A Report on the Feasibility of Mobile Devices for Mathematics Learning in Higher Education

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Overview

This report presents an investigation into the educational potential of mobile devices in supporting mathematics teaching and learning.

Aims

The aims of these feasibility studies are to identify and test some features and functionalities which may be of use for teaching and learning mathematics, both formally and informally; as well as for mathematics support. The results of the studies will be used for the selection of mobile device(s) for my PhD studies, which are focused on the integration of computer games and mobile technologies into teaching and learning mathematics in higher education.

The Mobile Devices Examined

Most of the mobile devices that the SIGMA CETL owns have been carefully examined. These examined mobile devices are Samsung Q1, Sony UX PC, Personal Digital Assistant (PDA or HP iPQA hx2100), Sony PlayStation Portable (PSP, model 1003), Video iPod, Nokia N95 mobile phone, Prada mobile phone and Nintendo DS.

The Rationale of the Selection of Maths Websites

In support of my PhD studies the emphasis was on testing the features that could be used for game-based learning, online learning and mobile learning.

Based on my earlier substantial literature review, I had some mathematics learning resources in mind, such as the "MathTutor" (both the online version and videos), online gaming "MyMaths", the BBC's Bitesize GCSE revision, Mathsnet and Math4mobile. Their characteristics are follows:

- MathTutor website contains a large collection of videos for maths learning, diagnostic tests and exercises. The video presenters are experienced maths educators, one of them was previously a TV education presenter. The contents are of up to A-level maths standard.

- MyMath website is devoted to students of 11-16 years. It contains many mathematical games, which are well-designed. The author has already visited a summer school in Yorkshire to see how students were attracted to this website and enjoyed playing the games for 5 hours that day.

- BBC's bitesize for GCSE revision includes some maths games and mobile games. This website has been widely used in UK schools.

- Mathsnet website also has a large collection of computer maths games and mock exam tests; the maths level is up to A-level standard.

- Math4mobile website has 5 free downloadable maths games for Java enabled mobile phones.

One of the foci of this feasibility studies is to look at whether or not the mobile devices examined can be used for making use of the above maths learning resources, including online mathematical computer games.

The Presentation of the Report

In these feasibility studies, approximately 100 tests were carried out on the 8 mobile devices and many photographs were taken to record the testing process and the results.

This report will describe the basic functions of mobile devices, operational issues, useful features, strengths and weaknesses and suggestions for each mobile. It also presents how a device copes with each selected mathematics learning resource in the selected websites.

The investigation into each mobile device will be described in a separate chapter and a summary will be given at the end of each, followed by some images showing the testing results.

In the conclusions chapter, apart from a descriptive text which reflects the author's thoughts and analysis, a table will be presented for a summary of useful findings on technical issues (See Appendix 9). The other appendixes will give summaries of findings on how each mobile device fared in the tests. Finally, some recommendations will be given.

Chapter 1. The Samsung Q1

Introduction

The Samsung Q1 is a small and strong UMPC (Ultra Mobile PC) with an Intel Celeron M ULV processor, 256MB (up to 1GB possible) DDR2 memory and with a 20~60 GB high capacity hard disk drive. It has a 7" touch screen with a basic resolution of 800*480 pixels. With an external display connected, it has maximum resolution of 2048*1536. It is managed by the Microsoft Windows XP Tablet PC Edition, with powerful multimedia functions and multiple network support, including wired LAN, wireless LAN and Bluetooth (optional). Its weight is only 779g (excluding the Bluetooth modules). It is a portable and yet fully functional PC.

Useful Features for Maths Learning

- Using the Microsoft Multimedia Player to play maths video games of various formats that might possibly not run on a PDA, PSP or a smart phone.
- Using PowerPoint slides to foster maths learning.
- Browsing websites with maths learning material and playing online games.
- Communications via email
- USB and Bluetooth technology enabled data transfer between different devices.

The Results of Testing for Maths learning:

1. Testing the display of a pdf file

The quality of the display of Word documents and pdf files is very good; the characters are very clear and graphs and pictures are shown in rich colours.

2. Testing the Internet connection

The Internet connection via Coventry University wireless network is functional and stable. Browsing webpage caused no problems.

3. Testing online gaming at www.mymaths.co.uk.

This website can be fully viewed. All games can be played. The graphs, characters, and images are very good (See Figure 1 and Figure 2). The quality of the display is very good, however, the website was not designed for this smaller screen, and hence some small characters (normally instructions on the menu) are too small to see. The access to the sub-webpage and hyperlinks is fine.

4. Testing Mathtutor videos at www.mathtutor.ac.uk.

The display of Mathtutor videos is excellent. The graphics and hand-writing are very clear (See Figure 3 and Figure 4).

5. Testing the access to web-based maths learning resources at www.mathsnet.net.

This website can be fully viewed, too. There are online interactive maths exercises and exam papers at A-level: The graphics are very clear (See Figure 5). Web pages can be downloaded and displayed. Characters are very clear too. There is also a link to another useful website for A level maths e-learning (www.livemaths.co.uk), in which there is a video A level maths tutor using web-based lessons; subscription is required for their use.

6. A collection of mathematical games called "Phoenix Quest" at www.cs.ubc.ca/labs/egems/

This website can be fully downloaded and displayed. The quality of display, including colour, characters and images is very good (See Figure 6).

7. Testing online maths games at BBC website: bitesize for GCSE revision.

The display of graphics and characters is very good.

8. Testing an online maths game entitled "Phoenix Quest"

The game is playable and the colours are very rich (See Figure 7).

9. Playing an online mathematical game called Dimenxian at www.dimenxian.com.

The visibility is good but the display area is only half the height of the window; tool bars have occupied the rest. It cannot show the whole pop-up window unless the resolution of the screen is changed. The auto scaling function supports 3-step resolutions (800*480 by default -> 800*600 -> 1024*600).

10. Testing maths games at www.math4mobile.com.

The visibility is good but sometimes the whole pop-up window cannot be displayed.

11. Testing www.google.com, search for "wave equation".

The contents are clearly displayed. The colours of the image are very rich (See Figure 8).

12. Testing the use of Bluetooth technology

Files were successfully transferred to a PRADA mobile phone via Bluetooth technology.

13. USB

The USB connection is functional.

14. Testing Emailing function

There is no problem in sending or receiving emails, including attachments.

Summary

The Samsung Q1 PC has most of the functionality available in a desktop PC, it can therefore perform similar tasks. The most useful features include playing video games or online games in different formats, viewing PowerPoint slides and accessing the Internet both wired or wireless.

Figure 1 MyMaths website on the Sumsung Q1. The characters are clearly displayed.

Figure 2 One of the computer games from the MyMaths website on the Samsung Q1.

Figure 3 An online video from the Mathtutor website shows hand-writing clearly on the Samsung Q1.

Figure 4 An online video from the Mathtutor website shows good quality graphics on the Samsung Q1.

Figure 5 A maths exam paper on the Mathsnet website displayed on the Samsung Q1.

Figure 6 A computer game called “Phoenix Quest” playing on the Samsung Q1.

Figure 7 A computer game called “Phoenix Quest” displays rich colours on the Samsung Q1.

Figure 8 A Google search for “wave equation”, in which a wide spectrum of colours and Greek letters in the equations are displayed.

Chapter 2. The Sony UX PC (Ultra Mobile PC)

Introduction:

The Sony UX PC is a light-weight fully functional computer, which runs Windows Vista™ Business system, with 1024 MB memory (RAM), using Intel® Core™ Solo CPU, at 1.33 GHz. It can be connected to the Internet by wireless LAN, and has Bluetooth functions. It has two cameras. There is a USB slot and a slot for a Memory Stick Duo/PRO Duo media card.

Like a standard PC, it can run Microsoft applications such as the MS Works word processor. It also has a Caps Lock key for typing letters in uppercase. However, subscript cannot be used, making it unsuitable for writing some equations.

Useful Features for Learning:

- Access to the Internet
- Playing Video games
- Running Microsoft applications (e.g. Word Processing, Excel, PowerPoint)
- USB feature
- Supports Bluetooth technology
- Emailing

The Results of Testing for Learning:

1. Testing the display of www.math4mobile.com

The website works well (See Figure 9). 5 maths games written in Java can be downloaded to Java enabled mobile phones free of charge.

2. Testing the display of www.mathsnet.net

This website contains maths learning resources up to A-level. It can be downloaded and displayed but the characters are quite small. Graphics are very clear (See Figure 10).

There are many games within the website; however the games take a long time to download.

3. Testing the display of www.mathsnet.com

An online game called "Queen v Knight" can be played (See Figure 11), although the downloading is very slow.

4. Testing the display of www.mymaths.co.uk

It works very well but some characters in the menu of a game or for game playing instructions are very small. Figure 12 shows a computer game called "Golf".

5. Testing the display of BBC Bitesize for GCSE Revision

The device handles these resources well. Maths games can be played and the images and graphics are very clear (See Figure 13). Sounds are fine.

6. Testing the display of www.mathstutor.ac.uk

Downloading is slow. The video tutorial cannot be downloaded and diagnostic tests and exercises cannot be displayed. There is difficulty with "View online", which may be due to the limitation of memory.

7. Using www.google.com

The search engine is functional and the display is very good (See Figure 14).

Summary

The UX PC is a fully functional PC, although being much smaller and lighter it is very portable.

It can easily be connected to the Internet wirelessly, and so it is possible to use it for mobile learning. However, the memory is often not enough for downloading large websites, especially those linked to a database. Downloading can be slow, but some websites and online maths games can be downloaded and viewed or played.

The display of characters is not always satisfactory; in particular, they are sometimes too small in a game playing menu or its instructions.

Figure 9 A webpage from the math4mobile website shows clear graphics on the UX PC.

Figure 10 On the Mathsnet website, characters are displayed clearly but small on the UX PC.

Figure 11 A game from the Mathsnet website played on the UX PC. The downloading is slow.

Figure 12 A mathematical game called “Golf” on the MyMaths website is playable on the UX PC but some characters are very small.

Figure 13 Games from the BBC Bitesize for GCSE revision can be played on the UX PC. The games cover different subjects including mathematics.

Figure 14 A Google search for “Singular value decomposition” on the UX PC.

Chapter 3. The HP iPAQ (Personal Digital Assistant or PDA)

Introduction

This PDA is made by Hewlett-Packard Development Company (2005). It is one of the HP iPQA hx2100 Pocket PC series and is powered by Microsoft Windows Mobile™ Version 5.0 for Pocket PC, which includes Windows Media Player 10 Mobile, Internet Explorer Mobile, PowerPoint Mobile, Word Mobile and Excel Mobile.

Useful Features and Constraints:

There are some useful features for learning, such as:

- Composing and sending email messages (12 items at a time), although attachments cannot be opened.

- Browsing web pages on the Internet, although some large websites cannot be displayed.

- Using Word Mobile to create and save documents. However, when writing an equation, there is no way of showing a superscript or a subscript. Microsoft Equation Editor software is not included. Symbols cannot be inserted, so it is difficult to input the Greek letters which often appear in mathematics expressions.

- Using PowerPoint Mobile to open and view slide show presentations created on your computer. You can copy a presentation to the PDA via a storage card (see www.hp.com/go/ipaqaccessories) or download a presentation from the Internet or obtain a presentation by synchronizing with your computer.

- Using Windows Media Player 10 Mobile that can be downloaded free from Microsoft to synchronise your music, videos and recorded TV to the PDA. Windows Media Player 10 Mobile can automatically convert video and recorded TV during synchronisation to an optimized and size reduced format for better viewing on the PDA.

Internet Connection

Since the PDA tested has no built-in WiFi function, a WiFi adapter is needed. Before installing the adapter, you need to connect the PDA to a PC in which Microsoft Active Sync software (free downloadable) is already installed. After the registration between the PDA and the PC, you can use wireless network provided your PDA is in a wireless range. The login process is confusing: after you enter your user name, password and press the "submit" box, you still see a login page, asking for login information again. Despite this you may already be logged in successfully, and entering a website address (URL) in the address box on screen will display the appropriate page.

The Results of Testing for Maths Learning by Using the PDA:

1. Testing www.mymaths.co.uk

The "Home" page is displayed, but the hyperlinks in the sub-menu are not. Perhaps the language used to write the webpage cannot be recognised by the PDA.

2. Testing www.mathcentre.ac.uk

The "Home" page can be displayed but the whole website cannot be downloaded (See Figure 15).

3. Testing www.mathsnet.net

The layout of the "Home" webpage is very different from that of the original website. The contents cannot be displayed and downloaded.

4. Testing www.mathtutor.com

The display of home page is clear and the links work. However, a web page on the website containing video tutorials (http://www.mathcentre.ac.uk/students.php) cannot be found. Some learning material, which should be viewable online by pressing "View Online" does not appear. The layout of the webpage is changed.

5. Testing the Google search engine

The Google search engine works very well (See

Figure 16). Hyperlinks work as well (See Figure 16). Characters are displayed clearly but sometimes some of them are missed out due to distortion of the layout. The display of some notations is not always clear as the image size is reduced (See Figure 17).

Summary

The PDA is pocket sized and is very convenient to carry on the move. It can be connected to the Internet by using a WiFi adapter and also can be used for receiving and sending emails, so mobile learning is possible. However, because its memory is very limited, many video games cannot be played and many websites cannot be shown. If an email has an attachment, the email may not be received, or the attachments cannot be opened.

Using an expansion memory card, PowerPoint slides or video games can be transferred from a PC to the PDA and the user can view them.

The Word Mobile application is useful and has some simple editing functions.

Figure 15 The home page of Mathcentre is displayed on the PDA. However, the whole website is too large to be downloaded

Figure 16 A Google search works well on the PDA. An on-screen keyboard is easy to use.

Figure 16 Hyperlinks work well in a Google search. The character display is good.

Figure 17 A Google search for “Heat equation”. Some characters are fuzzy in the graphics and the distortion of layout makes some letters disappear.

Chapter 4. Sony PlayStation Portable (PSP) 1003

Introduction:

The PSP system includes an AC Adaptor, a battery pack, headphones, and a built-in speaker. On either side of the PSP screen are 4-buttons; one set is for directional control and the other set for game specific functions.

Useful Features for Learning:

- Playing video games
- Accessing the Internet (Wireless LAN)

The PSP can also display photos and play music. The requirements for the connection to the Internet and wireless network are as follows:

- A subscription to an Internet service provider
- A network device, such as a DSL or cable modem
- A wireless LAN access point such as a wireless broadband router
- Settings for the access point.
- A PC

The use of a Memory Stick Duo™ allows the user to transfer data from a PC to the PSP; this can be very useful when downloading games or videos. The problem is that PSP only recognises the games made by PlayStation and videos in the MPEG4 format.

Internet Connection

Connecting to the Internet is not straightforward. On the “Home” page, using the directional keys on the left, you move a bright spot to a global sign, then to a “WWW” sign, then press the ⊗ function button on the right. This causes a login page to appear. Using the circle button on the left, gently press it and move a cursor to one of the boxes

for entering “user name”, “password” and “submit” respectively, when the colour of a box turns blue, you can select it, a on-screen multi-keyboard will appear, move the flash spot to a multi-key box, then press ⊗ button on the right, you can see a small group of letters and a number, press the ⊗ button to move a letter/number wanted, then press the right shoulder key to select one of them, or use a button with a circle to delete what you choose by mistake. Then the input finishes, move the flash spot to the “Enter” box, press ⊗ button to select it. After filling in your user name and password, move the cursor to the submit box, press ⊗ button. Login should be completed. If the PSP is situated in a wireless network area and the signal is strong enough, the Internet should be connected. Afterward, select the first-left icon at the bottom, press a button with a triangle, then press the ⊗ button, a menu should appear, select “Address Enter” on the menu, then you can enter a website address (URL) on the on-screen multi-keyboard in the way mentioned above.

Enabling Flash Player & WMA Playback

Before playing games written in Flash, the Flash Player has to be installed. Again, this is not straightforward.

Only after an Internet connection is established, then the Flash function can be activated by pressing the “Home” button, and the directional buttons on the left to move the bright spot to these icons: Settings -> System Settings, then press the button with a cross on the right in order to select it, move the directional button with downward sign to the icon of “Enable Flash Player”, then press the button with a cross to select it, this will work. Only when the Flash function is activated then Flash applications can be executed. In this way, “Enable WMA Playback” can be enabled.

It was also found that the wireless network of Coventry University is not suitable in terms of enabling the authentication of some mobile devices.

Once the PSP is connected to the Internet, search engines like the Google website can be displayed.

Data Storage:

The PSP supports two types of data storages: Memory Stick Duo™ and a UMD™ card.

The former can store various kinds of data while the latter is normally dedicated to storing commercial computer games. By using a USB cable, files can be transferred from a PC to the Memory Stick Duo card, including image and video files. It is necessary to have a particular folder structure with one folder named "VIDEO", however folders created within subfolders are not recognised. MPEG4 format video files in the VIDEO folder can be played. On a Sony Laptop computer, there is a slot which is compatible with the Memory Stick Duo used in the PSP.

The Results of Testing for Maths Learning:

In the testing process, some sample advertising games were played, as well as some music. The quality of pictures and sounds were good. Because there are no UMD cards with maths games currently available on the market, tests of math games have not yet carried out.

1. Testing for the display of MathTutor videos

The PSP can play flash games or videos in the MPEG4 format. Some Mathtutor online learning material has been converted into MPEG4 format, and these were played on the PSP (See Figure 18, Figure 19, Figure 20). The graphics and sound are excellent and the display of characters is generally clear, but very occasionally some characters were difficult to read with image pixels not very sharp. The size of the display frame is 35 *28 mm.

Technically, the display of Mathtutor is very good. Most importantly, the quality of the presentation is outstanding. The contents and tutors' explanations are both excellent, the pace is good, and the language used is clear to learners with A-level or above maths knowledge. The hand drawings of most lines, curves and shapes are very accurate.

2. Testing online games of MyMaths website at www.mymaths.co.uk

This is a popular website for mathematics learning, designed for pupils from 11 to 16 years old. There are some maths games. The "Home" page can be downloaded; however, the whole website cannot be downloaded due to insufficient memory.

3. Testing the display of the website of www.mathsnet.net

This website offers mathematics learning material at up to A-level. The whole website cannot be downloaded because of memory constraints. Only the "Home" page can be

seen (See Figure 21).

4. Testing the Coventry University website

The "Home" page can be viewed (See Figure 22), however, the whole website is too big to be downloaded.

5. Testing the BBC bitesize for GCSE revision website

There is not enough memory for downloading these pages.

6. Playing music

The sounds are very good.

7. Playing a leisure game called "Catch a banana"

The quality of pictures is excellent, and so are the colours (See Figure 23). In the absence of mathematical video games at A-level or above in the right format, this game demonstrated the potential of the device.

Battery

When playing a game, the battery lasts approximately 3-6 hours, and while using video playback, it lasts 3-5 hours. The battery life depends on the type of content being played and usage conditions such as screen brightness and environmental factors and aging. The battery can be recharged by using the AC Adaptor, this takes approximately 2 hours and 20 minutes. The battery life is long enough to make mobile learning with the PSP possible.

Summary

The PSP can be used for displaying excellent quality video games, playing music and browsing the Internet.

The PSP only supports MPEG4 format videos and games written in Flash 6.

The Flash script language could be used to create a friendly interface such as a touch screen keyboard.

The several methods of data transfer and storage are an advantage. You can use a mini USB to connect the PSP to a PC, or use a Memory Stick Duo which is compatible with

the slot of any Sony Laptops or use a UMD card which normally stores commercial games. The disadvantage is that the internal memory is not enough to allow many websites to be downloaded and viewed.

Figure 18 A video of Mathtutor being played on the PSP.

Figure 19 A video of Mathtutor on the PSP clearly shows the hand-writing.

Figure 20 A video of Mathtutor being played on the PSP. The size of the screen is good.

Figure 21 The display of the home page of Mathsnet website is excellent on the PSP. However, the website is too large to be downloaded.

Figure 22 The home page of the Coventry University website can be shown on the PSP. However, the website cannot be downloaded because of memory limitations.

Figure 23 A game entitled “catch a banana” being played on the PSP. The graphics are high resolution and the colours are bright.

Chapter 5. The Video iPod

Introduction:

iPod is a brand of portable media players designed and marketed by Apple and launched in October 2001. There are several versions including the hard drive-based flagship iPod

classic, the iPod touch, the mid-level video-capable iPod nano and the low-end screenless iPod shuffle.

The Video iPod examined was an iPod classic and of fifth generation. It has 80GB RAM (Random Access Memory), using a variable-speed ARM 7TDMI CPU, running at a peak of 80 MHz to save battery life.

Transfer Media Files with iTunes:

Apple's iTunes software (downloadable free) is used to transfer audio or video files to the device. It can also transfer files of photos and games. Simply copying media files to the drive with a typical file management application will not allow the iPod to properly access them. The user must use software that has been specifically designed to transfer media files to iPod, so that the files are playable and viewable. iTunes is one of the software packages that serves this purpose.

You should first install iTunes software in your computer, and drag a media file onto the iTunes icon; a window will automatically open to enable the file to be dropped there. If you want to transfer many files, you can do this one by one. Afterwards, when you connect your video iPod to the computer by using a USB cable, all the files will be automatically transferred to the video iPod and are ready to play.

Useful Features for Learning:

- Playing videos in MPEG4 format
- Podcasting
- Playing movies

The Results of Testing for Maths Learning:

1. Testing the videos of Mathtutor (www.mathtutor.ac.uk)

At the Mathtutor website, there is substantial online mathematics learning resources, including a large collection of video clips. These video clips have been split into small units (normally less than 2minutes) and converted into MPEG4 file format.

When playing these video clips, the display of characters, graphs and sounds are excellent (See Figure 24 and Figure 25). The maths tutors who explain the tutorials are very friendly, expressive and articulate. The video iPod is very lightweight and the level of the maths teaching video clips is suitable for new university students (up to A-level).

2. Testing playing music

The sounds are excellent.

3. Testing USB function

The USB is functional. By using a USB cable, the iPod can be connected to a computer to transfer media files. This also enables the iPod to start being recharged.

Summary

The video iPod is easy to carry within a pocket and it is excellent at displaying videos, although the size of the screen is not very big (40*52 mm). The effects of displaying videos of Mathtutor are striking. It certainly has an educational potential. The only factor that needs considering is the fact that it cannot play videos in formats other than MPEG4.

The video iPod cannot be connected to the Internet or WLAN, so it is impossible to play online games. It cannot be used for document management. As its name suggests, it is good at playing videos.

Figure 24 A Mathtutor video on the video iPod. Graphics and hand- writing are clear.

Figure 25 A video of Mathtutor displayed on the video iPod.

Chapter 6. The Nokia N95 Mobile Phone

Introduction

This Nokia N95-1 has 3G features which combine some common computer applications and communication functions. There are cut down version of Microsoft Word, PowerPoint and Excel. Not all file formats can be viewed or modified.

The mobile phone supports MMS, GPRS, and streaming and mobile internet functions. Content can be transferred from a compatible Nokia device to this phone by using either Bluetooth or infrared connectivity.

Useful features for Learning

- Multimedia – There is a Flash Player, Media player, radio and two cameras.
- Mini USB connector – A suitable USB cable can be used to transfer data between the mobile phone and a compatible PC.
- Fast downloading-- Downloading emails and web pages can be made faster by activating support for high-speed downlink packet access (HSDPA or 3.5G). This data connection service requires a subscription and availability. It is worth considering this when frequently playing simple online games or access to websites. However, because of the limitation of memory, downloading games or websites has proved to be difficult.
- Java enabled – This mobile phone is Java enabled, so you can play games written in the Java computer language.

The Results of Testing for Maths Learning

1. Testing the Internet

The mobile phone has built-in Internet connectivity and it is functional.

2. Testing www.mathsnet.net

This website cannot be downloaded, due to insufficient memory.

3. Testing www.bbc.co.uk/mobile

Following the link to "Learning" ->Bitesize -> Maths -> Quiz, you can solve some maths quiz (See Figure 26).

4. Testing www.mymaths.co.uk

Only the "Home" page can be displayed. The characters are clear but after entering the user name and the password, nothing can be seen on the screen. The website is too big to be downloaded.

5. Testing www.math4mobile.com

Only the first webpage can be displayed, the characters are clear but when following a link to play an online maths game ("Solve2Go", 75K), the screen unfortunately becomes blank.

6. Testing downloading maths games by phone browser

On the website of www.math4mobile.com, there are five midlet URLs at which maths games can be downloaded to a mobile phone. These are:

http://math4mobile.com/graph2go.jad

http://math4mobile.com/solve2go.jad

http://math4mobile.com/sketch2go.jad

http://math4mobile.com/fit2go.jad

http://math4mobile.com/quad2go.jad

By entering the above URLs respectively, the five games quickly downloaded onto the mobile phone and the installation was automatic. The maths games can be played easily. The graphics of the game are very clearly displayed. If the user changes the parameters of an equation, the shape of the graph changes accordingly (See Figure 27).

7. Playing Online Maths Games

This is difficult as many online games cannot be downloaded to the phone easily. Memory constraints are the main factor.

8. Testing Hyperlinks

They can work only when the linked webpage does not have large memory

requirements. .

Summary

The most impressive features are the provision of easy access to the Internet and allowing small video games written in Java language to be played. The phone is Java enabled. The display of graphics is clear.

The problem is that the internal memory is limited and does not allow many websites to be downloaded and displayed.

Figure 26 A maths quiz at the BBC bitesize website on the Nokia N95 mobile phone

Figure 27 A maths game from the math4mobile website on the Nokia N95 mobile phone. It can be played on the phone by changing the parameters of the equations.

Chapter 7. The PRADA Mobile Phone

Introduction

This mobile phone model KE850 is a 3G phone, well-designed, with a smart appearance. It is light-weight and has a touch keypad. Apart from communication functions such as making calls, sending and receiving emails and text messages, it can be used for playing MP3 format music. Some games can be played and there is a camera. Wireless Internet connectivity is supported as is Bluetooth technology which can be used to transfer files with compatible mobile devices or a PC. There is an external memory card slot.

Useful features for learning:

- Internet connectivity
- Game playing features
- Playing videos
- Emailing
- SMS (Short Message Service)
- MMS (Multimedia Message Service)
- Bluetooth support

The Results of Testing for Learning:

1. Testing the Internet function by browsing www.coventry.ac.uk

The Internet can be accessed; however, due to memory constraints many large websites cannot be downloaded. The home page of www.coventry.ac.uk can be displayed but the contents cannot be fully retrieved (See Figure 28). For example, the webpages of eLibrary or Web mail cannot be downloaded, perhaps because of memory limitations. However, CUonline can be displayed. A lot of horizontal scrolling is necessary due to the small screen size.

2. Testing the display of www.mymaths.co.uk

The "Home" page can be seen but the whole website cannot be downloaded, after entering a User name and a Password nothing happens, the screen is blank.

3. Testing the display of www.math4mobile.com

Only the "Home" page can be seen and whole website cannot be downloaded. Following a hyperlink, I tried to download a maths game by entering: http://math4mobile.com/graph2go.jad, it shows "Error MID cannot be found at this URL". The game is written in the Java language and this phone seems not to be Java enabled.

4. Testing the display of www.mathtutor.com

The Home page can be displayed but the sub-menu on the left does not work. The links do not work.

5. Testing playing an online game at www.dimenxian.com

The size of the file of a maths game called "Dimenxian" is 50MB, which is too big to be downloaded.

6. Testing the BBC bitesize for GCSE revision at www.bbc.co.uk/mobile

The Home page can be displayed. Following the links: →learning →Bitesize →Game, the games cannot be downloaded with a message stating "This application is not available for this handset".

At this website, you can see a list of mobile phones models to which the games can be downloaded.

7. Testing the BBC News website

It works very well, so as the hyperlinks and the graphics (See Figure 29).

8. Testing playing music

There is no problem with playing music.

9. Testing transfer of a video game file using Bluetooth technology

Using Bluetooth, a maths game written in Java was transferred from the Samsungs Q1 to this PRADA mobile phone and was stored automatically into a predefined folder called "Other". However, the phone can only recognise and play the games which are stored in a predefined folder called "Videos". The reason is that this phone is not Java

enabled and therefore cannot play this Java game.

10. Testing www.hotmail.com

This website cannot be downloaded and shows “currently not available”.

Summary

This device has many useful communication functions. Emailing is possible. SMS and MMS are very useful for peer learning. However, it is very difficult to download large websites, especially those database-linked, so it does not support serious web-based learning in terms of using online learning resources. As some websites can be viewed, such as the BBC News website, this phone is still quite useful for casual learning. The phone is not Java enabled, this mobile may not suitable for playing maths games.

Figure 28 The Coventry University website displayed on the PRADA mobile phone. Some hyperlinks work but some do not due to memory constraints.

Figure 29 The display of the BBC News website on the PRADA mobile phone. The characters and graphics are clear but a lot of horizontal scrolling is necessary.

Chapter 8. The Nintendo DS

Introduction

The Nintendo DS is a small handheld game console. Games are played with ultra-bright dual screens and touch- screen technology. It can be connected to the Internet wirelessly by using a Nintendo DS Lite Browser. It has a system storage of 4MB RAM. The user must use a game card to play a game.

Useful Features

- Playing games
- Browsing the Internet
- Hand-writing recognition

The Results of Testing

Testing a game called "Brain Training"

The game is consisted of 3 sub-games: Quick Brain Age Check, Quick Training and Quick Sudoku (See Figure 30).

The first two games aim to train the player with some simple cognitive tasks, such as to recognise the given colours or to do simple calculations, the quicker you complete the task, the better results or comments you can get. The user is invited to input hand-written answers by using the stylus pen on the touch-screen (See Figure 31), the hand-written input numbers can be recognised by the Nintendo DS correctly.

The last game called Sudoku is a more difficult, because the player must fill a number between 1 to 9 in a box, which must be unique in the row as well as in the column in where it is allocated (See Figure 32 and Figure 33). Playing such training games could improve memory or response times, and to help to improve the understanding of numbers.

Summary

The Nintendo DS is a useful hand-held game console. The most distinctive feature is its capability for handwriting recognition. This allows the user to have quick interactions with the game and make the game playing motivating and engaging.

Unfortunately, in the current market, the games in Nintendo game cards bear little relevance to maths learning at A-level or above, and Nintendo DS only allows games in Nintendo game cards playable.

Figure 30. A game called “Brain Training” played on the Nintendo DS game console.

Figure 31 A game entitled “Brain Training” played on the Nintendo DS game console. The player can write the answer on the left screen by using a stylus pen.

Figure 32 A Sudoku game played on the Nintendo DS game console.

Figure 33 A Sudoku game being played on the Nintendo DS game console. An answer can be handwritten on the left screen and then transferred to a printed form on the right.

Chapter 9. Conclusions

The findings of these feasibility studies suggest that some of the mobile devices examined have a potential to support game-based learning, online learning and mobile learning. Every mobile device has its unique characteristics and there is something in common —mobility.

Comparison between Samsung Q1 and Sony UX PC

The Samsung Q1 and Sony UX PC are both fully functional handheld computers. They can be used for manipulating text documents, playing multimedia files such as videos, photos and games; and they also have wireless Internet connectivity. However, the Samsung Q1 has more advantages for game based learning and online maths learning:

1. The Samsung Q1 has no problems of downloading computer games or maths websites tested but sometimes the Sony UX PC has problems due to memory constraints, as do the PDA, Nokia N95 mobile phone and PRADA mobile phone.

2. The Samsung Q1 can display superscripts or subscripts when writing an equation, but the UX PC cannot, there is no Microsoft Equation software.

3. The display of characters on the Samsung Q1 is better and bigger, because its screen size is 7" across (93*153 mm^2) while that of the UX PC is 4" across (60*100 mm^2). The Samsung Q1 also supports 3-step screen resolution.

Comparison between Nokia N95 phone and PRADA phone

Comparing the Nokia N95 mobile phone and the PRADA mobile phone, both are 3G phones or smart phones. They both have built-in Internet connectivity; however, they both suffer from insufficient memory for downloading maths websites which were tested.

Many computer games are written in the Java or Flash languages. The Nokia N95 is Java enabled while the PRADA phone is not. Thus, the chosen maths games from www.math4mobile.com can only be played on the Nokia phone. The BBC bitesize for GCSE revision website cannot be played on the two phones, as the games were

designed for some mobile phone models only.

Comparison between the PSP game console, Nintendo DS and Video iPod

The PSP and video iPod cost almost the same at around £150. They can both be used to play videos. The PSP has a bigger screen and can be used to play complex games but the iPod can only play a few simple games. The display of colours on the PSP is much brighter and richer than on the video iPod. The iPod is much lighter and easier to carry on the move.

The PSP and Ninetendo DS are both game consoles, but the DS has smaller dual screens, with two CPUs and allows hand-writing input which can encourage active learning. The PSP has a USB connection, which makes data transfer easier. The PSP can play music and display photos and enables Flash programming, it is a good game console.

About the Personal Digital Assistant (PDA)

The PDA is a palmtop computer. Compared to the Samsung Q1 and UX PC, it is a simpler computer, with a cut-down version of Windows to allow the user to view small documents or emails. It can be connected to the Internet by using a WiFi adapter and can transfer data files by using Bluetooth technology and a SD memory card.

I believe that each mobile device is potentially useful in its own environment. For example, in game-based learning and online learning, a Tablet PC such as the Samsung Q1 is best. For playing video games, the PSP is a sensible choice.

The continued improvement of electronic and digital technologies will mean that the functions of mobile devices are likely to be enhanced and costs to be reduced, leading to wider use of mobile devices. It will then become feasible to use mobile technologies in teaching and learning mathematics.