 1	Area 2	Area 3
Area 4	Area 5	Area 6
Area 7	Area 8	Area 9

Figure 3.2: (a) Example of artifact with label.(b) Sheet of 'blank' labels.

Figure 3.3: Pen and Paper Interaction Sequence

Visitors to a museum can collect worksheet(s) on specific artifacts. Penlets are accessed by using the 'nav-control' paper button (this is shown in Figure 3.3). Users can interact with a worksheet (shown in 3.4) in various ways:

- Tapping on one of the multiple choice answers plays an audio message.
- Double tapping on an option selects this as an answer.
- Double tapping 'Done' gives the user a response to their answer. If their answer was wrong, they can select another option.
- Tapping on the image gives an audio clue to what the artifact may be, or directions to find the artifact.
- Drawing an image.
- Recording audio to attach to a drawing.

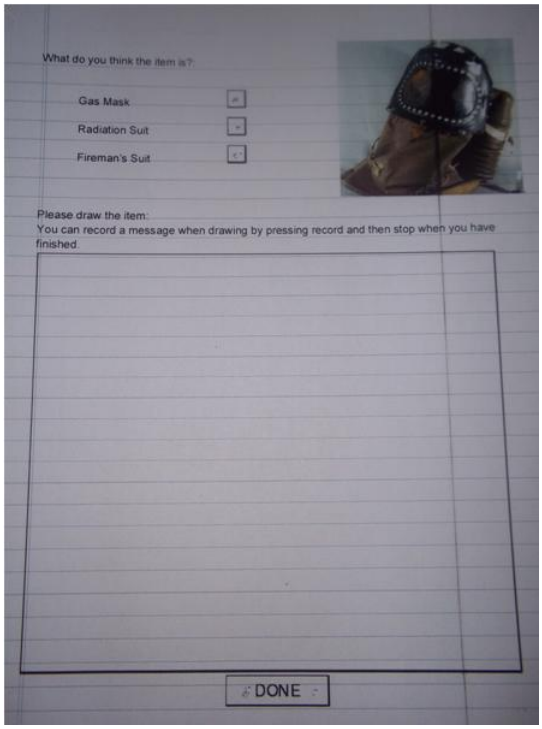


Figure 3.4: Worksheet V2 Design

3.2 Desktop Application

Using the augmented museum desktop application museum staff can view visitor's worksheet answers and drawings. When the application is opened the initial view is the generic worksheet (discussed in section 4.3.2). When the user selects 'get from pen' the worksheet specific data populates this worksheet as well as the visitor's answers. This before and after sequence is shown in figure 3.5 (a) and (b).

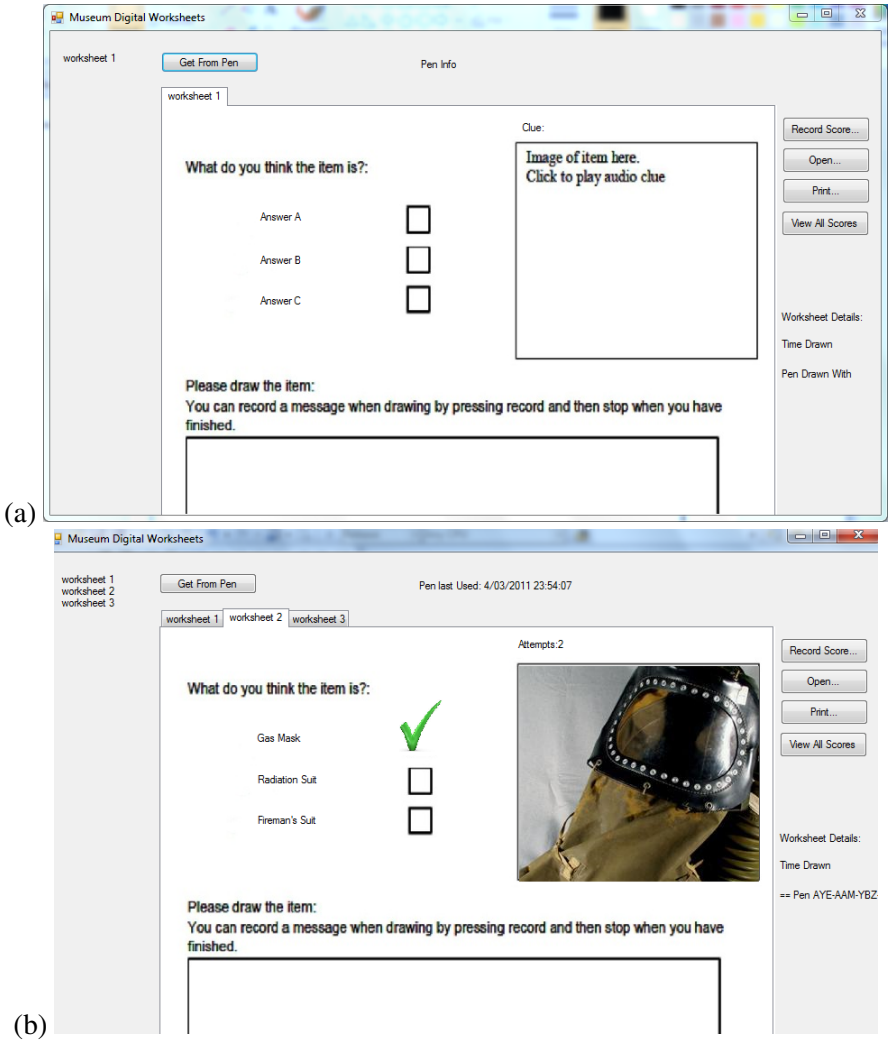


Figure 3.5: Desktop Application: (a) Initial View (b) After "Get From Pen"

To retrieve visitor's answers and drawings from the digital pen, museum staff should dock the pen via USB to the museum PC. A list of possible staff tasks:

- Staff can view and save visitor's drawn images using existing Livescribe Desktop software (Figure 3.6).
- View visitor's answers to worksheets using the 'Get From Pen' option (Figure 3.5 (b)).

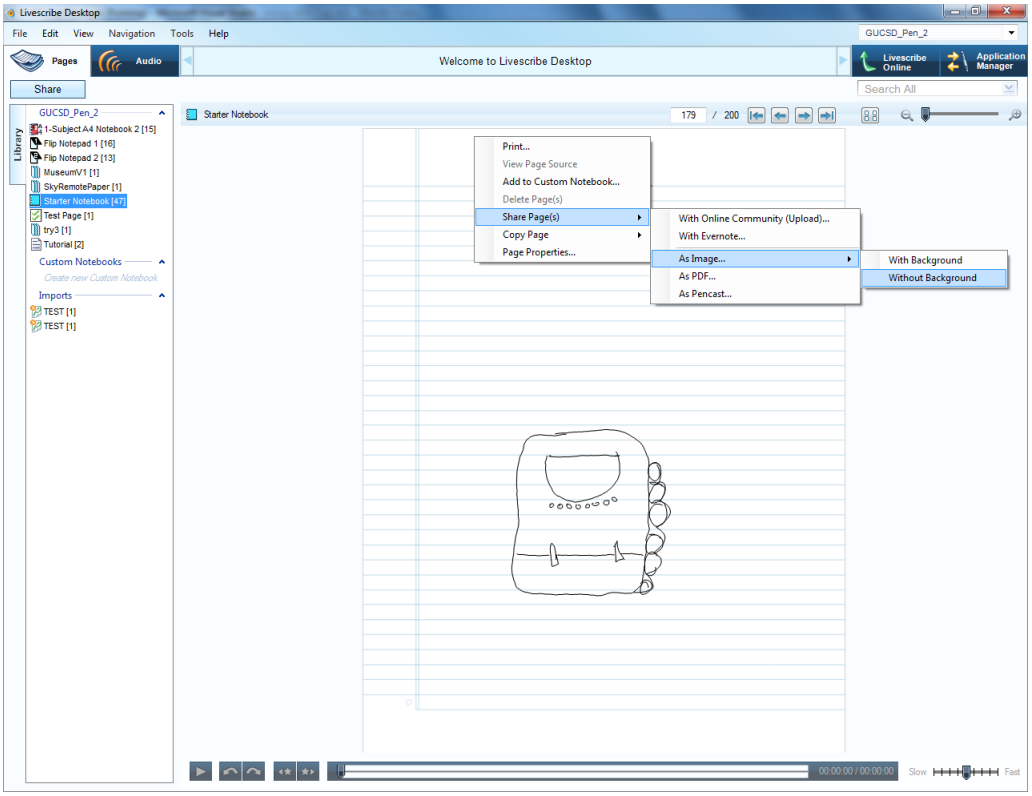


Figure 3.6: LiveScribe Desktop

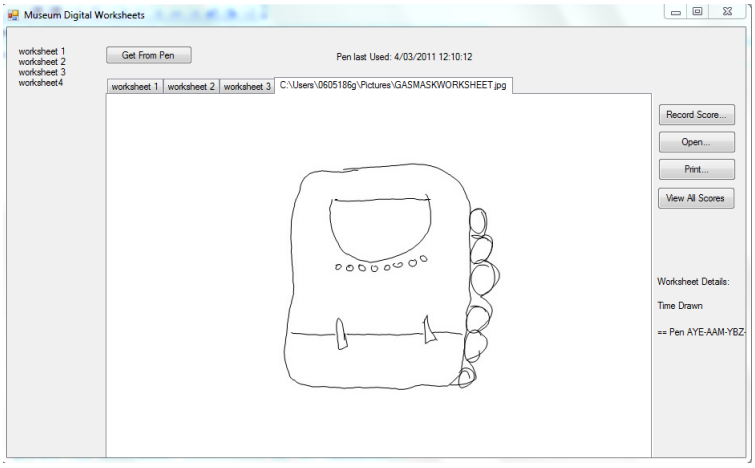


Figure 3.7: Desktop Application: Open existing image.

- Associate results and comments to a worksheet (Figure 3.8). This function could be used to grade worksheets in a school scenario and return the results to the class teacher. This option was included in the system as it allows for the possible transfer of the system to a school scenario.
- View all scores (Figure 3.9). For example, a teacher could grade each students worksheet then view a list of the entire class' grades to analyse, store or print.

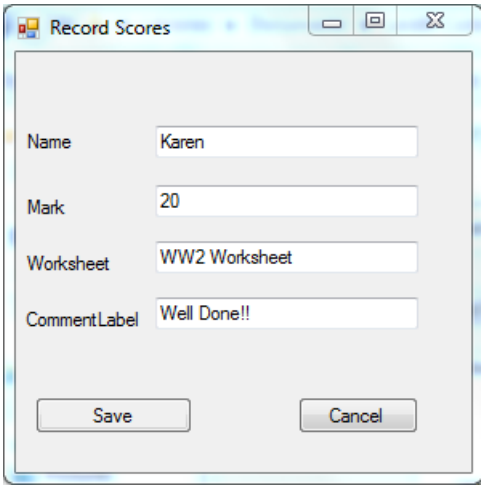


Figure 3.8: DesktopApplication: Recording Scores

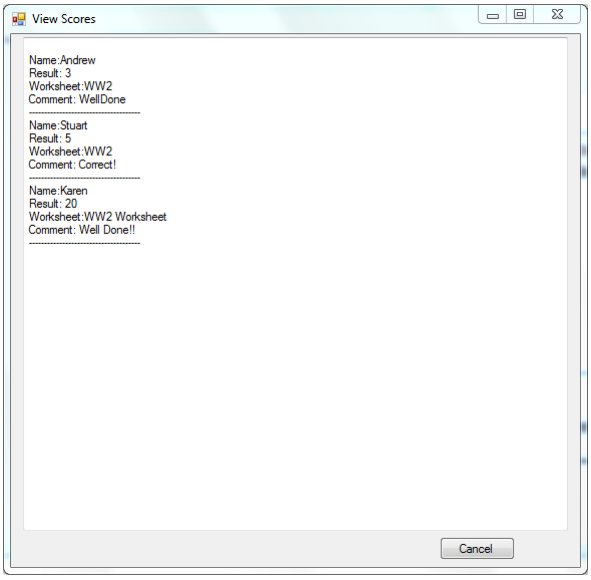


Figure 3.9: DesktopApplication: View Scores

Chapter 4

Requirements and Augmented Paper Design

4.1 Overview of Requirements Gathering Approach

As discussed in section 1.6 the structure of the project was iterative and consisted of 3 main iterations. As this project is deeply user centred, every stage involved input and feedback from stakeholders in each case study. This iterative cycle of user centred design allowed requirements to be extracted, designs to be validated and both formative and summative evaluation.
Phase one was mainly requirements gathering through interviews, a survey and evaluation of an initial prototype. Phase two included end users in a design focus group to inform the design of a second prototype. The prototype's design was then evaluated with users. Phase three concentrated on the creation of augmented labels. This chapter will discuss each phase of the iterative project, the tasks completed in this phase and the findings from each evaluation.

4.2 Phase One

To gather requirements for the prototypes research into digital museum interaction and medication compliance was conducted (see chapter 2). In addition, expert interviews were conducted, a medication management survey deployed and a focus group conducted with end users.

4.2.1 Museum

Expert Interview

An expert interview was carried out to gain information on museum interaction, current technologies in place in museums and how a digital pen could be used in museums for educational use. From this interview there were several interesting outcomes that helped in designing for a museum interaction system. This semi structured interview consisted of open ended questions concerning

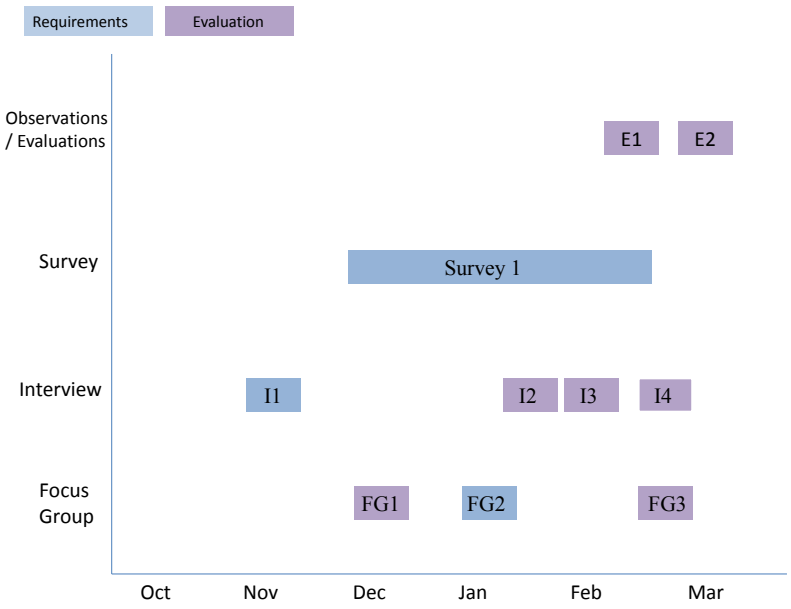


Figure 4.1: Requirements Gathering and Evaluations with Users

the current technology in museums and how digital pen technology could be used in a museum context. Interview notes were examined for emerging themes and to extract the design implications for the museum case study prototypes.

- **Current Technology**
  Current technology in museums is mainly visual displays with information and buttons to press below screen to select particular items. In some cases the screen is a touch screen, but this is still not a greatly interesting way of learning.

- **Family Visits**
  When visiting museums schools are given organised visits with a tour guide to show them around, yet families do not. It would be profitable to allow them to have an enjoyable tour too. For example, if they could have a pen to get information and take part in 'treasure hunt'. An idea suggested was that museum visitors could get results of quiz or treasure hunt and receive a certificate (and 10% off in shop, for example).

- **Education in Museums**
  An idea presented to the expert in interview was that the user/ a family of users could have a book of Livescribe paper with guide, quizzes and space for drawings to take around museum. Drawings could be sent to parents or teacher after visit or displayed on a virtual gallery in museum or on website. This received positive feedback as it would include family's to the tours given in the museum.

- **Design Implications**

  Expert views on pen interaction in museums and design implications for this project:

  - Pen could go beyond traditional audio guide.

- Pen is better for personalised visits, e.g with family rather than schools as schools are more likely to want group participation.
- Museums want people to interact with artifacts more.
- Audio is better for children as they are more expressive through speaking than in writing.

Usecases

As an output of the museum interview use cases were created. These were intended to aid the design process and where initially defined in the beginning of the project and refined throughout the requirements gathering iterations. The initial use case diagram is shown in figure 4.2. The full use case document can be found in AppendixA.1.

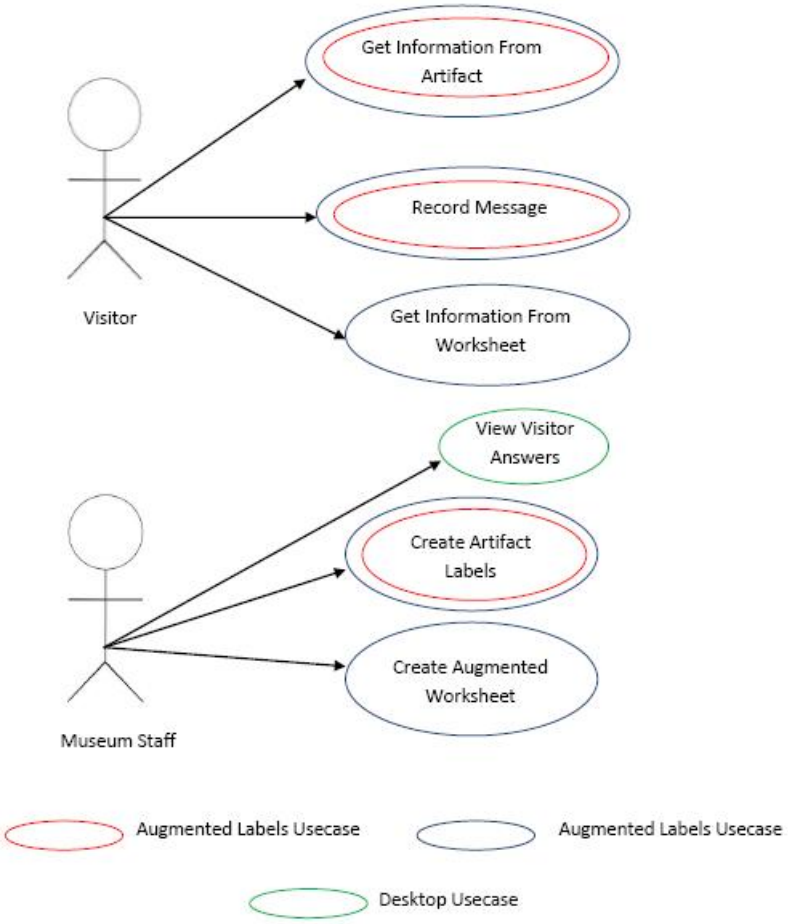


Figure 4.2: Museum Usecases

Museum Prototype Version 1

An output from the expert interview and usecases was prototype worksheet version 1 . The prototype was created for use in a focus group and consisted of a penlet used with standard Livescribe paper that has the worksheet design printed on top. This is a simple way to gain feedback on the interaction of the pen and the main functionality the application will provide. The augmented worksheet (figure 4.3) accompanied an artifact and asked the users (1) what they thought the artifact was and (2) to draw the item. Both of these could be accompanied by a recording of the user speaking while using the pen to draw or write. As it was predicted they may not know what the item was, a 'Clue' button was added to the worksheet which played a sound to give them an indication of what the item may be.

Focus Group

A focus group was conducted to gain feedback from possible end users a junior archaeologists group who were studying world war 2. The worksheet and labels were created with this theme.

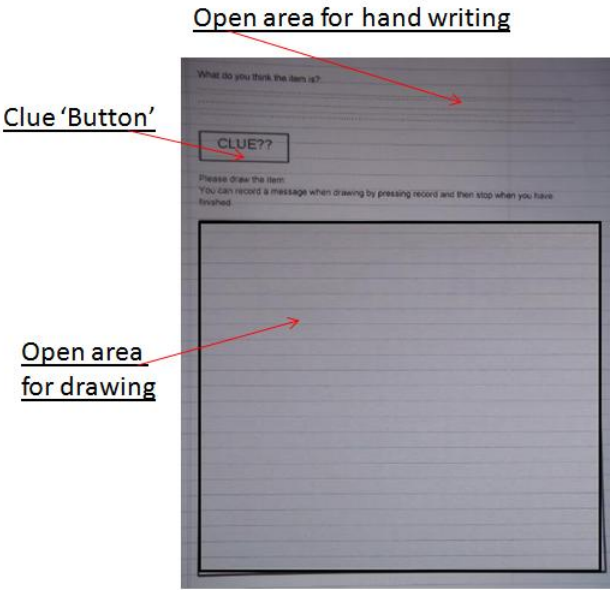


Figure 4.3: Prototype Worksheet 1

Each participant was given the opportunity to complete two tasks: complete an augmented worksheet and create a label for an artifact. All artifacts selected were related to their current study topic. Four artifacts were on display, with one specifically chosen to be used with the augmented worksheet and the others were to be labelled in any way the participants felt useful.

Figure 4.4: Participants Creating Labels in Focus Group 1.

All information collected in this is focus group was qualitative as it is aimed at gaining opinions on the suitability to using the pen in a museum and any other useful feedback from participants opinions on the pen. Analysis of this focus group consisted of analysing interviews, reviewing observation notes and viewing users labels and worksheets.

- **Augmented Worksheet**
  The artifact being investigated using the pen was a baby's gas mask from WW2. As discussed in section 4.2.1, the participants were given the option of writing and/or drawing while recording audio and also given the option to use the Clue. In this case the clue audio was the sound of an air-raid siren to indicate when this item would be used. Feedback from

the participants is that they liked the ‘Clue button as it let them know if their initial instincts were correct. One participant guessed ‘gas mask instantly but did not realise it was particularly a babys gas mask. When asked if would be better to have a further clue for those who did not get the item after the first clue then they could then select the second clue with the pen. An example given of an addition clue for this scenario was a sound of a baby crying or a mother yelling to get the baby into the gas mask.

All participants drew the item and recorded themselves speaking rather than writing, this was taken in to consideration in future designs of worksheets and was further investigated in the design focus group 4.3.1.

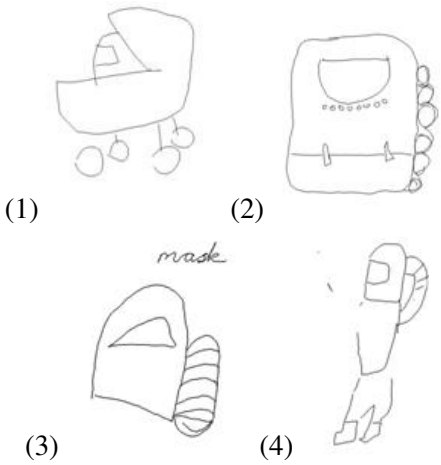


Figure 4.5: Drawings from focus group

From observations in the focus group, it was clear that users are unsure of when an augmented region has been selected. To resolve this issue, it was decided to give additional user feedback to make it clear the region has been selected. This feedback was decided to be a simple audio clip, similar to those user’s will be familiar with in a conventional computer system.

- **Labels**

When creating labels different techniques were used when recording the message: Writing a shorter version of what is being said, drawing a picture and a randomly drawn scribble. These are shown in Figure 4.6.

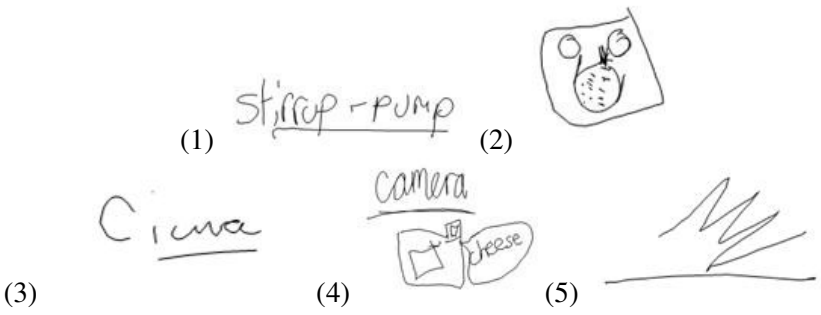


Figure 4.6: Labels from Focus group

  - 1 shows a label that is just the name of the item with recorded audio.
  - 2 is a label that has a sketch of the item with recorded audio.
  - 3 is a recorded message with the associated writing of the name of the participant.
  - 4 is a combination of 1 and 2, the name of the item and a drawing with associated audio message.
  - 5 is a random scribble with associated audio.

- **General Comments**

  One participant suggested that the pen would be better suited to use in education than a museum as it could be used by younger children or those with messy hand writing to record their answer while speaking, allowing the teacher to know what they mean even if the writing was unreadable.

  One participant decided that instead of writing on the worksheet and the labels, they drew a scribble while recording. As the information is given in the audio message, they saw no need to write the words on the page.

  All of the discussed findings were considered when designing a further prototype and also the creation of any other system using a digital pen, particularly medication compliance.

4.2.2 Medication

Survey Design

A survey was created to gain information on medication compliance. Patients, carers , and medical professionals were the target audience of the survey to gather knowledge on several key issues: if there is a problem with their current system,what would be expected from a system to aid medication adherence and who should be involved in the creation and design of a in home medication compliance system.

There are four main sections to the survey:

- Introduction
- Medication Management
- Computer Assisted Medication Management
- Pen Based Technology

The full survey is available in appendix B.

Survey Results

The survey had 40 participants, 32 of which replied their role in home care was within the categories provided in Q1. As shown in figure 4.2.2, there were:

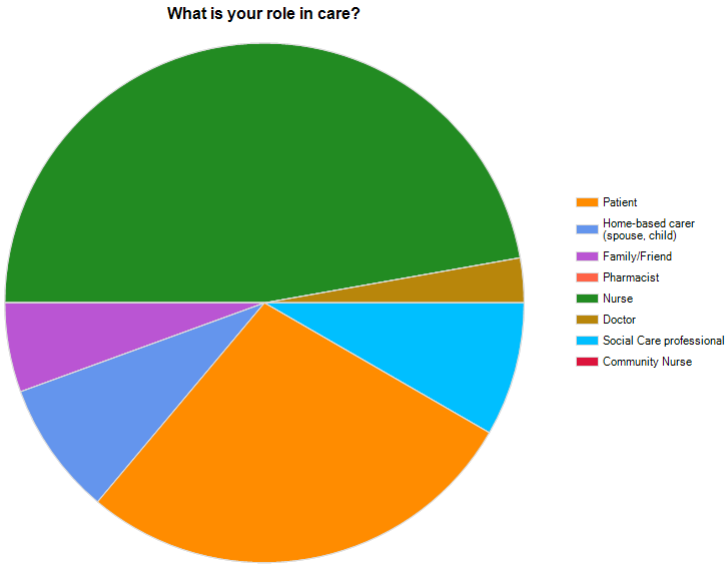


Figure 4.7: Role in Health care.

- 10 patients
- 3 home-based carers
- 2 Family/Friend
- 0 Pharmacists
- 17 Nurses
- 1 Doctor
- 3 Social Care Professionals

However, 8 replied ‘other’ with the responses being:

- 3 Occupational Therapists
- 1 Product Developer
- 1 Clinician
- 1 Former Carer
- 1 Manager Local Authority
- 1 AHP

When asked why patients do not comply with their medication participants were asked to give three reasons. The solutions to these were combined and a tag cloud created to get a representation of the

Figure 4.8: Tag Cloud Displaying the Key Responses of Non-Compliance with Medication

common themes in responses. As shown in figure 4.2.2, the most frequently given responses were: side effects, memory, forgetfulness and understanding.

Any system to aid compliance should therefore contribute towards patients' increasing their understanding of prescribed medication. Since forgetfulness is a recurring theme, the system must remind of any medication to be taken or perhaps if a particular medication has already been taken. Many responses noted that side effects are a major reason why medication compliance is a problem. Some suggest this is because patients dislike the effects of a medication and do not allow time to feel the benefit.

The questionnaire also included a section investigating the use of digital pen technology in health care. The main issue that was recurring throughout the answers in the section was the ability of a older user to use technology. Many were concerned that they simply would not understand how to use the digital pen to their benefit. When asked "Would patients be willing to use a digital pen to record and to get information on their medication?", the majority of responses (85.7%) replied 'Maybe'. However, there were no selections of 'No'. A selection of responses shows the variation on opinion in answer to this question:

- "Some people like technology & would find this easy & helpful"
- "Less of a complicated technology"
- "Elderly patients may struggle"
- "It is again the problem of older patients being suspicious of any kind of new process, and the need for sufficient time to be given to introducing it."

To aid in the design of a home-based medication system to exploit digital pen technology the survey included a question to discuss what features should be provided and what data should be stored (Figure 4.2.2). The feature that received an almost unanimous 'Very useful' (91.2%) was the confirmation of time medication should be taken. Therefore, it is seen as essential for a medication label or worksheet to include details on the time medication should be taken. An interesting feature that had varying responses was the functionality to allow users to record symptoms and have this transferred to medical professionals. This was included as an option as patients often forget a symptom

if is not effecting them at the time they visit their doctor. Responses in the survey for this feature were mainly positive, 63.6% replying it could be 'Very Useful'. Open response comments on this topic were also interesting and give varying viewpoints that should be taken into consideration when designing the system:

- "Patient may write too much causing extra workload to health care professionals."
- "Might help them to remember symptoms they don't remember at appointments."

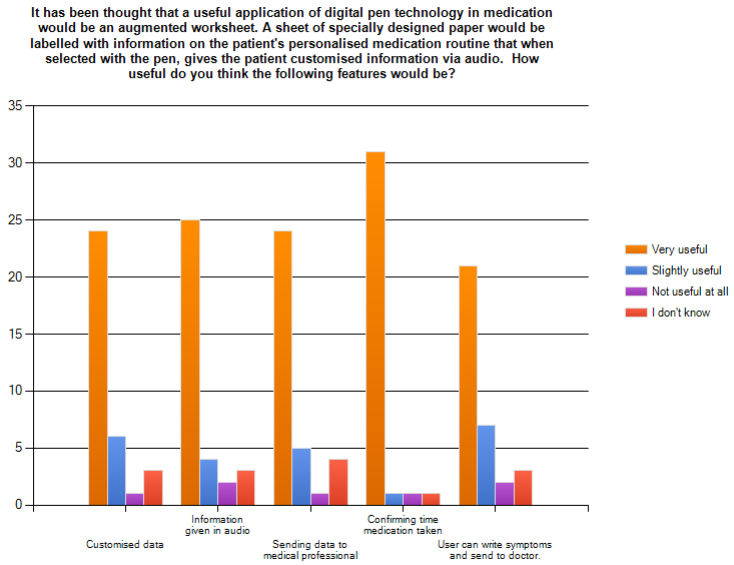


Figure 4.9: Response to Possible Pen Features.

Usecases

Similarly to the museum case study, use cases were created in the beginning of the project and refined throughout the requirements gathering iterations. The initial use case diagram is shown in figure 4.10. The full use case document can be found in AppendixA.1.

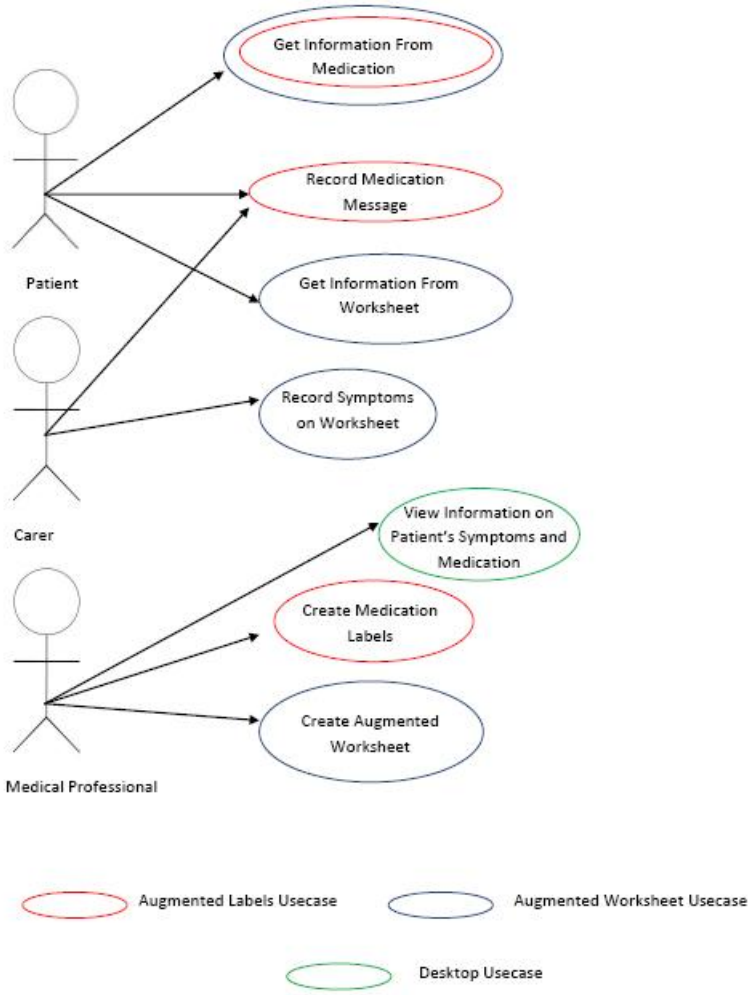


Figure 4.10: Medication Usecases

4.3 Phase Two

4.3.1 Design Focus Group

To aid in the design of the augmented worksheet a second focus group was conducted to allow users to design the augmented worksheet that gives users information on a given artifact while

being entertaining. This provided feedback on what features (text areas, open drawing areas, sound buttons etc) users like and dislike.

In this focus group, participants were members of the junior archaeologists used in focus group one. They were given a demonstration of the prototype worksheet version 1 4.2.1, and where then given another mystery item which they were asked to create a worksheet for by themselves. They were asked to include the features that they thought would be best to ensure learning and enjoyment of the pen interaction in a museum.

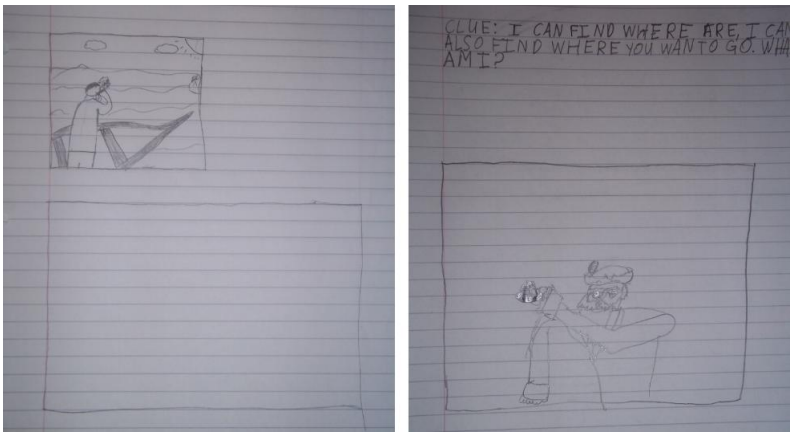


Figure 4.11: User Aided Design Sketches

Feedback given was that the clue should remain but be replaced by an image of the item, meaning the worksheet would still be understood when away from the particular artifact location (see figure 4.11). The large open drawing area was also unanimously kept in the user designs. All participants confirmed the prediction from focus group 1- that they would not use the open text writing area. When asked if multiple choice questions were a suitable replacement for open text area of prototype version 1, participants agreed that this was more likely to encourage visitors to answer the question. A suggestion of why this was the case given by a participant was that the text area required the visitor had to have an idea of what it was. However, multiple choice allows them to guess if they don't know the answer.

4.3.2 Prototype Version 2

As an output to the design focus group, Version 2 of the museum prototype was created with feedback from the testing of version 1 and from the design focus group described in section 4.3.1.

The worksheet design (Figure 4.12) was significantly different from version 1, the only remaining region was the large section for drawing the item. The clue button was replaced with a region to contain an image of the item, that when pressed plays the audio clue for the item. This was direct user feedback given in the design focus group (see section 4.3.1.) Replacing the text area in V1 with a set of multiple choice answers was a decision made based on the findings of focus group one showing that users do not answer the written question. When a multiple choice answer is selected users can verify their answer by clicking the 'Done' button. This provides an audio message providing feedback and encourages the user to try again if wrong. This penlet stores data in the internal pen storage. It was decided to store the 3 multiple choice options, user's final answer,

number of attempts at question and number of times the clue is selected. The data stored on a visitors worksheet interaction is used within the augmented museum desktop application (section 5.3).

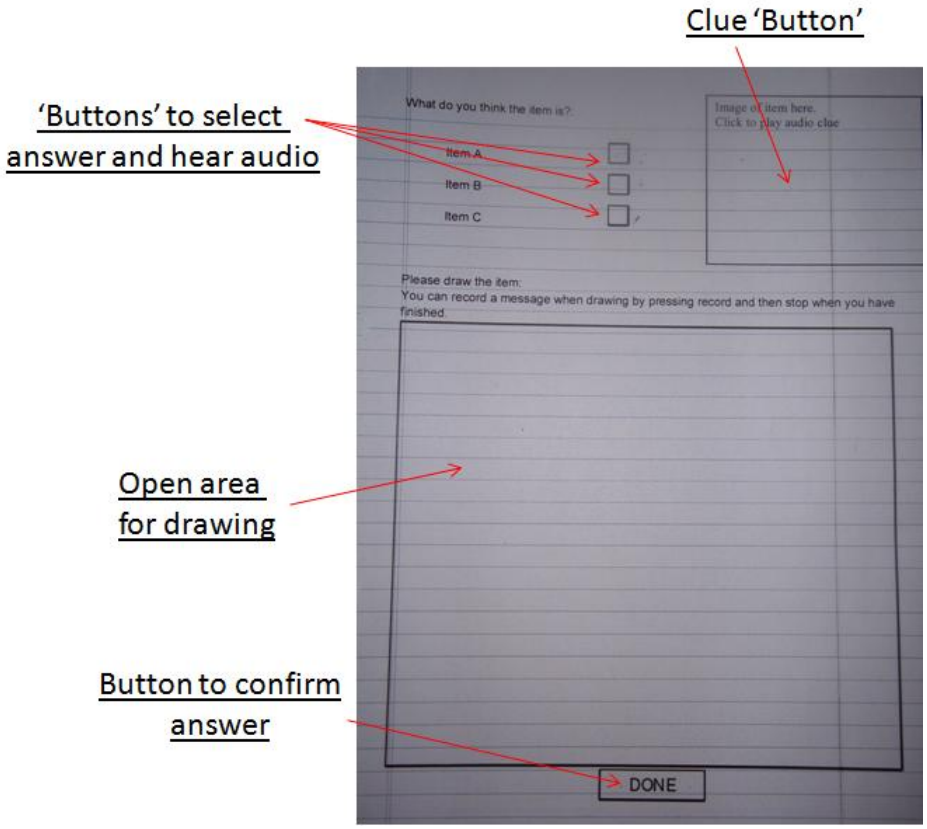


Figure 4.12: Worksheet V2 Design

An addition to the prototype was an audio message to give feedback to the user that they have selected an active region.This gives the user immediate feedback that their selection with the pen has been recognised and alerts them to the task they should be doing (shown on screen or played via audio from the pen).

Design Validation

To ensure the worksheet design was not only suitable for end users but is also educational and validate the worksheet design, interviews with teachers were conducted. In these informal interviews, the teachers were shown both prototype worksheet V1 and V2, given a demonstration of how they work followed by an interview where all feedback was quantitative.

The feedback showed that in their opinion the worksheets would be suitable for catching the attention of younger children and therefore renforcing what they have learned. One suggestion was that the children could create the worksheets for their classmates to then use, therefore they must understand the topic to be able to make a worksheet.

A suggestion from the interviews was the use of prototype V1 was more appropriate for a school scenario as the students must write the answer form their own knowledge rather than from a multiple choice question. This creates a difference in the types of worksheet required in different situations. While both should be educational, V1 is suited to a classroom scenario and V2 is more appropriate for a museum. Although this project was intended to create a worksheet museum use, it is also important to allow the system to be easily adapted for use in other formats such as in the classroom. This need for the system to be as generic as possible is addressed in section 5.4.

4.4 Phase Three

Phase three was intended to complete the museum system by implementing prototype augmented label and desktop application system.

4.4.1 Augmented Labels

The final use of augmented paper in the case study of an augmented museum was artifact labels to give museum visitors information on specific items. One issue with traditional museum audio tours is that the visitor must see each artifact in a specific route through the museum. It was decided to create an alternative to this to illustrate how the digital pen and augmented paper can be further used in this area.

The implementation of the labels was completed in a similar method to the previous penlets for worksheets. Livescribe paper was divided in to 9 active regions and the co-ordinates were coded into the corresponding java penlet code. Each of these regions can be associated with a particular artifact in the museum and give the user an audio message with information on the item.

The penlet was developed to store when a user selected the label with the pen. This functionality was used to create a "Treasure Hunt" application, as discussed in the expert interview (section 4.2.1). Therefore, when a user visits an artifact and selects a label they are given the associated audio message and then a progress report on their tour (figure 4.13). This gives users the freedom to travel around the museum in a random route without missing any information and also to allow them to hear only the information they wish to. However, to encourage younger users to listen to all information the application tells the visitor how many labels they have still to visit, hopefully creating a competitive and fun element to the user experience.

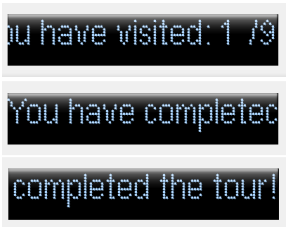


Figure 4.13: Tour Application : Screenshot Sequence

4.4.2 Desktop Application

As shown in the overview of final system, a desktop application was created to retrieve data from penlets and display to museum staff. An initial prototype was created in phase 3 of this project, as this was the final iteration no further developments were created. However, evaluations were conducted and areas for future work are discussed in section 6.4.

When opening the desktop application a blank worksheet is displayed with the multiple choice answers showing "Answer A", "Answer B", "Answer C". When selecting 'get from pen' these options are changed to the multiple choice options from the relevant worksheet. Answer options are stored within the penlet code, transferred to the desktop when the pen is docked and displayed on the GUI. This design decision was made to allow the application to be suitable for any version of the worksheet made by museum staff.

Although this application was designed with a museum as the environment, it was decided early on to include features that provide functionality suitable to support an educational environment. This choice was made to allow augmented worksheets to be used in a classroom environment as an alternative to the museum. An example of a feature that was transferable to the educational scenario is the option to record the scores and comments for a students worksheet.

4.5 Common Features

To aid in the development of both of the prototypes with maximum code reuse, the common functionalities were found to help in the code design of the toolkit. There are two main parts to the development of the system: (1) Augmented Paper (both worksheets and labels) and (2) Desktop Software.
When analysing the use cases of both case studies there are clear common functions the pen should provide. These common use cases were extracted as these informed the design of a generic toolkit for digital pen applications.

4.5.1 Augmented Worksheet and Labels

- Open areas for users to record their own views/issues.
- Set areas for audio to communicate a preset message to give information.
- Set areas for text to communicate a preset message to give information on pen screen display.
- Information on number of times label is selected.
- Store a user's response to a question.

4.5.2 Desktop Software

- Recognise that a pen is docked via USB.

- View open area input by users.
- View pen information such as battery or memory.
- Retrieve answers to ”tick box questions”.

Chapter 5

Implementation

This chapter will discuss the implementation of the museum desktop prototype, the generic toolkit developed and implementation challenges met in the process.

5.1 Communication between Digital and Physical Components

As discussed, there are two main parts to the system, Penlet and desktop application. ASUR diagrams [13] show the communication between physical and digital worlds. The interaction between users, physical and digital items can be shown. As this system has various physical items to communicate with users and a desktop application, this is appropriate for use in this project.
Figure 5.1, an ASUR diagram shows the communication between digital and physical elements of the entire system. This includes pen applications, augmented paper, users and the desktop applications.

This diagram shows the individual components of the digital pen, which is both an input and output device. The Livescribe Pulse pen consists of:

- Infrared camera
- Microphone
- Speaker
- Screen Display

Shown in the ASUR diagram by a double line, the pen is in physical proximity to the user and augmented paper objects (labels and worksheet). The single arrowed line shows the flow of information between components.This relationship can be physical or digital information. For example, the user receives visual information from the monitor. However, digital information is transferred between the pen and desktop applications.

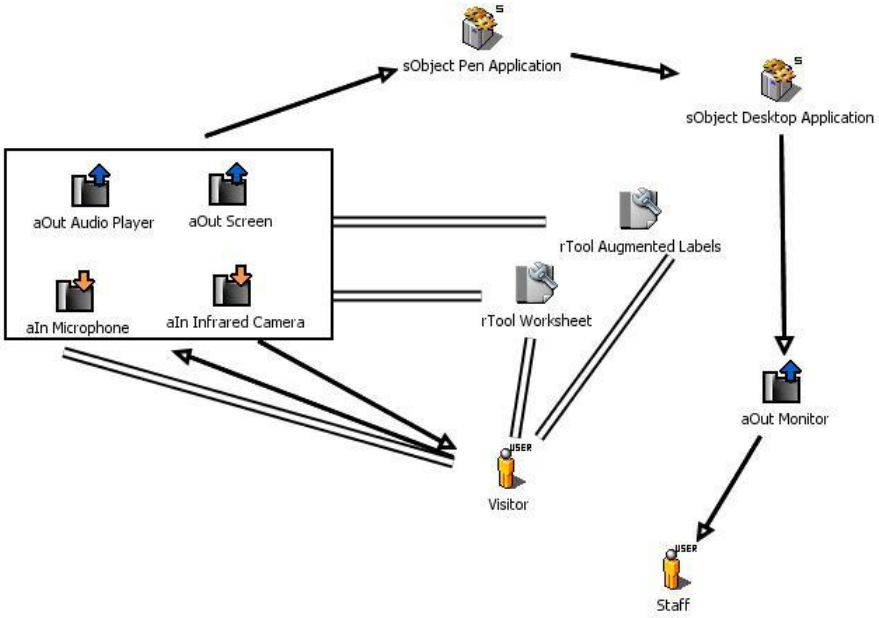


Figure 5.1: Museum ASUR Diagram

5.2 Printing

As discussed in section 2.1.1 to create Livescribe compatible paper it is necessary to add an anoto dot pattern to the paper design that allows the infrared camera to recognise the area and link with the associated penlet. This dot pattern requires a high resolution printer of 600dpi or over. When creating customised paper using Livescribe paper perspective in Eclipse issues were encountered when printing. After attempting to resolve this problem it was decided to find an alternative due to project time limitations. It was decided to create a penlet that had the relevant areas integrated into the code, therefore acting like the custom paper and calling the relevant methods when pressed. Although this means the application must be selected via the menu, this was suitable for demonstration purposes and in prototypes that investigate interaction using the pen.

Throughout the iterative requirements process the prototypes were created in this way as the relevant sections discuss. To create these sheets, they were designed and printed on existing livescribe paper. The museum staff would open the relevant generic worksheet, edit it to suit the circumstance and print on the paper as they would in regular worksheet printing. The advantage to this method of creating worksheets is that users that are not developers need not interact with the eclipse paper development interface to create worksheets, they will use a common office tool such as Microsoft Word or Open Office as they likely would when currently creating educational materials.

In the early stages of phase one, a penlet was written to read the co-ordinates of the point the pen selected and display these to the screen display, allowing the developer to insert these in to the java penlet code for the application relevant to a particular worksheet/ set of labels. This “giveCoords” penlet is attached to the generic toolkit as it gives any future developers the chance to create new worksheets using the same technique used in this project.

Although this technique was used to create worksheets, the generic toolkit code is still usable within penlets associated with custom designed paper. Therefore, the code components would still be valid for a future developer who did not encounter issues when printing custom worksheets.

5.3 Desktop Application

As discussed in 4.4.2, a SDK is used for retrieving data from the pen. This SDK is different from the penlet development environment, the main difference being in language- C#. This was a challenge in this project due to inexperience in this language and with time limitations as the desktop application was created in the final phase of the project. This section will discuss the main points of desktop implementation.

5.3.1 Structure

The augmented museum desktop prototype has 3 main parts:

- **GetPenInformation:** Retrieves pen information such as model, storage level etc.
- **DataCapture:** Retrieves penlet data as described in 5.3.2.
- **GUI:** User interface to display information from each of the above.

The system was created in this structure to allow elements to be swapped with others easily. For example, if DataCapture were changed to retrieve data from a different penlet no changes would be necessary to the main GUI (assuming data was saved in the correct format).

5.3.2 Data Transfer

Information on user's interaction with worksheets is stored in the pen's internal storage and transferred when docked via USB to a PC running the desktop application. The data to be sent to the desktop is defined in the penlet code in the sendData() method within penlet code 5.2.

The provided PenComm libraries recognise when a pen is attached via USB and it then calls the code in the PenAttachEvent() method. The relevant code to retrieve the data from the pen is now run. This reads the storage data associated with the penlet and calls the writeData() method to write the information to a file. The augmented museum desktop application code reads from this file and displays the relevant data on the interface.

5.3.3 Problems Encountered

The Livescribe desktop SDK provides developers with the ability to retrieve details of user's pen strokes from the smartpen and render these on screen. In the original design of the augmented museum desktop it was planned to have visitor's drawings from the large open area shown within

```
private long sendData(OutputStream outputStream, long syncTime)
      throws IOException {
            if (data != null) {
                  data.close();
                  data = null;
            }
            long strokeTime = 0;
            DataInputStream inputStream = new
      DataInputStream(penletStorage.openInputStream(dataFile));
            try {
                  while (true) {
                        strokeTime = inputStream.readLong();
                        String appData=inputStream.readUTF();
                        if (strokeTime > syncTime && outputStream != null) {
                              outputStream.write(appData.getBytes());
                        }}}
            catch (EOFException e) {
            } finally {
                  if (inputStream != null)
                        inputStream.close();
            }
            return strokeTime;
      }
```

Figure 5.2: sendData() code

the interface. However, considering time restrictions as this was in the final phase of the project it was decided to find an alternative. As Livescribe desktop software allows this functionality as a standard use of the pen, museum staff can save the image using this software and import into the augmented museum desktop. Although this was not the preferred implementation of including user drawn images, this was discussed in evaluation with museum staff and was not seen as negative. This is an area for future work for this project.

5.4 Generic Design

As the system should support the creation of worksheets and penlets by non programmers,museum staff, it was designed with this in mind. The need for easy creation of education materials became clear throughout the requirements process as it is important for museums (or schools) to have the ability to have changes to worksheets or labels with no programming experience.

Chapter 4 discusses the iterative process carried out to design the augmented worksheet for use within a museum. This was important as the system has been designed to allow the same worksheet layout to be used in many different scenarios with little change or expertise needed by museum staff.

As the active regions will not change, staff will only have to update the audio files for these regions and edit the worksheet in a image editing software they are familiar with to change the image and multiple choice labels.

To aid the design of the generic system, a typical work flow of how museum staff would used the system was outlined and used when creating techniques to reduce the amount of steps to a minimum. An example of this reduction is the naming conventions used in the code. It was decided to have the name of files permanent in all code. Meaning the staff had no code editing tasks to complete and the audio files generic names should be placed in resources folder in the Eclipse workspace (As shown in5.3). For example, all audio in labels penlet was named ”1”, ”2”, ”3”... meaning the files were easy for staff to associate with labels from the worksheet and no changes to the code were necessary.

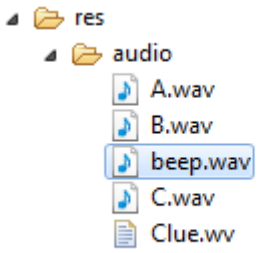


Figure 5.3: Eclipse Resources Example

Figure 5.3 shows an example of this, in the worksheet implementation. A, B and C are the audio associated with the multiple choice question options, as these will change each time the museum staff will replace these file with those related to the new question and name these the corresponding letter. A similar process will be used to change the clue for the worksheet. The ”beep” file will remain unchanged as it is the audio that gives users feedback when selecting an active region.

5.5 Code Re-Use

The Java penlet code in the early iterations was written for the single purpose of the application it was contained. Later in the iterative process the penlets were analysed for recurring actions and together with the use cases created in the requirements and high level design section, they informed the creation of a set of generic methods.

A notation for documenting these generic methods was designed to ensure the toolkit was easy to read and use by future developers (See C for a full code listing of toolkit).

Each reusable method has a comment of similar structure:

```
/*
Generic Toolkit Code: (ID#) method name
Changes Needed = X
Description of parameters and possible changed needed when implementing.*/
```

A ‘changes needed’ ranking scale was created to provide the developer with an indication of the level of change needed to the toolkit method before being usable in the penlet code.

- 0= No changes needed to toolkit code. Entire method should be used in application.
- 1= Configuration data may need to be changed.
- 2= Substantial changes needed to toolkit code. Method is an example that may need significant change before being suitable for use in an application.

```
/*Generic Toolkit Code: (#6)createSound
 * Changes Needed: 0
 * String fileName is the name of file to be created in to a sound resource.
 * File extensions are not necessary (e.g a file Sound.wav should be "Sound")
 */
public SoundResource createSound(String fileName){
```

Figure 5.4: Example of Toolkit Commmenting

The internal code annotation was designed to aid the development of pen applications. When conducting a code reuse evaluation (section 6.6) this ranking scale was used as a metric to analyse the generic toolkit and how successfully it can be used to create pen applications using augmented labels and worksheets.

Chapter 6

Evaluation

6.1 Overview Of Evaluation Approach

As discussed in section 4, evaluation of the system was carried out throughout each phase of the project. The final and more summative evaluation for the system was in two forms: user evaluations and code re-use evaluation. This section will discuss the user evaluation of both the augmented paper and desktop systems. Also, an evaluation of the generic toolkit was conducted and is discussed in this section.

6.2 Augmented Labels User Study

6.2.1 Evaluation Plan

When preparing the evaluation of the augmented museum system a museum expert was interviewed to discuss the system that has been created and how this should be integrated in to a museum. From this feedback, the scenario for a user evaluation was created.

This scenario included using the "Treasure hunt" version of the museum tour that allows users to select labels with the pen to hear the audio message. During the interview it was confirmed that adding a competitive element to the tour would encourage visitors to complete the entire tour rather than skip artifacts. A suggestion was that in a realistic tour scenario only certain artifacts would be in the treasure hunt and would be identifiable by a logo denoting they are part of the hunt.

The evaluation was created to suit the topic the club were currently studying: Romans. A set of 6 artifacts were chosen to use in a museum evaluation environment. These items had an augmented label attached with information on the item. To encourage the visitors to listen to the message rather than just attempt to find all items and therefore complete the treasure hunt, there was one artifact that was 'odd one out'. A worksheet was given to participants to draw or write about each of these artifacts and to help in remembering them when selecting which is not related to the others.

Participants: The evaluation was carried out with participants from the Hunterian Junior Archaeologist Group used in the previous evaluations discussed in sections 4.2.1 and 4.3.1. This evaluation

also included parents of the children, intended to investigate the collaboration between visitors in the museum and how this technology could be used for families visiting a museum. As discussed in the initial expert interview, this is a situation where a tour guide would generally not be available. Total Participants=8

Method: The system was evaluated by observing users while completing the treasure hunt and conducting short interviews after the tour is complete. Observations were used to view how easily visitors can use the system and how several visitors on the tour communicate or collaborate with each other.

Figure 6.1: All Evaluation Artifacts

6.2.2 Evaluation Results

Observation notes and interview recordings were analysed to find user views in the following categories:

- **Usability**
  A main objective of this user evaluation was to observe the participants to gain information on the usability of the pen in the tour scenario. An important observation during the evaluation was how comfortable younger users are using the pen. For example, when double tapping on a label or ensuring the infrared camera was not covered when holding the pen. In this evaluation, artifacts were attached to windows. On some occasions the camera did not react to the double tapping, potentially due to light effecting the camera. This should be taken into consideration if the labels were to be implemented in a realistic museum setting.

- **Visitor Collaboration**
  On two occasions participants decided to work in pairs, selecting artifacts together, listening to the pen together and discussing the image. In both cases, the pairs were parent and child. When observing these pairs, it was clear that the children were in control of the pen and parents usually listened to the audio and helped the child with the 'odd one out'. Figure 6.2

(a) shows an example of a parent and child collaborating during the tour. After completing the tour , one parent said it that in a larger museum with more artifacts they would probably get a pen each so they could go to they could visit what interests them more but then still meet up and continue tour together.

In several cases when participants were working individually with separate pens they would collaborate if they were at same artifact (see Figure 6.2 (b)). Similarly, when it came to finding the answer to the question (odd one out in this case) participants often discussed the artifacts and re-visited labels to hear the audio. However, If there was someone at the next artifact in the direction they were progressing through the museum then the participants would often just go to the next one and come back later.

- **Interesting Observations**
  Although users usually listened to the audio message given when selecting an artifact, to check the spelling of artifact (to write on worksheet) some people would click the label again, but check the screen for the text description of the artifact. Therefore, although audio is the best option to communicate via the pen, sometimes text on the screen is useful to give information with the audio rather than replace it.This should be taken into consideration when designing information output in penlets.

(a)

(b)

Figure 6.2: User Evaluation

6.3 Augmented Worksheet User Evaluation

6.3.1 Evaluation Plan

The structure of the worksheet evaluation was similar to the design validation of worksheets with teachers (section 4.3.2). Interviews were conducted with children to ensure the worksheets were usable with the age group they were intended for. In the interview participants were shown worksheet V1 and V2 and asked to use both and discuss what they found fun or interesting to use.

Participants: The participants were 10 years old (male) and 12 years old (female).When describing the interviews they will be interview A and B respectively.

Method: There were two interviews conducted in this evaluation. The audio from evaluation was analyzed for positive or negative feedback on the worksheet or digital pen.

6.3.2 Evaluation Results

Main outcomes from the interviews were:

Digital Pen Use
It was important to evaluate how users interact with the digital pen and exploited it's features.

- An interesting observation from evaluations throughout the project is how users annotate drawings and handwriting with audio. As observed in phase one focus group, users often don't draw and speak at the same time. Another observation is that many say "I am drawing..." or just say the words they are writing rather than give additional information.
- It was important to get the opinion of interviewees of how useful and enjoyable it would be to use the worksheets in a museum. Interviewee A replied:

  > "I think this pen is really smart. Plus, I would love to do that in a museum."

- When asked what they liked about the pen, A mentioned many of the standard Smartpen features such as "How you can record messages then hear". They also discussed the existing paper features on the Livescribe notepads such as the controls to navigate to the application. This is interesting within this project as it was due to technical constraints that this paper is used. Although it was initially thought this would be a disadvantage, it has been found that particularly younger users like the paper controls and can navigate through menus easily.

Worksheet Design
The interviewees were shown both worksheet v1 and V2 and were asked for comments on design and usefulness of features. There was interesting feedback and this should be taken in to consideration by those creating worksheets for specific scenarios such as museum staff or teachers.

- Interviewees had several alternative suggestions for the clue sound effect. For example, an idea was to give audio directions to the artifact in the museum. Both interviewees thought the clue could be changed to give more information on artifact such as "This was used by..." or

"This was used in year...". This would be more informative for visitors and could also be used in an educational scenario. As discussed in teacher interviews, the pen may be suitable when studying content the students have already been taught. Therefore, giving clues to prompt their existing knowledge may be a valuable technique.

- In addition to the multiple choice or open text questions already in the prototypes, an idea from interviewee B was that true/false questions could be included in a worksheet.
- When asked to compare the worksheets interviewee A suggested V2 was better for younger users as they can listen to the clue and choose an multiple choice answer. It was thought V1 was better for older users as they will have to write a sentence rather than just tick the answer.

Use in Education
Since the evaluation participants were school pupils it was important to evaluate the thoughts of the interviewees of how the pen could potentially be used in education.

- B thought in a classroom environment they would like it to be used with the Smartboard.
- In interview A it was suggested the pen would be useful for foreign language learning. For example, write the word in English when recording the word in another language. Meaning when the English word was selected with the pen, the equivalent in another language was played via the speaker. A possible future worksheet implementation could be creating paper active regions containing English words. When clicking this region the word should be played via audio in the target language. This could be created using the same methods as worksheet V1 and V2 in this project. Use of the generic toolkit would provide the necessary functionality to do so with little new code needed (see section 6.6).

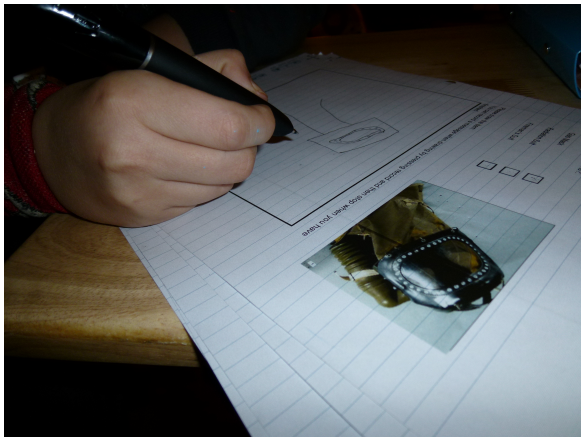


Figure 6.3: Worksheet User Evaluation

6.4 Desktop Application User Study

6.4.1 Evaluation Plan

A typical work flow for the creation, use and analysing of worksheets and labels was created for use in the evaluation of the desktop system (as shown in Chapter 3). This evaluation not only included the desktop software but also the use of a generic worksheet and eclipse to deploy penlets to the digital pen.

- Design worksheet: Edit generic worksheet to include appropriate details and images.
- Edit penlet details: Add sounds and answer choices to penlet folders.
- Send to pen: Deploy using eclipse.
- Visitor uses pen: Penlet can now be used by users in the museum.
- Get information from pen: Launch museum desktop application and retrieve details from pen.

Participant: A museum expert at University of Glasgow.

Method: This work flow was discussed with a museum representative in a demonstration and informal interview style.

6.4.2 Evaluation Results

The response to the demonstration of the full system work flow was positive. Confirmation that creating worksheets using a generic template was acceptable in the scenario was given when the interviewee explained that museum staff usually have knowledge and experience using tools to do so and would not be intimidated by doing so.

When discussing how to populate the penlet with worksheet specific information it was confirmed that the generic design was useful as it allowed staff to complete this task by placing audio in file directory and entering artifact descriptions in to Eclipse. However, it was suggested that entering these artifact descriptions in a text file and placing this in a file directory would be preferable. This is less intimidating as viewing and editing code is not a task they have experience with. In a future implementation this should be edited as it would provide the ability to create penlets to control a worksheet with no programming necessary.

When the additional step of retrieving images from Livescribe desktop was explained, the interviewee responded that this was not an issue that would stop the system being used. However, it would be an advantage if it were integrated.

6.5 Educational Use Evaluation

6.5.1 Evaluation Plan

Participants: To ensure the system was suitable for use in an education a focus group of teachers was held to gain feedback. Total participants=3

Method: The group of participants were shown the demonstration of worksheets V1 and V2, asked to discuss the use of the digital pen in education and shown a demonstration of the desktop application.

6.5.2 Evaluation Results

Pen Use in Schools
As the participants were school teachers the focus group was aimed at getting their feedback on how the pen could be integrated into a classroom environment.

- Would be useful for students who are shy and although they know the answer do not answer in class. They could complete a digitally annotated diagram on their own and still have their answers presented to the teacher.
- Would be good to increase enthusiasm with students. But the question of using technology in place of traditional teaching techniques was raised:

  > "Is it just fun or is it of value. Or is it of value because it is fun."

  This is an interesting point as it implies that although the pen may not add to what can be taught in a lesson it could encourage pupils to learn if they are having fun.
- Would be used when younger children are learning new words. Similarly to the foreign language suggestion given in section 6.3 the word could be written while recording the spoken word. Meaning when it was selected later it would be played via the speaker.

Desktop Application
As shown in section 3.2 the desktop application was designed to be adaptable to education and included options to record scores or comments for a pupil's worksheet. The participants were positive about the use of a desktop application to review and mark their students work. One participant discussed having to take work home to mark and thought being able to do so on a laptop would be better than taking all the worksheets home.

> "I would rather after school be looking at that [The desktop software]".

From the teachers focus group there was positive feedback on pen use in schools. Although they thought the pen would not be something used in every class, it would be useful as a tool to encourage enthusiasm from the students. Since the evaluation shows that teachers would be willing to use the system in class this could possibly be tested as future work to this project.

6.6 Code Re-Use Evaluation

To evaluate the generic toolkit for developing pen applications, a prototype of the medication management case study was created. This system was created using the methods in the generic code listing, which was then analysed to evaluate how re-usable it was in an application other than augmented museums.

Using the labels template created in phase three of requirements and design 4.2 altered to the medication application area a code re use evaluation was created. Similarly to the implementation of all augmented paper, the co-ordinates were integrated into Java code to create the active region for each label.

6.6.1 Evaluation Plan

Evaluation Aims:

- To have a metric of how useful the generic toolkit is for the creation of penlets.
- To discover if the correct common features/use cases were extracted in the requirements phase.

Plan:

- Create a penlet for medication management case study using toolkit code.
- Evaluate how much of this code was reused code. This is divided into:
  - Change level 0.
  - Change level 1.
  - Change level 2.
  - Completely new code.

6.6.2 Evaluation Results

The development of a medication management prototype was successfully created using the generic toolkit code. A metric for measuring this was existing within the documentation of the methods, the change level notation. The use of each change level was measured to find the code re-use.

Penlets that reused code to seek information from pen (i.e play audio or view on screen text) showed high levels of generic toolkit code reuse. For example, using the toolkit code to create medication labels. As shown in Figure 6.6.2, of the 'new' code lines needed in the medication labels penlet, the majority are lines of code to initialise the penlet rather than add functionality. Therefore, the core functionality of augmented labels has been created in the generic toolkit and can be used in a variety of scenarios. Developers can create these labels by using toolkit methods for the recognition of regions, playing of sound, presentation of text message. Most editing will be needed when scenario specific initial data is needed (for example, medication data in this case study).

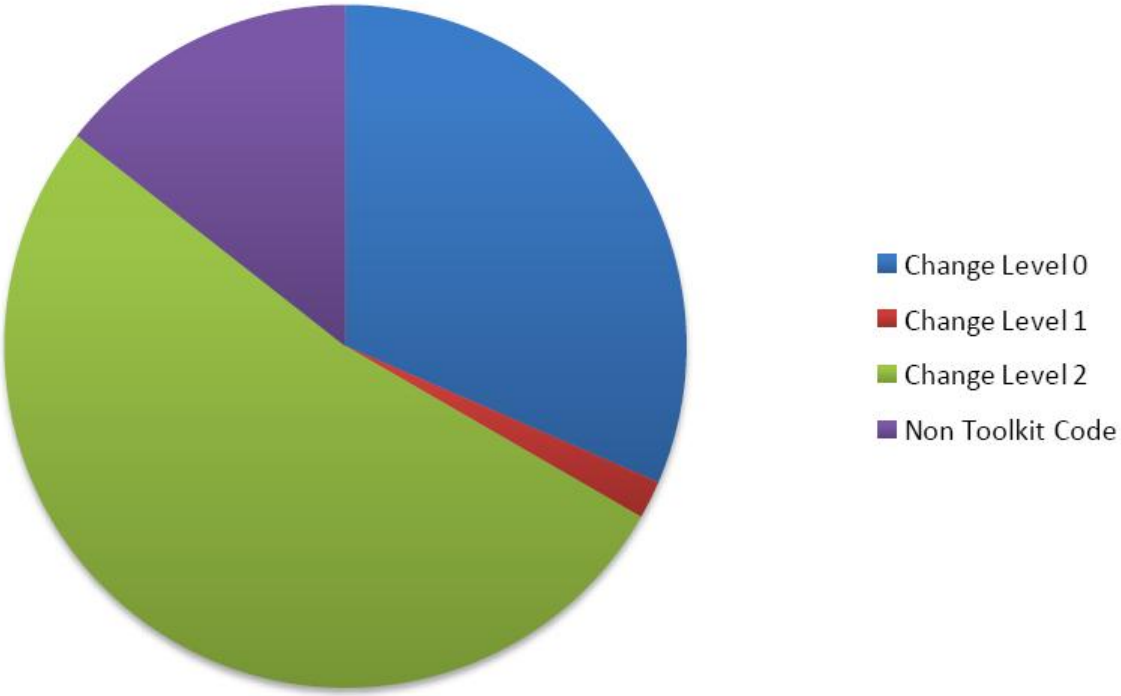


Figure 6.4: Medication Labels: Code Breakdown Per Line

Chapter 7

Conclusions & Future Work

This section will reflect on the success of this project by: discussing the aims and objectives outlined, considering the limitations of the system created and suggesting future work to be completed to improve or further develop the project.

7.1 Achievements

In the beginning of the project the main aims were : (1)Develop one or more applications to exploit worksheets and labels for use in museum and medication scenarios. (2) Develop a toolkit of generic code for use in digital pen applications. To achieve these aims a set of objectives were outlined (section 1.3). These objectives were:

- Research existing ubicomp and smartpen systems in museums.
- Research existing medication management systems supported by technology.
- Create usecases to find the common features of digital pen applications.
- Conduct surveys, interviews and focus groups to gather requirements for creating a generic toolkit for digital pen applications.
- Create a generic software tool kit for use in digital pen
- Deliver a piece of software that uses digital labels and worksheets to give audio messages to the user.
- Investigate the amount of code reuse between pen applications is possible.

This section will discussed how each objective was met.

Research existing ubicomp and smartpen systems in museums

As discussed in Chapter 4, expert interviews and background reading were used to research the existing use of ubicomp systems in museums. An area of these existing systems that could be improved became evident. This area was the difficulty of editing tours and exhibits using technology as these systems required expert companies to do so, therefore costing time and money to the museum. Within this project, a prototype of an alternative system was created and evaluated. Section 4.4 discusses the augmented labels created using a penlet to create a tour application. An important aspect to this implementation was ensuring the code was created in away that allowed museum staff to easily replace audio and information.

Research existing medication management systems supported by technology

Background reading and research in to existing systems in medication compliance were conducted to inform the design of a medication management system. It was discovered that a common issue for many over 65 year old's was low medication compliance. Therefore effecting their health and ability to live independently. It was decided to use the information found to create a survey to seek information on this issue from medical experts, patients and carers as they would be the user groups in a medication management system to resolve this problem.

Create usecases based in the two application areas to find the common features of digital pen applications.

Usecases were created in the first phase of the project to design the initial prototypes. They were informed by background reading and requirements gathering. A survey and expert interview were techniques used to include stakeholder feedback into the use cases. These use cases were analysed to create a set of common functionalities that were developed in to a generic toolkit of code to allow for code reuse in the development of digital pen systems.

Conduct surveys, interviews and focus groups to gather requirements for creating digital pen applications.

This project was iterative in nature and focused on user input and feedback when developing the digital pen applications. Initial requirements were gathered in phase one by seeking user input in several different ways including a survey and an expert interview. A worksheet prototype was created and a focus group was conducted to gain feedback from the end user group. In phase two, a user aided design focus group was held to ensure the next version of the worksheet was suitable for it's purpose- enjoyable education in a museum context. After further development of the worksheets, both versions were discussed with a different user group to ensure all stakeholders were involved in the design. Phase three concentrated on the development of an augmented museum tour labelling system and an initial version of a museum desktop application to retrieve data from the pen. After the creation of these applications, they were evaluated by a variety of users. This included the end users of the museum system and those who will be responsible for creating the museum specific versions of the labels and worksheets.

Create a generic software tool kit for use in digital pen

A generic toolkit of Java penlet code was produced to allow developers to create pen applications using the common usecase functionality studied in this project. All methods were given a unique

identifier and a 'change needed' level (0,1 or 2) to give the developer an indication of how much work will be necessary to integrate this method in to their penlet code.

Deliver a piece of software that uses digital labels and worksheets to give audio messages to the user

By the end of three iterations within this project there were several software deliverables.

- Museum Worksheet V1 Penlet
- Museum Worksheet V2 Penlet
- Museum Tour Labels
- Museum Desktop Application
- Medication Labels

Investigate the amount of code reuse between pen applications.

As the purpose of creating a generic software toolkit was to allow the development of penlets with minimal new code writing necessary. This was measured by creating a prototype augmented labelling system for the medication management case study. The evaluation carried out on this code showed that penlet consisted of mainly generic toolkit code. Therefore, this toolkit should be transferable to other digital pen application areas where the focus is labelling physical items with digital information.

7.2 Limitations

As discussed throughout, the desktop application created is an initial prototype. This was not developed iteratively like the augmented paper. Therefore, feedback from museum staff and teacher evaluations should be taken into consideration in a future development.

Since there were many iterations in designing augmented paper this was where the majority of time was allocated in the project. Therefore the limited time used in development of C# applications was allocated to desktop application development was used in implementing simple data transfer from penlets via text files. The Livescibe Desktop SDK provides the functionality to integrate user drawn pages to the user interface. Given more time this feature would be implemented to remove the step involving museum staff retrieving images from the livescribe desktop software and penlet specific data from the museum desktop. I.e, a visitor's multiple choice answers and drawings should be linked and displayed in the next implementation of the museum desktop.

7.3 Future Work

As the augmented labels and worksheets have been successfully and evaluated, the next progression in the development of this system in the museum case study is to evaluate in a realistic environment.

Evaluating in a museum context would test if the system was usable in a large, busy museum. This future evaluation would also show issues that cannot be revealed in a lab evaluation.

Throughout the project, use of the system in education has been considered in design and evaluation. A further step in this area of the project would be an evaluation in a classroom environment to determine if it is realistic for a class of school pupils to use the augmented worksheets and labels to learn.

Requirements for a medication management system were gathered in this project. An initial augmented labelling prototype was created but is yet to be evaluated. An evaluation and further development of this case study should be a carried out to create a system that could be used in a home care environment to potentially increase medication compliance and prolong user Independence. A desktop application to transfer a patient's medication compliance and symptoms to the appropriate medical professional should be implemented to create a full medication management system. This is now being implemented as a masters student project.

Through the study of two application areas and continuous user centred design, an output of this project is generic toolkit of code to allow pen applications using augmented labels and worksheets to be developed easily. Future work using this toolkit could include any system that would utilise these paper items and digital pen technology.

Appendix A

Usecases

A.1 Museum Usecases

Usecases provided here are those defined in phase 1 of the requirements and design process. Therefore these use cases to not define the final system. Actors:

Visitor- A user that is a guest at the museum, possibly for the first time.

Staff- A user that is employed by the museum and is trained on how to use the pen and accompanying software

A.1.1 Artifact Labels

Usecase1: Get information form exhibit

Users can select a labelled artifact with the smartpen, which will then play a previously defined audio message. For example, information about the item in the museum.

1. User selects digital label with the pen.
2. Audio is played via the pen for the user to hear.

UseCase 2: Record message

Visitors to the museum can leave personalised messages when at a place in the exhibit they are encouraged to do so. This allows users to create a digital guest book with their views and opinions.

1. Visitor selects “record” with the pen.
2. Visitor now writes/draws while speaking.

3. When finished recording they will click “stop”
4. To hear the message they have recorded, the visitor should select their hand written/drawn message.

Usecase 3: Create artifact labels

Staff in the museum must be able to create new labels to give information on artifacts. There will be an associated image/ text.

1. Create image/text.
2. Record audio message.
3. Associate image with this image.
4. Deploy the images and penlet to smartpen(s).
5. Print label and place in exhibit.

A.1.2 Augmented Worksheet

UseCase 1: Get information from worksheet

Users can select a labelled region on a sheet with the smartpen, which will then play a previously defined audio message. For example, an audio message of the question selected.

1. User selects digital label with the pen.
2. Audio is played via the pen for the user to hear.

UseCase 2: Get information form exhibit
Users can select a labelled artifact with the smartpen, which will then play a previously defined audio message. For example, information about the item in the museum.

1. User selects digital label with the pen.
2. Audio is played via the pen for the user to hear.

UseCase 3: Record answer on worksheet

Visitors to the museum can record an answer to the question on the worksheet. This allows users to have either written or spoken answers.

1. Visitor selects “record” with the pen.

2. Visitor now writes/draws on the specified area while speaking.
3. When finished recording they will click “stop”.
4. To hear the message they have recorded, the visitor should select their hand written/drawn message.

Usecase 4: Create augmented worksheet

Staff in the museum must be able to create worksheets for the visitors to answer based on information they receive through the pen from labels. There will be an associated image/ text.

1. Create image/text.
2. Record audio message of questions.
3. Associate image with this image.
4. Deploy the images and penlet to smartpen(s).
5. Print worksheet.

A.1.3 Desktop

Usecase 1: View Visitor Answers
Staff in the museum should be able to view user answers and any drawings/ annotations on the augmented worksheet.

1. Dock pen via USB
2. Launch Desktop Application
3. View user answers
4. Save user answers

A.2 Medication Usecases

Actors:

Patient-A user who has one or more prescribed medications and lives at home, possibly receiving out patient care.

Carer- A user that is responsible for helping a patient with their medication.

Medical Professional- A user that is able to prescribe medication.

A.2.1 Medication Labels

Usecase1: Get information from medication

Users can select a labelled medication with the smartpen, which will then play a previously defined audio message. For example, information about the dosage of the medication.

1. User selects digital label with the pen.
2. Audio is played via the pen for the user to hear.

UseCase 2: Record message

Patients or Carers can leave personalised messages on their medication to give reminders that they are likely to understand or remember.

1. User selects “record” with the pen.
2. User now writes/draws while speaking.
3. When finished recording they will click “stop”.
4. To hear the message they have recorded, the user should select their label.

Usecase 3: Create medication label

Medical workers must be able to create new labels to give information on their prescribed medication. There will be an associated image/ text with the audio message.

1. Create image/text.
2. Record audio message.
3. Associate image with this image.
4. Deploy the images and penlet to smartpen.
5. Print label and place on medication container.

A.2.2 Augmented Worksheet

UseCase 1: Get information from worksheet

Users can select a labelled region on a sheet with the smartpen, which will then play a previously defined audio message. For example, an audio message with medical information or reminders.

1. User selects digital label with the pen.
2. Audio is played via the pen for the user to hear.

UseCase 2: Get information from label
Users can select a labelled medication container with the smartpen, which will then play a previously defined audio message. For example, information about the a dose.

1. User selects digital label with the pen.
2. Audio is played via the pen for the user to hear.

UseCase 3: Record symptoms on worksheet

Patients can record symptoms or opinions on their health or medication routine on the worksheet. This allows users to have either written or spoken messages for medical professionals to view when reviewing their medical record.

1. Patient selects “record” with the pen.
2. Patient now writes/draws on the specified area while speaking.
3. When finished recording they will click “stop”.
4. To hear the message they have recorded, they should select their hand written/drawn message.

Usecase 4: Create augmented worksheet

Pharmacy/ doctors staff must be able to create worksheets for the patients containing up to date information and messages to receive through the pen from labels. There will be an associated image/ text.

1. Create image/text.
2. Record audio message of message/dosage.
3. Associate image with this image.
4. Deploy the images and penlet to smartpen.
5. Print worksheet.

A.2.3 Desktop

Usecase 1: View information on patient's symptoms and medication
Medical professionals such as doctors or pharmacists must be able to get information on patient's medication compliance or symptoms.

1. Dock pen via USB.
2. Launch desktop application.
3. Select which patient to view details.
4. View details.
5. Contact patient.

Appendix B

Survey

As discussed in section 4.2.2 a survey was conducted to gather requirements for the design of a medication management system. The results are discussed in section 4.2.2 and the full survey listing is displayed in this section (next page).

Medication Management

1. Introduction

Thank you very much for your participation in this survey which is being conducted as part of a final year undergraduate Computing Science project

The main aims of this survey are:
* To identify if there is a need for an alternative for monitoring and improving people's medication intake.
* To identify who should design and create the new procedures and system for this.
* To discuss the possible use of technology to provide this service.

This survey should take you no longer than 20 minutes to complete. It consists of multiple choice and open text questions. At the beginning of each new section a glossary of terms that will be used are given. Please read these to ensure you understand the questions.

No personal information will be stored and the survey is anonymous. Please do not put your name of any other identifying information on the survey.

You may withdraw from the questionnaire at any time without prejudice, and any data already provided will be discarded.

If you have any further questions regarding this survey, please contact:

Carole Rennie Grieve
4th year student
School of Computing Science
University of Glasgow

0605186g@student.gla.ac.uk

Once again, thank you very much for your time and participation.

The survey begins on the next page.

Medication Management

2. Medication Management

This section will identify the need for an improvement in the medication monitoring for patients.

In the following questions "patient" is used informally to refer to a person who has one or more prescribed medications and lives at home, possibly receiving out patient care.

"Medication Compliance" describes the degree to which a patient correctly follows medical advice and their prescribed medications.
Thank You

1. What is your role in care?

- Patient
- Home-based carer (spouse, child)
- Family/Friend
- Pharmacist
- Nurse
- Doctor
- Social Care professional
- Community Nurse

Other (please specify)

2. How important is medication compliance?

- Very important
- moderately important
- Slightly important
- Not at all important

Please explain:

Medication Management

3. Please state the extent you agree or disagree with the following statement:

“Patients often do not comply with their prescribed medication.”

- Strongly disagree
- Disagree
- Agree
- Strongly Agree
- I don’t know (I don't have information on this)

Please explain:

4. Please give the top three reasons why, in your opinion, patients do not comply with their medication.

Reason 1:

5. Reason 2:

6. Reason 3:

7. What are the main benefits of medication management to increase compliance?

Medication Management

8. Who should be involved in the medication management of a patient?

	Must be involoved	Should should be involved	Could be involved	Should not be involoved	I don't know
Patient					
Home-based carer (spouse, child)					
Family/Friend					
Pharmacist					
Nurse					
Doctor					
Social Care professional					
Community Nurse					
Other					

Other (please specify)

Medication Management

3. Computer Assisted Medication Management

Medication Management is collaborative and involves people from many different groups. We are interested in identifying the most important stakeholders for creating a medication management system.

The term "Medication Management System" is used to describe a piece of software/hardware to support patients in complying with their prescribed medication and symptom management. This could be in the form of software on a desktop computer or on a mobile device such as a mobile phone or digital pen.

1. Do you think a medication management system could help patients?

- Yes, to a great extent
- Yes, to a moderate extent
- Yes, to a slight extent
- No, not at all

Please explain:

2. Give the top 3 aspects of compliance that technology could help:

Part 1:

3. Part 2:

4. Part 3:

Medication Management

5. Who should be involved in the design of the user interface (appearance) of a medication management system?

	Must be involved	Should be involved	Could be involved	Should not be involved	I don't know
Patient					
Home-based carer (spouse, child)					
Family/Friend					
Pharmacist					
Nurse					
Doctor					
Social Care professional					
Community Nurse					

6. Who should be involved in designing the functionality of a medication management system? I.e, what the system does.

	Must be involved	Should be involved	Could be involved	Should not be involved	I don't know
Patient					
Home-based carer (spouse, child)					
Family/Friend					
Pharmacist					
Nurse					
Doctor					
Social Care professional					
Community Nurse					

7. In your opinion, would medical professionals be willing to use such a system?

- Yes
- No

If no, please explain:

Medication Management

8. In your opinion, would patients be willing to use such a system?

- Yes
- No

If no, please explain:

Medication Management

4. Pen Based Technology

This section is seeking information on your views towards digital pens for use in a medication management system.

Digital pens can be used to capture what people write and can have audio associated (for example, the name of a medication with a audio recording of when to take it). The pen we are using is the LiveScribe Pulse Smartpen (www.livescribe.com). This technology can be used to label items with a specially designed paper and when the pen is pressed to this label an associated message is played.

It is thought that digital pens could be used in medication management as it is not a complicated piece of technology to use and, therefore, those who may not be comfortable using a computer may like to use this option as it similar to writing with a regular pen and paper. Also, digital pens are small, portable and can be taken anywhere.

1. Have you ever used a digital pen?

- Yes
- No

If yes, what did you think of this technology?

2. In your opinion, would patients be willing to use a digital pen to record and to get information on their medication?

- Yes
- Maybe
- No

Please explain:

Medication Management

3. It has been thought that a useful application of digital pen technology in medication would be an augmented worksheet. A sheet of specially designed paper would be labelled with information on the patient's personalised medication routine that when selected with the pen, gives the patient customised information via audio.

How useful do you think the following features would be?

	Very useful	Slightly useful	Not useful at all	I don't know
Customised data				
Informaion given in audio				
Sending data to medical professional				
Conifming time medication taken				
User can write symptoms and send to doctor.				

Please explain:

4. With whom do you believe patients would be willing to share personal information about their medication use?

	Very Willing	Somewhat Willing	Not at all	I don't know
Home-based carer (spouse, child)				
Family/Friend				
Pharmacist				
Nurse				
Doctor				
Social Care professional				
Community Nurse				
Other				

Other (please specify)

Medication Management

5. What information should be stored about a patient's medication routine?

- Time medication taken.
- Frequency of checking medication information
- Symptoms/ reasons for taking medication.

Other (please specify)

Appendix C

User Manuals

C.1 Museum Staff Guide

This document provides a step-by-step guide to the producing labels and worksheets for museums. All documents and files discussed are found in the 'Paper Museum Toolkit' folder. This guide gives instructions on:

- Creating an augmented worksheet.
- Creating an augmented tour.
- Deploying applications to digital pen.

C.1.1 Creating an augmented worksheet

To create an augmented worksheet an audio (.wav) file and text description will be needed for each multiple choice answer option and for a clue. Figure C.1.1 shows how audio files are linked with the worksheet options A, B and C. Each audio file for an option should be named "A.wav", "B.wav", "C.wav" and the clue audio should be named "Clue.wav".

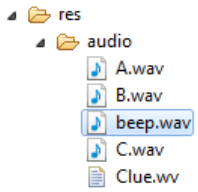


Figure C.1: Museum Staff Guide: Naming Resources

Options should be entered into the area shown in the Eclipse code window. Figure C.1.1 shows an example of this. The correct answer should also be entered ans "A", "B" or "C".

```
/*
 * MULITPLE CHOICE OPTIONS EDITED HERE
 */
private String AnswerA="Gas Mask";
private String AnswerB="Radiation Suit";
private String AnswerC="Fireman's Suit";
private String correctAnswer="A";
```

Figure C.2: Museum Staff Guide: Multiple Choice Options Input

C.1.2 Creating an augmented tour

To create an augmented tour an audio (.wav) file and text description will be needed for each artifact. Figure C.1.2 shows how audio files are linked with the artifact label template. Each audio file for an artifact should be named "1.wav"..."NumberofLabels.wav". For example, if there are only 6 artifacts then only 1...6 should be in the resources. The pen application will automatically ignore the unused regions on the labels template.

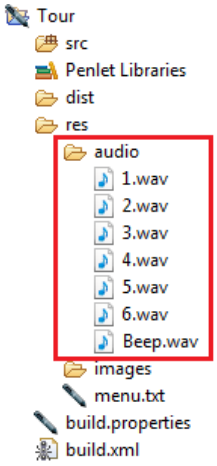


Figure C.3: Museum Staff Guide: Naming Tour Resources

Names or descriptions of artifacts should be entered into the area shown in the Eclipse code window. Figure C.1.2 shows an example of this. Similar to the audio files, if not all artifacts labels are needed then only enter those necessary in ascending order. For example, if there are 6 artifacts then name label1...label6. Additionally, to allow the pen application to ignore the unused labels the total number of labels should be entered as shown.

C.1.3 Deploying applications to digital pen

The same instructions should be followed when deploying both worksheets and labels to a digital pen. Firstly, the smartpen should be docked via USB and "Read Pen" selected (see figure C.1.3).

To deploy the application to the pen: select the folder containing the application (see figure C.1.3)

Tour.java | TreasureHunt.java

```
14    //ENTER NAMES OF EACH ARTIFACT (IF ALL 9 NOT NECESSARY, LEAVE BLANK)
15    private String artifact1="Ludos Latrunculorum";
16    private String artifact2="Emperor Antoninus Pius";
17    private String artifact3="Ushabti Figure";
18    private String artifact4="Terracotta Oil Lamp";
19    private String artifact5="Child's Leather Shoe";
20    private String artifact6="Strigil";
21    private String artifact7="";
22    private String artifact8="";
23    private String artifact9="";
24    //ENTER NUMBER OF LABELLED ARTIFACTS
25    private int NumberOfLabels=6;
```

Figure C.4: Museum Staff Guide: Naming Artifacts

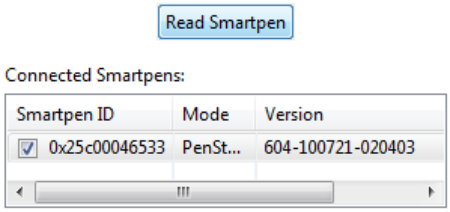


Figure C.5: Museum Staff Guide: Read Pen

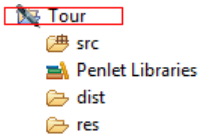


Figure C.6: Museum Staff Guide: Application Folder

C.2 Visitor Guide

A user guide was created for visitors to the museum. Since users are unlikely to read an instruction manual, a poster displaying how to launch an application was created. The worksheet and penlet provide guidance throughout use. In user evaluations the majority of users were able to use the pen after a quick demonstration.

Augmented Museum: Visitor Guide

More pen controls:

- Tap on worksheet for information
- Double tap to confirm

C.3 Developers Guide

This document provides a guide to developers to create pen applications (penlets) for LiveScribe Smartpens. This guide gives instructions on:

1. Setting up the programming environment.
2. Creating a worksheet.
3. Creating a penlet.
4. Testing a penlet.

Setting up programming environment
Penlets are written in Java and development is supported in Eclipse IDE. The Livescribe Platform SDK provides Eclipse plug-ins to provide functionality to communicate with the Smartpen.

Full install instructions and documentation is located within the SDK download.

Creating a worksheet
Worksheets can be created by printing a design on existing Livescribe paper.

- Worksheets can be created in any word processing, image manipulation or publishing tool that allows A4 size documents to be created. The worksheet design including open areas and paper 'buttons' should be created using the tool chosen.
- When the design is complete the worksheet design should be printed on Livescribe A4 paper.
- Using the 'giveCoords' application provided in the generic toolkit collect the coordinates of the printed regions on the worksheet. These (X,Y) coordinates will be integrated into the penlet code.

An alternative is to create specialised Livescibe paper using Eclipse paper perspective. This tool allows regions to be associated automatically.

- Create a worksheet design using a tool that supports the creation of .eps files.
- Import this image into Eclipse paper perspective.
- Associate active regions with image using tools provided.
- Associate actions to be carried out on clicking of the region using toolkit code.

Creating paper using this technique requires a high definition printer (600dpi), this can often not be possible and also has it's disadvantages. This document will describe how to create penlets for use with existing Livescribe paper. However, code from the generic toolkit will also be usable in

developing paper products.

Creating a penlet
Penlets can be created using generic toolkit code. This section will give basic instructions on how to create penlts. Full instructions on using Eclipse and Livescribe SDK can be found in the documentation. This section discusses the main instructions and knowledge needed to develop penlets.

- Switch to Penlet Perspective in Eclipse.
- Create new penlet.
- To allow the penlet to recognise the pen touching the paper the class should extend 'PenTipListener'. This requires several methods to be included in the class:
  - penUp()
  - penDown()
  - singleTap()
  - doubleTap()

  The toolkit code listing provides examples of using singleTap or doubleTap methods to recognise the region on paper the interaction is occurring.
- Methods to use the multimedia functions of the pen are contained in the generic toolkit code listing. For example:
  - createSound()
  - playSound()
  - playBeep()
- To deploy the penlet to the Smartpen:
  1. Dock the Smartpen via USB.
  2. Click 'Read Smartpen'
  3. Right click on the penlet file and select 'Deploy to Smartpen'.

  The penlet is now available to use on the Smartpen and can be launched using the paper navigation controls. Main Menu- Applications- penlet-name.

Testing a penlet

- When a penlet is deployed to a Smartpen, it should be tested to ensure the required functionality is provided when interacting with the worksheets.

Applications need 4 methods by default: initApp(), activateApp(), deactivateApp(), destroyApp().
As there are typically 3 variables always necessary in a penlet as they communicate to the user via the screen and audio player:

```
      private Display display;
      private ScrollLabel label;
      private MediaPlayer player;
      private DataOutputStream data = null;
```

Therefore a generic initApp would initialise these:

```
      /*Generic Toolkit Code: (#1) initApp()
       * Changes Needed =2
       * Necessary for every application. Contents can change depending on
       what variable have been created.
       */
      public void initApp () throws PenletStateChangeException
        {
               this.display = this.context.getDisplay();
               this.label = new ScrollLabel();
               this.player = MediaPlayer.newInstance(this);
               this.data = null;
        }
```

A corresponding activateApp:

```
      /*Generic Toolkit Code: (#2) activateApp()
      * Changes Needed = 2
      * Text to welcome user when selected app will most likely change for
      every application.
      * Necessary for every application. Contents can change depending on
      what variable have been created.
      */
    public void activateApp (int reason, Object[] args)
    {
      if (reason == Penlet.ACTIVATED_BY_MENU) {
             this.display.setCurrent(label);
             displayMessage("Welcome");
            this.context.addPenTipListener(this);
            }
    }
```

```
      /*Generic Toolkit Code: (#3) deactivateApp
      * Changes Needed=2
      * May vary depending which API references were being used (e.g
      PenTipListener, Stroke Listener etc))
      */
    public void deactivateApp(int reason) {

      this.context.removePenTipListener(this);
    }
```

```
      /*
      * Generic Toolkit Code: (#4) destroyApp
      * Changes Needed=2
      * If no data stream being used then the relevant code can be removed.
      */
```

```
    public void destroyApp () throws PenletStateChangeException
    {
      if (data != null) {
                  try {
                        data.close();
                  } catch (Exception e) {
                        handleException(e, "Closing output stream");
                  }
            }
    }
```

```
      /* Generic Toolkit Code: (#5) canProcessOpenPaperEvents
       * Changes Needed=0
       */
    public boolean canProcessOpenPaperEvents ()
    {
        return true;
    }
```

```
      /*Generic Toolkit Code: (#6)displayMessege
       * Changes Needed: 0
       * String m is the message to display on pen screen.
       */
      public void displayMessage(String m){
            this.label.draw(m,true);

      }
```

```
      /*Generic Toolkit Code: (#7)createSound
       * Changes Needed: 0
       * String fileName is the name of file to be created in to a sound
       resource.
       * File extensions are not necessary (e.g a file Sound.wav should be
       "Sound")
       */

      public SoundResource createSound(String fileName){
            SoundResource sr=
      this.context.getResourceBundle().getSoundResource(fileName);
            return sr;
      }
```

```
      /*Generic Toolkit Code: (#8)playBeep
      * Changes Needed: 0
      * This method works, assuming the file Beep is in res\audio folder in
      project directory.
      */
      public void playBeep(){
            SoundResource
            beep=this.context.getResourceBundle().getSoundResource("Beep");
            this.player.play(beep);
      }
```

```
      /*Generic Toolkit Code: (#9) penDown
       * Changes Needed=2
       *
       */
      public void penDown(long time, Region region, PageInstance
pageInstance) {
            // TODO Auto-generated method stub
      }
```

```
	/*Generic Toolkit Code: (#10) penUp
	 * Changes Needed=2
	 *
	 */
	public void penUp(long time, Region region, PageInstance
pageInstance) {
		// TODO Auto-generated method stub
	}
```

```
	/*
	 * Generic Toolkit Code: (#11) wait
Changes Needed: 0 System waits n
	 * milliseconds before completing the next instruction
	 */
	public void wait(int n) {
		long t0, t1;
		t0 = System.currentTimeMillis();
		do {
			t1 = System.currentTimeMillis();
		} while (t1 - t0 < n);
	}
}
```

Worksheet Specific Methods:

```
	/*Generic Toolkit Code: (#12)writeOptionsToFile
	 * Changes Needed: 0
	 * Writes multiple choice questions to file
	 */
	private void writeOptionsToFile(long time){
		writeToFile(time, AnswerA);
		writeToFile(time, AnswerB);
		writeToFile(time, AnswerC);
	}
```

```
	/*Generic Toolkit Code: (#13) doubleTap
	 * Changes Needed=0
	 *
	 */
	public void doubleTap(long time, int x, int y) {
		if((x>=3194&&x<=3362)&&(y>=1684&&y<=1855)){
			this.label.draw("You answered: Answer A",true);
			userAnswer="A";

		}
		if((x>=3190&&x<=3357)&&(y>=1957&&y<=2116)){
			this.label.draw("You answered: Answer B",true);
			userAnswer="B";

		}
		if((x>=3189&&x<=3352)&&(y>=2233&&y<=2385)){
			this.label.draw("You answered:Answer C",true);
			userAnswer="C";

		}
```

```
            if((x>=3133&&x<=3949)&&(y>=6762&&y<=6988)){

                  if(userAnswer.equals(correctAnswer)){
                        displayMessage("You Answered Correct");
                        AnswerAttempts++;
                        writeToFile(time, "User answered: " + userAnswer);
                        writeToFile(time, "Attempts:" + AnswerAttempts);
                        writeToFile(time, "Clue used: "+ clueCount );
                        gotCorrectAnswer=true;
                  }

                  else{

                        displayMessage("Your answer was wrong, Try
again.");
                        AnswerAttempts+=1;

                  }
            }
            lastclickTime=time;
      }
```

```
      /*Generic Toolkit Code: (#14) single Tap
       * Changed Needed: 0
       * Method to recognise Generic Worksheet regions and provide
information via text and sound.
       */
      public void singleTap(long time, int x, int y) {
            //check if it is the first use of pen, if so write options to
file
            if (beenUsed!=true){
                  writeOptionsToFile(time);
                  beenUsed=true;
            }

            if ((x>=4000&&x<=5840)&&(y>=1255&&y<=2730)){
                  displayMessage("Clue");
                  player.play(createSound("Clue"));
                  clueCount++;
            }
            if ((x>=1476&&x<=5525)&&(y>=3240&&y<=6758)){
                  displayMessage("Draw the item here.");
                  playBeep();
            }
            if ((x>=1329&&x<=2928)&&(y>=1159&&y<=1484)){
                  displayMessage("What do you think it is?");
                  playBeep();
            }
            if((x>=3194&&x<=3362)&&(y>=1684&&y<=1855)){
                  playBeep();
                  displayMessage("Answer A");
                  player.play(createSound("A"));
            }
            if((x>=3190&&x<=3357)&&(y>=1957&&y<=2116)){
                  playBeep();
                  displayMessage("Answer B");
                  player.play(createSound("B"));

            }
            if((x>=3189&&x<=3352)&&(y>=2233&&y<=2385)){
```

```
                playBeep();
                displayMessage("Answer C");
                player.play(createSound("C"));

            }
            if((x>=3133&&x<=3949)&&(y>=6762&&y<=6988)){
                playBeep();
                displayMessage("Double click when you are done.");
            }
            lastclickTime=time;
      }
```

Tour Specific Methods:

```
/*
       * Generic Toolkit Code: (#15) doubleTap Changes Needed=2
       */
      public void doubleTap(long time, int x, int y) {
            if (checkRegion(x, y, 1308, 2810, 1127, 3107, "a", "Artifact
A", createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 2977, 4454, 1135, 3113, "b", "Artifact
B",createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 4571, 6064, 1147, 3117, "c", "Artifact
C",createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 1300, 2793, 3270, 5236, "d", "Artifact
D",createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 2965, 4440, 3279, 5241, "e", "Artifact
E",createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 4560, 6050, 3291, 5255, "f", "Artifact
F",createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 1289, 2783, 5406, 7373, "g", "Artifact
G",createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 2956, 4430, 5422, 7384, "h", "Artifact
H",createSound("Clue"))) {
                tourProgress();
                return;
            }
            if (checkRegion(x, y, 4541, 6042, 5440, 7410, "i", "Artifact
I",createSound("Clue"))) {
                tourProgress();
```

```
                return;
            }
        }
```

```
        /*
         * Generic Toolkit Code: (#16) tourProgress
Changes Needed: 1 Gives progress
         * of tour on screen Only changes needed is to the value (here it is
9) if
         * the labels are developed into a larger tour.
         */
        public void tourProgress() {
            if (clueCount == 9) {
                displayMessage("You have completed the tour!");
            }
            if (clueCount < 9) {
                displayMessage("You have visited: " + clueCount + " /9");
            }
        }
```

```
        /*
         * Generic Toolkit Code: (#17) checkRegion Changes Needed: 0 This
        method
         * works, assuming the string selected is defined in the penlet to
        hold the
         * charachter id's that show the region has beem selected. int x, int
        y are
         * co-ordinates of the paper the pen has selected. Passed from
              * PenTipListener methods. regionx1,x2,y1,y2 are the
        coordinates of the
         * region on paper. String regionChar is the identifier for this
        region.
         * String text is the message to be displayed on screen. Sound
        Resource
         * sound is the audio file to be played when region is selected.
         */
        public boolean checkRegion(int x, int y, int regionx1, int regionx2,
            int regiony1, int regiony2, String regionChar, String text,
                SoundResource sound) {
            if ((x >= regionx1 && x <= regionx2)
                    && (y >= regiony1 && y <= regiony2)) {
                playBeep();
                if (selected.indexOf(regionChar) == -1) {
                    this.player.play(sound);
                    selected += regionChar;
                    clueCount += 1;
                } else {
                    displayMessage(text);
                    this.player.play(sound);
                }
                wait(500);
                return true;
            } else {
                wait(500);
                return false;
            }
        }
```

Data Storage/Transfer Methods:

```
	/*Generic Toolkit Code(#18) sendData()
	 * Changes Needed=0
	 * Transfers data stored in pen storage to desktop when docked and
	desktop application is run
	 */
	private long sendData(OutputStream outputStream, long syncTime)
	throws IOException {
		if (data != null) {
			data.close();
			data = null;
		}
		long strokeTime = 0;
		DataInputStream inputStream = new
DataInputStream(penletStorage.openInputStream(dataFile));
		try {
			while (true) {
				strokeTime = inputStream.readLong();
				String appData=inputStream.readUTF();
				if (strokeTime > syncTime && outputStream != null)
{
					outputStream.write(appData.getBytes());
				}}}
		catch (EOFException e) {
		} finally {
			if (inputStream != null)
				inputStream.close();
		}
		return strokeTime;
	}
```

```
	/*Generic Toolkit Code(#19) getAppData()
	 *Changes Needed=0
	 */
	public void getAppData(long lastSyncTime, Command command,
			DataSender dataSender) throws IOException {
		OutputStream outputStream = null;
		try {
			outputStream = dataSender.sendDataStream(dataFile);
			sendData(outputStream, lastSyncTime);
		} finally {
			if (outputStream != null)
				outputStream.close();
		}
	}
```

```
	/*Generic Toolkit Code(#20) sendData()
	 * Changes Needed=0
	 * Gets the time when the application last modified its data.
	 */
	public long getDataLastModifiedTime() {
		if (lastTime == 0) {
			try {
				lastTime = sendData(null, 0);
			} catch (IOException e) {
				e.printStackTrace();
			}
		}
```

```
/*Generic Toolkit Code: (#21) putAppData
 * Changed Needed:0
 * Necessary method in API when transferring to desktop, yet is un
implemented
 * */
public String putAppData(Command arg0, DataReceiver arg1)
throws IOException {
      return null;
}
```

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