

# Recent Advances in Ambient Intelligence and Context–Aware Computing

Kevin Curran  
*University of Ulster, UK*

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# Chapter 17

## A Literacy and Numeracy E-Learning Mobile Application for Pre-Schoolers

**Niall McCarroll**  
*University of Ulster, UK*

**Kevin Curran**  
*University of Ulster, UK*

### ABSTRACT

*The Northern Ireland pre-school curriculum promotes educational development through enabling learning environments and active learning through play and exploration. Enabling learning environments are rich in books, pictures, signs, symbols, rhymes, and multimedia technology. Through play and exploration, children are engaged in activities that interest and preoccupy them. The resources that are used as a context for play have an important bearing on the depth of learning experienced by a child. According to the Early Years Foundation Stage, from age 40 months, a child's literacy and numeracy can develop rapidly with the support of a wide range of interesting materials, activities, media, and technologies (Department for Education, 2008). The aim of this project is to create the "SmartFun" literacy and numeracy E-Learning application. "SmartFun" is a fun, engaging environment to promote the early learning of letters and numbers for pre-school and primary one children.*

### INTRODUCTION

The Nursery Education Guidelines Curriculum is a comprehensive statutory framework that sets the standards for the learning, development and care of children from birth to five in Northern Ireland. The guidelines set values for the educational development of young children in settings outside of home, in an effort to promote educa-

tional progress and positive partnerships between parents and teaching professionals (NICC, 1998). Every child is a competent learner from birth and a nurturing environment plays a key role in supporting and extending children's development and learning. Children develop and learn in different ways and at different rates and all areas of learning and development are equally important and inter-connected (DENI, 1997). According to the

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pre-school curriculum in Northern Ireland, as set by the Department of Education (DENI) “There is no place at this stage for the introduction of formal schooling in the sense of an established body of knowledge to be acquired or a set of skills to be mastered” (NICC, 1989). The aim instead is to build upon children’s learning experiences and development at home through a rich variety of play activities and other experiences.

The curriculum aims to develop learning associated with Personal, Social and Emotional Development, Physical Development, Creative/Aesthetic Development, Language Development, Early Mathematical Experiences, Early Experiences in Science and Technology and Knowledge and Appreciation of the Environment. In order to fully understand how these areas are approached within local schools, an interview with a pre-school teacher was conducted. This helped to identify a number of important parameters within the pre-school educational framework that had particular relevance when designing this early learning application, such as limitations on formal learning techniques (Eames & Milne, 2011)

While there is no formal schooling as such, a number of key developmental areas are identified—or early learning goals—including language development and numeracy, which the ‘Smartfun’ application aims to promote. In the rest of the UK the curriculum is weighted slightly more in favour of formal academic teaching regarding letters and numbers, but the objectives are essentially the same—to effectively teach children in a stimulating and challenging environment. The Early Years Foundation Stage (EYFS) recommends that all the goals for learning and development must be delivered through planned, purposeful play, with a balance of adult-led and child-initiated activities (Department for Education, 2008). “Language development” is one of the main areas of development within the Northern Ireland pre-school curriculum. The areas within language development focus on communication with others, attention and listening, enjoyment of books and writing/

mark making. The ‘SmartFun’ application aims to incorporate all four of these key skills on different levels, as well as impart basic information about letters and their function within words. It is essentially aimed at bridging the gap between pre-school and primary one age children, when children move from simply recognising letters and being aware of their use, to actually using letters to form words and sentences (Fox-Turnbull & Snape, 2011).

Mathematical development and basic numeracy are also important components of the curriculum (Edwards, 2009). The areas within mathematical development aim to support children in their understanding of numeracy, reasoning and problem solving and focus on counting reliably up to ten everyday objects., recognising numerals 1 to 10, using language such as ‘greater’, ‘smaller’, ‘heavier’ or ‘lighter’ to compare quantities, talking about, recognising and recreating simple patterns., using language such as ‘circle’ or ‘bigger’ to describe the shape and size of solids and flat shapes and using everyday words to describe position, such as, in front of, behind, above and below. While this application primarily concentrates on language development, ‘SmartFun’ also incorporates some numeracy tasks to demonstrate how it can be further developed to promote learning in other areas. The focus here will be on recognising numerals 1 through to 10, basic counting of objects and simple number matching activities.

Much emphasis is placed on the role of imaginative and creative activities which can help children to make sense of their experiences and ‘transform’ their knowledge, fostering cognitive development ((Rabah, 2005; Mano et al., 2006; Tomas & Castro, 2011). By creating colourful characters which children can interact with on-screen, the ‘SmartFun’ application aims to create a new learning environment through story-telling and animation. It should appeal to children on a familiar level through the stories, as well as appeal to their sense of curiosity by teaching new skills and technology via a tablet device. There is a

strong focus on allowing children to learn without experiencing a sense of failure. That is why tools such as iPads and other new technology have such a useful place in the classroom, providing a novel and innovative way of teaching through play and interaction. All children learn more effectively through engaging activities, making interactive games the ideal vehicle for learning. The aim is to create a flexible learning environment – allowing the child to interact with technology, and also to engage in a range of different activities with a shared goal. DENI also recommends that children explore different media and respond to a variety of sensory experiences, which makes the use of the tablet devices ideal as new learning tools. Children can engage with the ‘SmartFun’ application on different levels—simple story telling, or identifying letters and numbers and interacting with the application. If they choose to engage with it their efforts are acknowledged and rewarded visually by the characters.

Teaching children to use simple learning applications such as this has a twofold effect: it enhances their ability to focus on tasks such as identifying letters, as well as using a new technology to complete them. On a practical level the ‘Smartfun’ environment is therefore also a way of not just enhancing children’s learning experiences in language and numeracy, but also in the area of information technology. Primary schools are now being built with state of the art computer suites, and classrooms are being equipped with interactive whiteboards and other technology designed to support teaching. So learning to use tablet devices at nursery level is already familiarising children with the use of technology as another medium for learning and communication, making it a natural progression for them at a later stage. Having identified the key areas within pre-school education that would most benefit from an interactive learning tool, the challenge is to develop an application that is both effective and fun. But perhaps the bigger challenge is the creation of a programme that can

be easily manipulated and enjoyed by such young children, who, as we all know, are the most critical and demanding customers.

## **BACKGROUND**

The goal of this learning application is to create a fun, engaging environment to promote the early learning of letters and numbers for pre-school to primary one children. Because the emphasis is on learning through play, the application had to be visually entertaining and appealing with bright colours and engaging animation. Keeping in mind the DENI recommendation that children should not be taught through formal learning techniques, the programme is very much child-led and fun. While encouraged to follow the letter and number shapes children can enjoy doodling on the screen, but they will also be praised for following the patterns and achieving the stipulated goals. It is hoped that through positive reinforcement they will learn without even being aware of it, about letters and numbers, and their functions.

## **Choice of Learning Medium**

The aim was to produce a clean and simple user interface which would be easily navigated by young pre-school children with limited motor skills. In order to facilitate full interaction it was decided the best medium was the touch screen which meant children did not have to learn to control a mouse. Instead they can enjoy a completely tactile experience by controlling things with their own fingers, similar in many ways to finger painting or playing with a magna-doodle. According to mobile manufacturer Ericsson, studies indicate that soon 80% of people accessing the internet will do so from a mobile device, so it makes sense that children have early access to a technology that will be so prevalent in their lives in the future. And the touch screen aspect is a tactile way for children to

engage with learning, just as in drawing or painting. The 2011 Horizon report reveals that the age at which children access their first mobile device is dropping, and with the popularity of tablets steadily growing, more and more children will be using them at home and in the classroom (New Media Consortium, 2011). The report highlights the fact that many people now have access to full length books on their mobile devices with software accessing literature, textbooks, children's books, novels, articles, and journals in a pocket sized format. This collection of features and their potential for enhancing learning experiences is what is of most interest to schools.

Thus it makes sense that these new educational tools are introduced at such an early stage, using simple applications in a fun environment. While the use of mobile phones is still taboo in a classroom situation, the use of tablets is much less so and could transform traditional lessons, according to the Horizon Report. These devices effectively “encompass many of the tools smartphones have to offer, while presenting an ever-expanding collection of tools for learning”. While much has been made of the difficulty faced by children in manipulating buttons and keypads, and the limitations on usage, Shuler (2009) points out that “developments in touch screen and gestural input may significantly improve the way children interact with mobile devices”.

Another reason for using such applications is their accessibility, they can be implemented as learning tools, not just in a classroom environment, but also at home. A child's first educators are its parents, and there is much emphasis on the role of the parent in pre-education. In fact the DENI curriculum describes parents as partners in children's education. By downloading learning applications such as ‘SmartFun’, parents are employing a useful tool that can be used to reinforce classroom based lessons, allowing them a more active role in their child's education. The fact that children are becoming exposed to technology at a younger age means that tablet devices are also being used

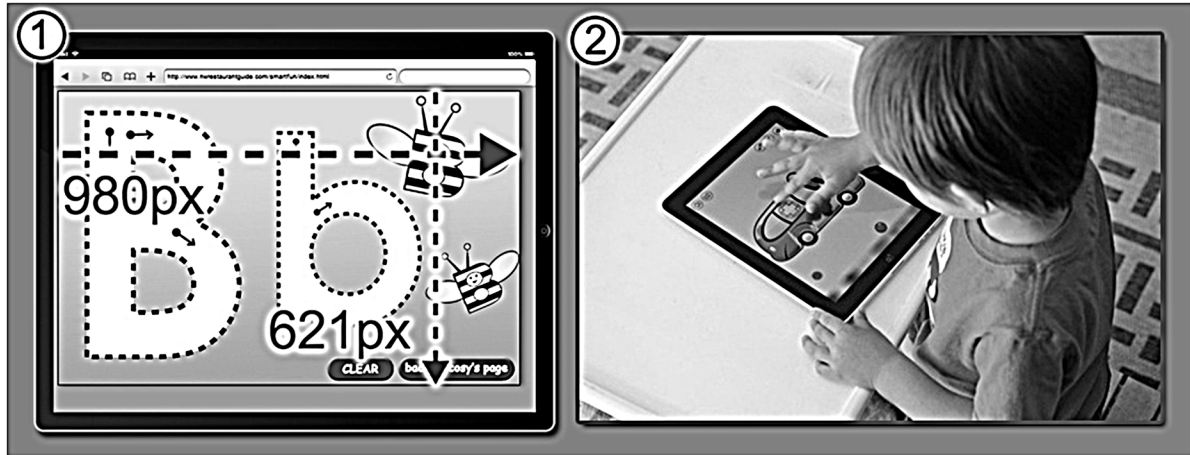
by increasing numbers of children at home. This fact is manifest in the launch of the Leapfrog Leappad tablet for children in 2011, which is so popular that manufacturers simply cannot keep up with demand. In fact it has sold out across Ireland in the run up to Christmas, indicating the levels of demand for toys that mimic adult technology (Irish Daily Mail online, 2011).

The screen resolution for the iPad in a landscape position is 1024 x 768 pixels and 1024 x 620 pixels for the Samsung Galaxy Tab. A design decision was made to fix absolute width and height for the interface of the ‘SmartFun’ application at 980 x 620 pixels to fit in with the dimensions of these tablet devices in the sideways orientation (Figure 1 (1)). Fixing absolute widths and heights goes against design best practice in terms of creating an application that can run on multiple screen resolutions—from mobile phones to large widescreen monitors. However, the decision was considered appropriate given that a sufficiently large workspace is required for young users to navigate with ease. The learning activities that the ‘SmartFun’ application supports would not be feasible on a smaller mobile device screen (Figure 1 (2)).

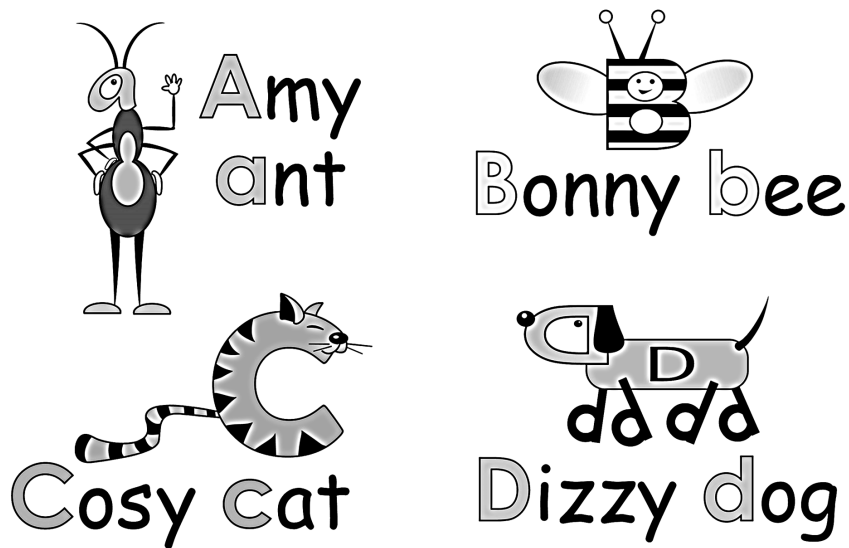
## **Interface and Character Design**

Four characters were created—Amy Ant, Bonny Bee, Cosy Cat and Dizzy Dog. As well as using alliteration in their names to reinforce the learning of the letters, each character is visually composed of their letter to some extent. Again the first name is the upper case and the second name the lower case of their representative letter (Figure 2). It was important that the font itself also reflected the simplicity of the design, with easily recognisable letters and numbers scaled up for visual impact. The application prototype is restricted to the letters A, B, C and D to make development manageable within the time-frame of the project. A limited release of letters also makes sense commercially, as the initial batch could be released for free with further letters available to buy on demand.

*Figure 1. Design decisions for the 'SmartFun' application: 1. the interface has a fixed width and height (980 x 621 pixels) creating an accommodating workspace for a child user; 2. the tablet touch screen makes it very easy for a child to manipulate on-screen elements.*



*Figure 2. The SmartFun characters are bright and colourful and visually composed of the letters they represent.*



The characters themselves are designed to appeal to children's sense of creativity and fun—bright colours and quirky designs, things they are familiar with on TV and in story books. This puts more emphasis on the entertainment aspect of the design, rather than the educational focus. This application is as much for fun as a learning tool, which is in keeping with the emphasis on learning through play at this level in schools. Keeping in mind the limited dexterity of children at this age, who are still gripping their pencils with their fists or palmer grasps, it was important that the interface was as simple as possible. Navigation is achieved simply by pressing the characters using Image Maps, removing buttons and smaller links which may overcomplicate the interface—keeping it simple and clean. This will allow the child as much control as possible without having to rely on an adult to help navigate through the application (Figure 3).

This ease of navigation is also in keeping with recommendations regarding Active Learning, which stresses that to be mentally or physically

engaged in learning, children need to feel at ease, secure and confident.

Active learning occurs when children are keen to learn and are interested in finding things out for themselves, so by making the 'SmartFun' interface simple to use, children can gain a sense of satisfaction from their explorations and investigations. They can share the experience with adults if they wish, but they are not entirely reliant on them to use the application effectively.

### Amy Ant's Story Telling Section

The story element of the application is a key feature as it is a link between the familiar—story books—and the new technology children are learning to use. Story telling plays a significant role in nursery learning, as stressed in DENI's curricular guidance document, which recommends that "Children should have access to a well stocked library of story and information books suited to their needs, interests, race and culture." It also states that "Children (should) enjoy and share books with each other and engage in role play"

*Figure 3. Using image maps over the 'SmartFun' characters makes the application easy to navigate on a touch screen device.*



(p.18). Using iPads or other tableted devices provides another opportunity for children to access stories and become aware of the written word. Teachers use simple stories to both entertain and educate, establishing links between home and school, as well as introducing new words and concepts to children, building both knowledge and experience. Each 'SmartFun' character has an associated story to provide a vehicle for introducing the letters in a number of different contexts and words, providing more opportunity for children to familiarise themselves with them visually. They also provide entertainment and reinforce the letter itself in a child's mind by providing an extra memory trigger—a name they are probably familiar with already, i.e. Amy Ant.

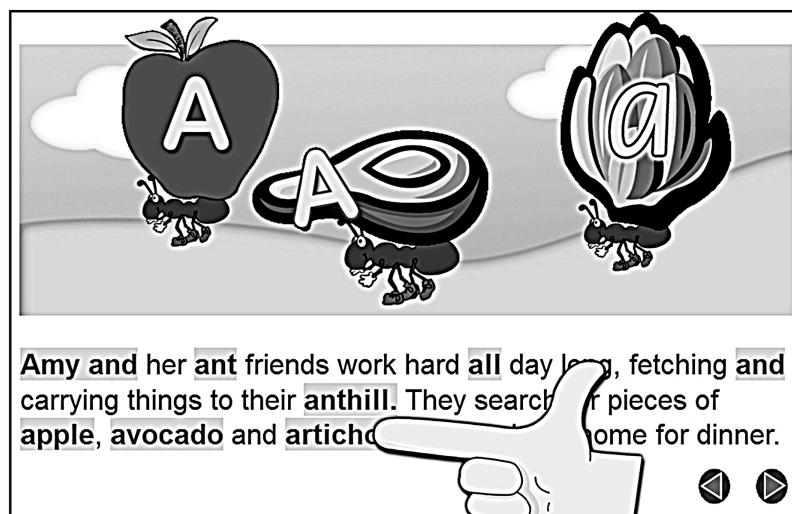
According to research carried out into the effects of vocabulary training by computer at nursery level, the audio and visual elements of 'living books'—books read on computer—provide extra motivation for children. Sergers and Verhoeven (2003) carried out research based on children who

used living books for 300 minutes over a seven week period. At the end of this time they observed a significant learning gain on the combined variable of 'verbal abilities', these included pictorial and verbal memory, word knowledge, verbal fluency, and opposite analogies. This supports the use of audio and animated cues and rewards in basic literacy and numeracy applications, as simple but effective methods of reinforcing information in a child's mind (Figure 4). As Shuler (2009) highlights in her paper 'Pockets of Potential' mobile devices can actually make learning experiences more personalised, as they encourage one to one interaction between parent and child. 'There are significant opportunities for genuinely supporting differentiated, autonomous and individualised learning through mobile devices,' she argues.

### ***Early Learning Goals***

The Story telling section achieves a number of the DENI early learning goals for language and literacy:

*Figure 4. The Story telling section provides a number of different ways for the child to interact. Pressing any of the 'A' words will sound out the letter 'A' and pressing the target food words - 'apple', 'avocado' or 'artichoke', will cause the pictures of the food to pop up in the air through animation of their associated <div> tags.*



1. Letters:
  - a. Linking sounds to letters.
  - b. Naming and sounding letters of the alphabet.
  - c. Hearing and saying sounds in words.
  - d. Identifying and using knowledge of letters.
2. Reading:
  - a. Developing an interest in books.
  - b. Knowing that print conveys meaning.
  - c. Showing an understanding of the elements of stories, such as main character, sequence of events and openings.

### Cosy Cat's Letter Trace Section

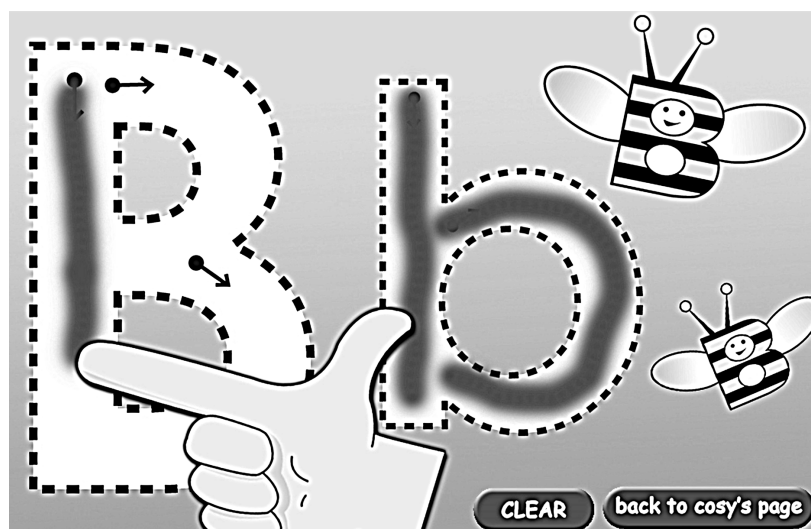
In the Cosy Cat, or letter trace section, children will learn to trace out the capital and lower case versions of letters using the touch screen. This application will make use of the powerful new canvas element which has been introduced to HTML 5. By using their fingers to trace the shapes of the letters children can improve their dexterity and learn how to form the appropriate letter shapes. This level of engagement with the actual letters

helps to reinforce their learning, rather than just relying on visual recognition (Figure 5).

As the letter guides are in the background with the canvas floating on top there are no strict guidelines for adhering to the trace guides. In theory the user can doodle on the entire canvas but the aim is for the parent to encourage the child to copy the letters by tracing the shapes with their fingers. The space is quite big so that younger children aren't too restricted in reproducing the letters, as children at this age generally like to draw things on a bigger scale.

One of the market leading products for letter tracing is 'Alphabet Fun' which is developed by Tapfuze ([www.tapfuze.com](http://www.tapfuze.com)). Alphabet Fun is aimed at slightly older children as it uses line rules for the child to trace within, whereas this application is more simplified for use by a younger less dextrous child. Alphabet Fun simply presents the letter and then provides a separate area for the child to redraw the letter shape. The 'SmartFun' application encourages the child to draw directly over the letter shape simplifying the interface for a younger user (Figure 6).

*Figure 5. The child can draw anywhere on the canvas using their fingers but should be encouraged to trace the letters following the trace guides.*



Both DENI and the Early Years framework stress the value of experimenting with mark-making in the interim stage before children learn to write, and the importance of children learning to associate meaning with the symbols produced. The letter trace section of the App is ideal for children trying to experiment with reproducing shapes and letters.

### *Early Learning Goals*

The letter tracing section achieves a number of the DENI early learning goals for writing and literacy:

1. Letters:
  - a. Identifying and using knowledge of letters.
2. Writing:
  - a. Experimenting with mark-making, sometimes ascribing meaning to marks.
  - b. Using some clearly identifiable letters to communicate meaning.

As the child builds a greater understanding of the relationship between the spoken and written

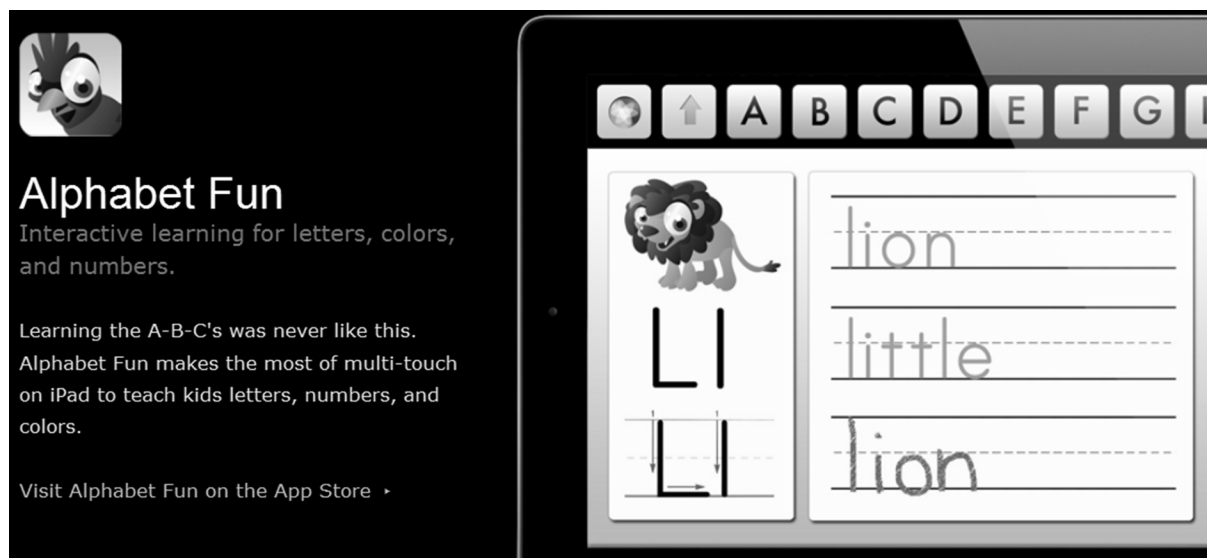
word, their writing skills develop from making random marks and lines to writing basic recognisable letters.

### **Bonny Bee's Letter Match Section**

The Bonny Bee section has a letter match function where the child can touch and drag an unsorted letter to the appropriate place in the sorted word. Each letter will sound upon being placed in the right location and a large cartoon version of the letter will also appear on screen to reinforce the letter in the child's mind. If the letter is moved to the wrong position it will be indicated through a gentle error sound. When the user matches all letters correctly there will be an animated response by the Bonny Bee with an associated 'applause' sound and the option to play again (Figure 7).

Another important aspect to note here is that the child is simply matching patterns, not specifically spelling words, which is in keeping with the DENI recommendation that children should not have to learn off letters at this stage in their development. But ultimately it is reinforcing the concept of

*Figure 6. The Tapfuze Alphabet fun application is geared towards older more dexterous children with a focus on word formation as opposed to simple single letter training.*



forming words by matching the letters and hearing the resulting sounds. The child doesn't even have to know the alphabet to be successful at the task because it is simply a matching exercise—so they are learning without realising they are learning.

### *Early Learning Goals*

The Letter Matching section achieves a number of the DENI early learning goals for language and literacy:

1. Letters:
  - a. Identifying and using knowledge of letters.
  - b. Naming and sounding letters of the alphabet.
  - c. Hearing and saying sounds in words.
  - d. Linking sounds to letters.

### *Dizzy Dog's Number Section*

A few simple numeracy tasks are introduced in Dizzy Dog's section to promote learning of the numbers one to ten. Number Match is a replication

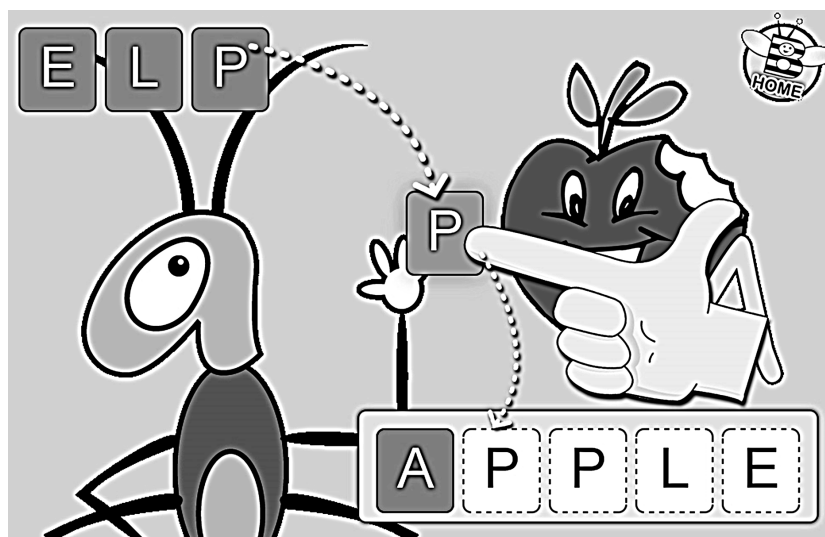
of the Letter Match game with numbers replacing letters and Number Trace again uses the canvas element to allow children to trace over number templates. As children are not expected to understand mathematical procedures at this level, the focus is on recognising and matching up the numbers in order, which can be easily achieved through the number match and number trace functions. In the Number Match game, numbers are presented out of order along the top of the screen and the child must identify and match them to the ones in sequence at the bottom of the screen. This teaches them to identify the correct number sequence, and by listening to the numbers being said aloud, to identify the numbers themselves (Figure 8).

The number trace function allows children to become familiar with the shapes of the numbers and to practice reproducing those shapes on the screen.

### *Early Learning Goals*

The Number Match and Number Trace sections achieve a number of the DENI early learning goals for numeracy and writing:

*Figure 7. The Letter Match game is more about pattern matching than direct training of letters.*



1. Numbers as Labels for Counting:
  - a. Saying number names in order from one to ten.
  - b. Counting reliably up to ten everyday objects.
  - c. Recognising numerals one through to ten.
  - d. Ordering numbers up to ten.
2. Writing:
  - a. Experimenting with mark-making, sometimes ascribing meaning to marks.
  - b. Using some clearly identifiable numbers to communicate meaning.

## IMPLEMENTATION

This section will present a detailed walkthrough of the 'SmartFun' application in use. The application was tested on a 31/2 year old girl with assistance from her mother. All relevant issues, including observed strengths and weaknesses, were recorded in order to assess the degree to which the prototype addresses the intended goals. Conclusions will be drawn and this information will be used as additional requirements for a second

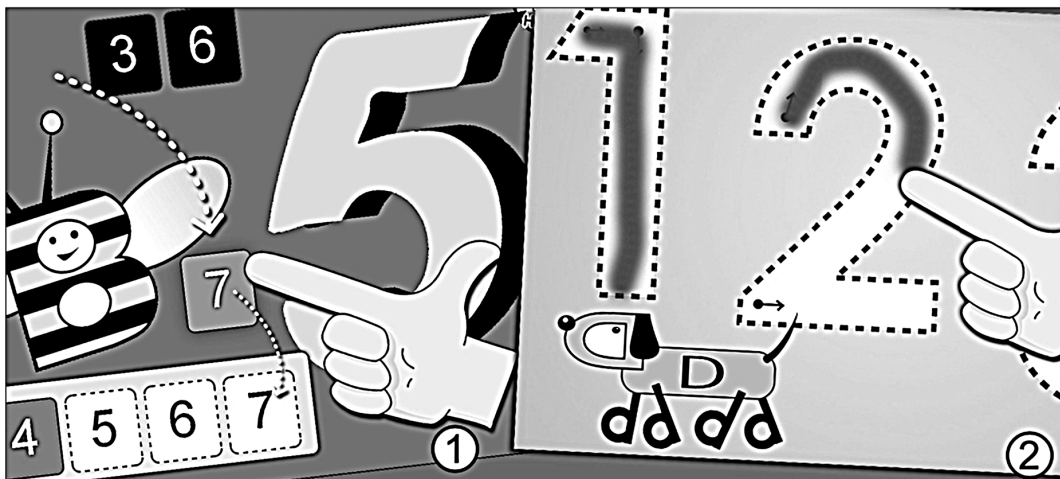
revision of the system that will address recorded implementation issues.

## Screen Navigation

As the 'SmartFun' application is targeted towards young children in the three to five age group, navigation has to be made as simple as possible. Text and small button links were rejected in favour of large area image maps that can be easily pressed without any great level of accuracy. To create the feel of a cartoon or picture story book, the interfaces use bright colours and engaging graphics with minimal text (Figure 9).

The content structure is on three levels so that learning games are only two navigation clicks from the home page. Each section also has a visible button that allows back-tracking to the home page making navigation straightforward and obvious. There is always a concern about using large images in web pages when considering download times. All images were maintained at screen resolution (72 dpi) to ensure smaller file sizes. Even with this simple navigation system, assistance was needed from the test subject's parent when attempting to return to the home or sub-menu screens. given the very young age of the candidate, but this is not

*Figure 8. The SmartFun number games: 1. The Number Match Game, 2. The Number Trace Game*



surprising. It should be emphasised that this application is to be used as a teaching along tool for pre-schoolers and encourages as much interaction from the parent or teacher as possible, especially in the reading sections.

### Amy Ant's Story Telling Section

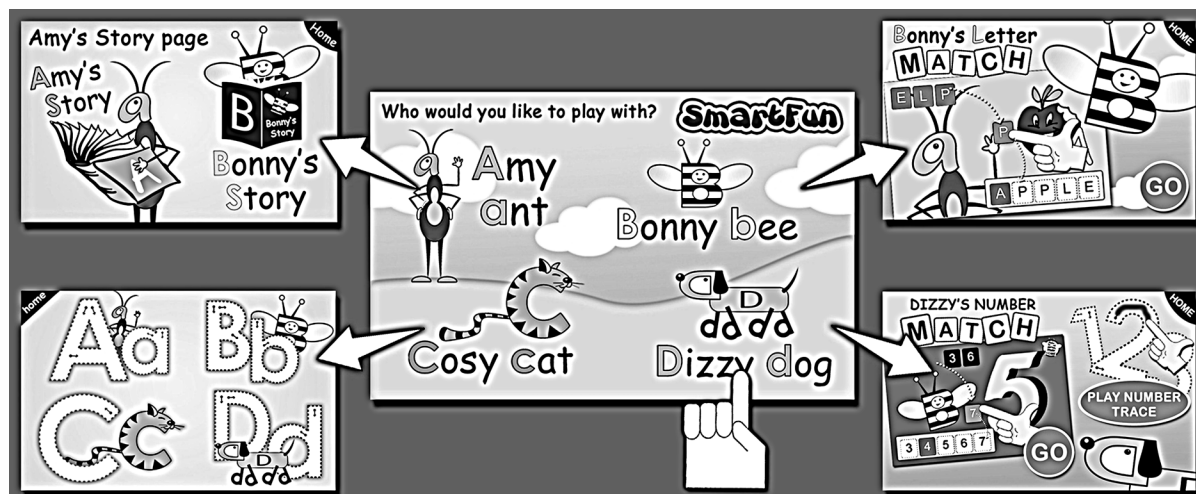
In the interactive story telling section, the first step was the creation of colourful characters to represent each letter and examining how the use of alliteration would help to reinforce the role of the letters within simple words and sentences. According to the Early Years Foundation Stage Framework, children should explore and experiment with sounds, words and texts so the sound element became a key component of the programme. The EYFS framework emphasises the importance of linking sounds to written letters, and naming and sounding letters of the alphabet.

Each character has a story related to them, which is divided into segments each containing a small amount of text and images. Within the text, alliteration is used to continually emphasise the target letter that the character represents. In this section parents can read the story to their child,

and each time the child presses a word, it sounds out the letter, so they are always aware of the sound the letter will make within the word. There are also a few target words, such as 'Apple', 'Bee' or 'Cat', which are highlighted within the story. When the child presses a target word an associated image representing the word will be animated or an associated noise will be sounded. This promotes interaction and the child can clearly link the words with the animated characters or sounds.

The amount of interaction is up to the child, and parents can simply read the stories to begin with to familiarise the child with the characters, before moving on to linking in the letters. This is in keeping with the DENI recommendation that a child should know that print carries meaning and, in English, is read from left to right and top to bottom. It was found through testing this section that it is better to let an adult navigate through the pages and direct the child's attention to the various learning elements, which is in keeping with all parent led learning activities. The test subject found the story sections engaging, continually pressing the target words to listen to the associated letter sounds.

*Figure 9. The colourful 'SmartFun' user interface creates the feel of a comic book with more emphasis on play than learning.*



## Letter Match and Number Match Sections

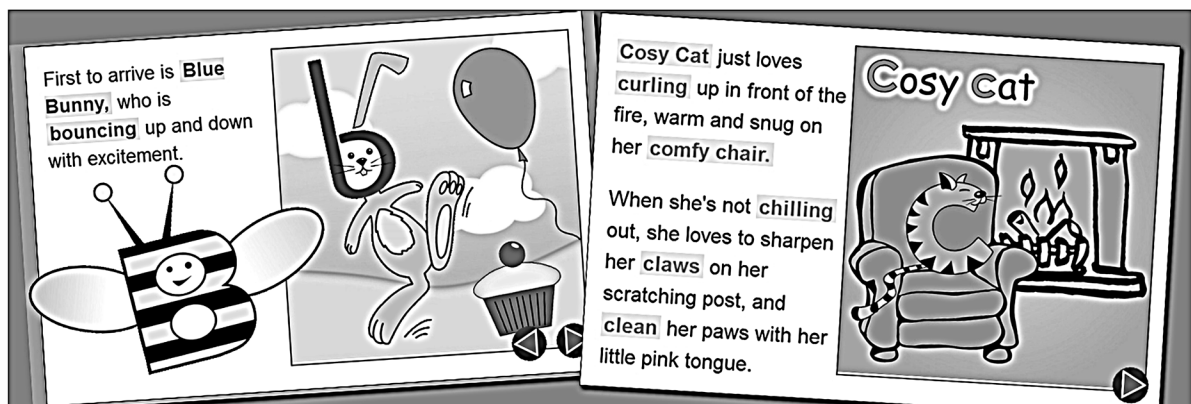
The Letter Match and Number Match games are implemented in code using a combination of jQuery functions and CSS styles to add drag and drop functionality to the set of letter or number boxes. Dragging and dropping is a very intuitive way for the child to interact with these matching games. Many matching games played at home or in a nursery environment involve dragging cards from one pile to another to form paired groups. The letter/number boxes are big enough to be easily grabbed by the user and a 'snap-to' function ensures that the child does not have to be precisely accurate when dropping the boxes over their matching pairs.

HCI guidelines are adhered to as constant feedback is given to the user in a number of different ways. When a random letter/number box is selected it switches from green to blue to indicate that it is active. When a letter/number box is dropped on its matching target the corresponding letter or number is sounded to the user, a large cartoon version of the letter or number is displayed, and the white target box turns green to indicate success. If an unsorted letter/number box is dropped over a mismatched target, the box will be returned to

the top unsorted pile and a gentle error noise will be sounded. After successful completion, when all cards have matched correctly a 'congratulations' message box appears showing Bonny Bee giving the thumbs up accompanied by an applause sound bite (Figure 11).

A random set of letters or numbers is generated every time each game loads by using the Math.random() function in JavaScript. This allows the child to match up a unique combination of letters or numbers each time the game is played keeping the experience fresh and challenging. An observation of the test subject's interaction with the Letter and Number Match games was that more instruction is initially needed to explain the purpose of the game. An initial design decision had been made that a graphic showing the movements of the hand with dotted lines was sufficient (Figure 11 (1)). On reflection, more clarity is needed as the purpose of the game is not entirely apparent from the beginning. This could be achieved by a small animation explaining the basic steps of the game or a helpful voiceover. The game was thoroughly enjoyed by the child, who requested to replay a number of the games a number of times. A particularly positive response was observed upon successful matching of all letters when the

*Figure 10. Amy Ant's story telling section makes good use of alliteration to reinforce the role of letters within words.*



'Bonny Bee' congratulations message pops up with the sound of applause.

## Letter Trace and Number Trace Sections

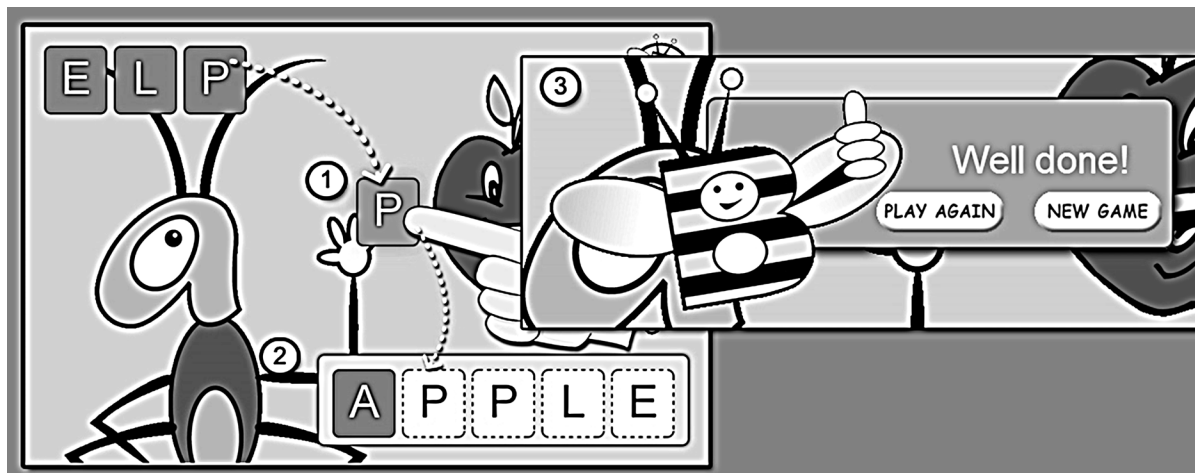
The Letter and Number Trace sections make use of the powerful new HTML5 canvas element. The canvas element is used in conjunction with the JavaScript API for two-dimensional drawing of lines and fills with functionality very similar to Microsoft's MS Paint. The canvas tag defines a drawable region within a HTML document with height and width attributes. JavaScript code is then used to access the area defined by the canvas element allowing for dynamically generated graphics. In the 'SmartFun' application the canvas is floated above a background image of letter or number outlines that act as tracing guides for the child. The child should be encouraged to trace over the letters or numbers but also has the freedom to doodle over the entire canvas.

The Cosy Cat and Dizzy Dog Letter and Number Trace sections proved very popular with the test subject. Initially the child drew at random

enjoying the experience of making marks and lines on screen. With active encouragement from her parent she began to follow the trace guidelines and make recognisable letters and numbers as can be seen from the screen shots in Figure 12. It was noted however that the child attempted to fill in or scribble over the trace guides instead of tracing one complete line. An initial design decision had been made to keep the trace letters large and wide enough to accommodate the finger movements of less dextrous younger children. It is possible that the letters are too wide and, with a white background, appear to be a space to be coloured in as opposed to a line that has to be traced over.

There are a number of letter tracing products on the market today that incorporate a lot more additional functionality than the simple tracing functions of 'SmartFun'. Two products that are very popular and feature prominently in Apple's App store are Montessorium's 'Intro to letters' and GDIplus' 'iWriteWords'. Both these products have impressive interfaces and functionality but are equally quite restrictive and result driven. 'iWriteWords' displays numbered discs that dictate the order in which letter tracing should

*Figure 11. Examples of the interaction and feedback with the letter and number match games: 1. when an unsorted letter/number box is selected it turns blue to indicate that it is active; 2. when an unsorted letter/number box is dropped on to its matching pair it turns green and sounds out the letter or number. 3. after successful completion a 'congratulations' message appears with the sound of applause.*



be carried out (Figure 13 (2)). ‘Intro to letters’ displays arrow cues and restricts tracing within the confines of the letter outline (Figure 12 (1)). Both applications do not let the user move on to the next screen until the letter has been successfully traced. These products are probably more suited to older children who are being taught letter writing in the more formal framework of primary education.

### **Cross Browser Compatibility**

At the time of project submission there are a number of unresolved cross browser compatibility issues that require further attention and workarounds in the next revision of this application. All of the application’s functionality is fully realised in the Mozilla Firefox and Opera browsers with identical performance.

There are a number of issues with the ‘Smart-Fun’ functionality on Apple’s Safari browser. The first obvious problem is that none of the sound effects work in any of the sections. This may be due to the use of .WAV files which are not readily supported by Apple. A workaround for this will involve using cross browser compatible sound files such as .MP3 files which will be sourced for all letter and number sounds for the next revision.

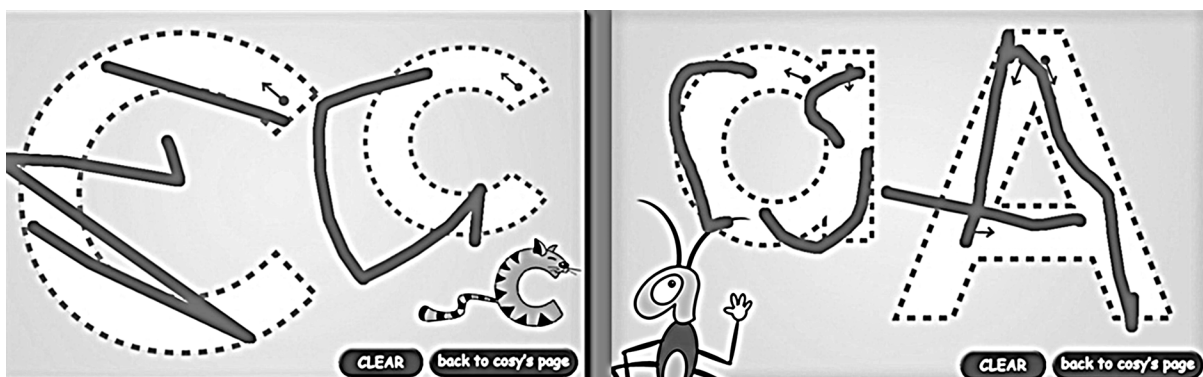
In the Letter and Number matching sections, the draggable letter/number boxes work to some extent. However, if you drag a letter/number over an incorrect target it sticks and cannot be moved. It was also noted that after successful matching of all letters or numbers no ‘congratulations’ message appears making it impossible to play again or move to the next game (Figure 14).

Tests on Internet Explorer 9 also show that the sound effects do not work on this platform. A more serious error was observed in the letter and number match games. In the IE9 platform the CSS styled letter and number boxes do not display on screen (Figure 15). Upon further research it has been discovered that IE9 only offers partial support to the new CSS3 drop shadow style effects that are used for the letter/number boxes. It is possible that these styling effects have resulted in the boxes not appearing. A stripped back version of the Letter and Number Match games will be created to test if this is the cause of the fault in the IE9 browser.

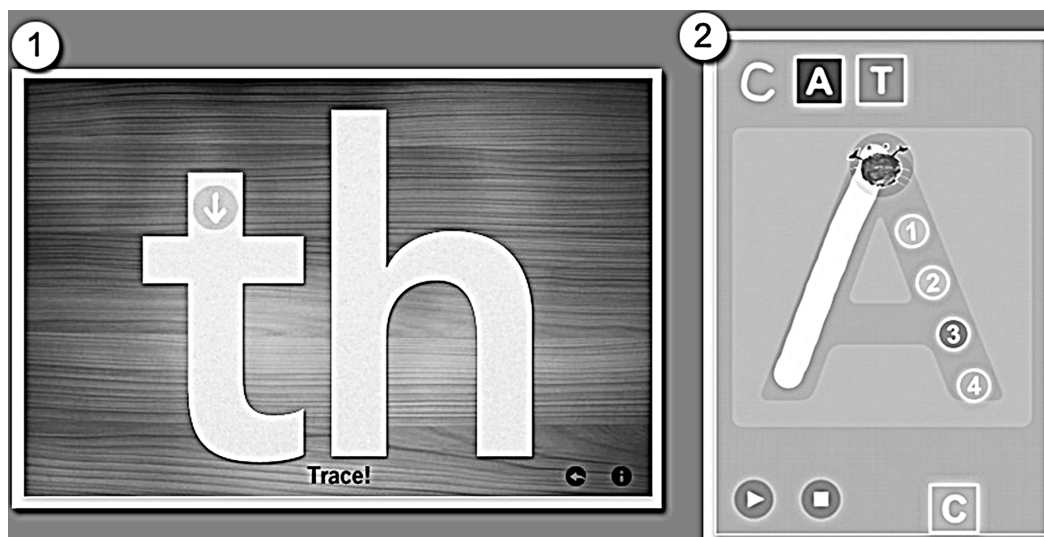
### **Touch-Screen Functionality**

Work is continuing with efforts to port the ‘Smart-Fun’ application to a touch-screen tablet. There have been a number of issues with the integration of mouse events with finger touch and trace events.

*Figure 12. Screen grabs from the tracing efforts of the child subject; at time of submission, work has been continuing to port ‘SmartFun’ onto a touch screen tablet. Experiments were carried out using the traditional mouse click method which will be less accurate than the results produced from finger tracing.*



*Figure 13. Two of the Apple App Store's most popular letter tracing apps: 1. Montessorium's 'Intro to letters' and 2. The GDIplus 'iWriteWords' app.*



The interface has to work with both of these events which are handled differently in JavaScript. Testing of the 'SmartFun' application was carried out using the traditional mouse method which does not truly reflect the simplicity of its functionality. Work also continues on disabling elastic scrolling feature in iPad as it is important for the canvas to remain static with touch-move events.

### **W3 XHTML VALIDATION CHECKS**

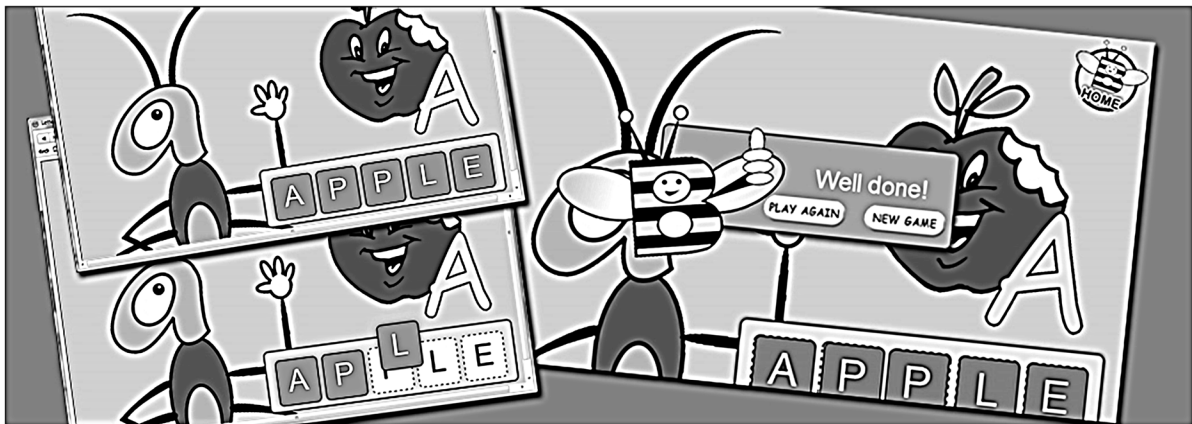
The W3 Consortium's validation service is used to check the validity of web documents coded in a number of languages including XHTML. Each page that was created for the 'SmartFun' application was tested by the validity checker implementing XHTML 1.0 Strict. Validation results yielded a number of errors on a few documents that were easily remedied. However, pages that use the canvas element still have a number of unresolved errors. The W3 XHTML validation service had issues with attributes assigned to the canvas such

as 'id', 'width' and 'height'. The same errors were observed even when testing switched from Strict to Transitional. Removing the direct width and height styling attributes from the canvas tag and placing them into a linked Cascading Style sheet caused unusual behaviour with the 'paint' trace being offset from the point of contact. These issues and potential remedies will be investigated further in the second revision of the application. All other documents successfully passed the XHTML 1.0 Strict validation test.

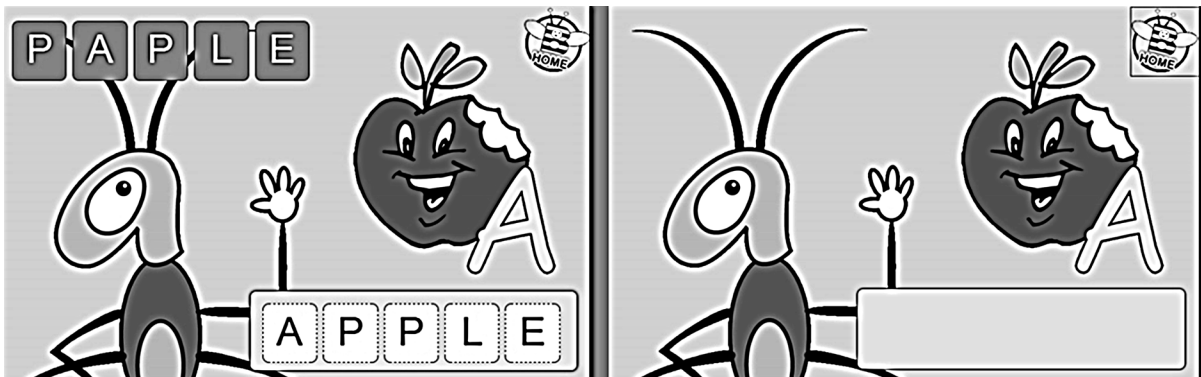
### **MobiReady Mobile Readiness Check**

The mobiReady testing tool provided by the dot-Mobi resource centre evaluates mobile-readiness of web sites and applications using industry best practices and standards. As mentioned earlier, studies from Ericsson indicate that 80% of people accessing the internet will do so from a mobile device making it important to evaluate how accessible an application is on these types of devices. The 'SmartFun' home page was tested as

*Figure 14. Problems on the Safari browser: 1. the success message does not appear after all letters have been successfully matched. The matched letter boxes remain the blue colour and do not switch to green to indicate success; 2. when an unsorted letter box is dragged over the incorrect target the box sticks and does not release back to the unsorted pack; 3. this is the successful implementation of the letter match game on Mozilla Firefox browser with a success message and all matched targets switched to green colour.*



*Figure 15. The screen on the left shows the Letter Match game displaying properly in the Mozilla Firefox browser. The screen on the right is Letter Match game displayed in the IE9 browser with all letters missing.*



a representative page on the mobiReady validator and as can be seen from Figure 16, performed quite poorly.

There are a number of reasons why the 'Smart-Fun' application does not rate highly on the mobi-Ready test. Some issues are important for overall functionality and need to be addressed, whereas others are more unique to smaller mobile devices which are not the target medium of this application. The use of image maps is not supported on

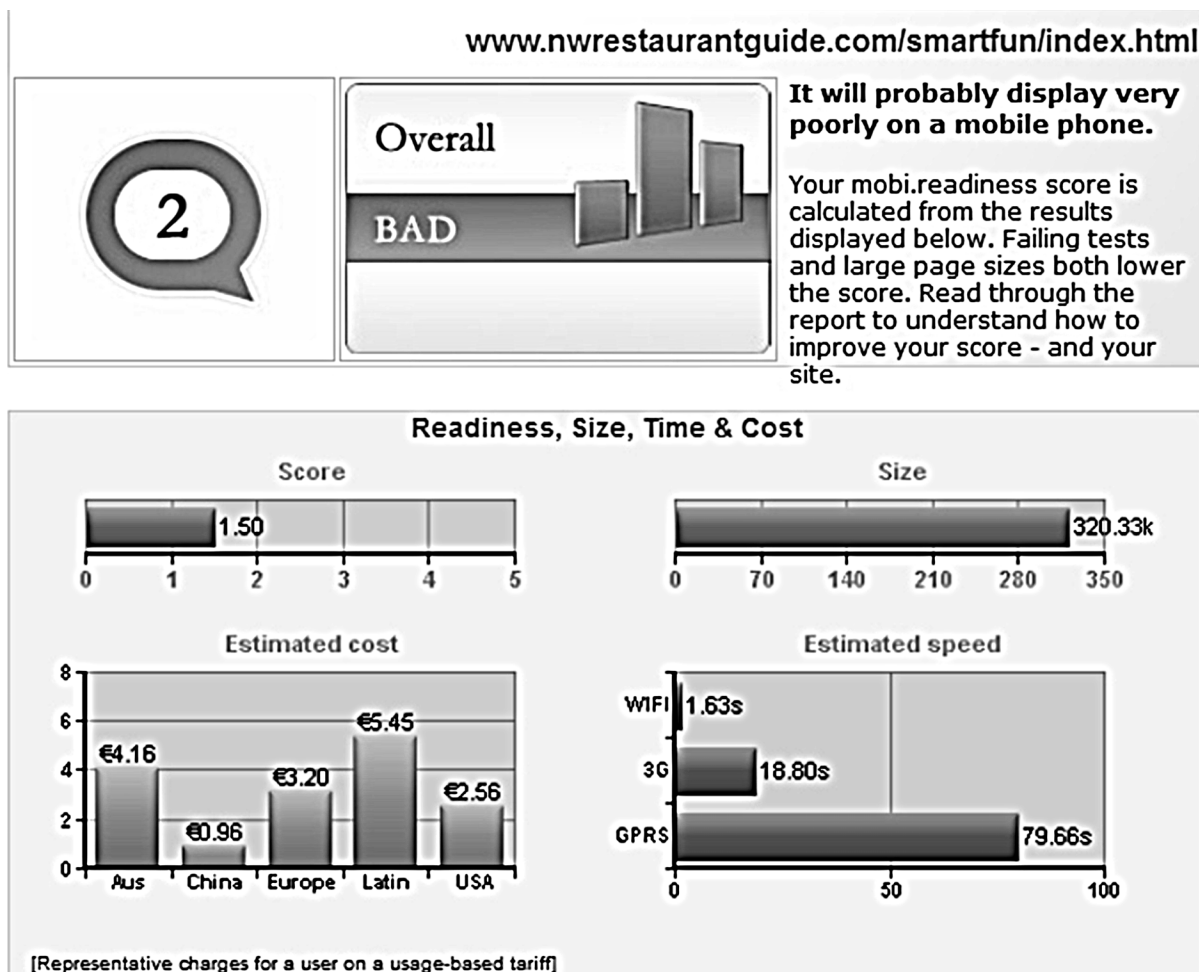
some mobile devices. This design decision was intended to make it easy for young children to tap a touch screen and navigate without any great precision. This could be replicated using larger clickable images that can be positioned using div styles. Large images are used throughout this application and this has led to large download sizes for some of the pages. However, it is intended that this application be downloaded and run from an operating system as opposed to online. Regardless

of this implementation decision, all efforts should be made to make file sizes as small as possible for efficient operation.

The mobiReady validator reported measure errors with the use of pixel or absolute widths, heights and positioning being detected in the style sheets. It suggests using relative measures such as percentages, ‘em’ and ‘larger’ to allow the mobile browser to ‘decide’ on flow of content . Absolute measures were used deliberately in this application. It is intended that the ‘SmartFun’ environment be presented on a tablet device in a landscape orientation to make use of both the touch screen capabilities and the dimensions that

are required for ease of use by a young pre-school child. The interface dimensions of 980 x 621 pixels is way beyond those of most mobile devices which average around 200 pixels. However, as stated above, a larger screen is needed for less dextrous smaller children. It was decided that there was no better way to present the information as the tracing and letter/number matching games would be impossible to implement on such small screens. When developing a web application, important consideration has to be given to the range of potential devices that will be accessing the service. Before launching a product such as ‘SmartFun’ commercially, it would be important

*Figure 16. ‘SmartFun’ does not perform well on the mobiReady mobile-readiness test.*



to stipulate in the marketing that this product is aimed towards very young children, and designed for tablet devices with larger screen dimensions.

## **CONCLUSION**

As stated in ‘Pockets of Potential’ by Carly Shuler: ‘Just as Sesame Street helped transform television into a revolutionary tool for learning among young children four decades ago, advances in mobile technologies are showing enormous untapped educational potential for today’s generation.’ (Shuler, 2009). The ‘SmartFun’ application is being developed within a burgeoning market for child education apps, however it has a number of unique selling points that sets it apart from the competition. Firstly it is targeted at the pre-school market with its very simplistic interface and functionality. Many of the alternative applications that are on the market, including ‘Alphabet Fun’, ‘Intro to letters’ and ‘iWritewords’ are geared towards slightly older children. These products are more restrictive in that they are slightly too regimented for a younger audience, demanding strict adherence to writing procedure. The child can’t draw outside the letter outlines or number discs that have to be followed, which is unsuitable for young children who are experiencing letters for the first time. The Letter/Number Trace games in the ‘SmartFun’ application allow the child the freedom to make random marks or follow the guidelines if they choose, rather than focusing on accuracy. When the user is finished with that section they can move on and enjoy a different game rather than making the application results driven. It is simply a colourful and child friendly way to introduce basic letter and number skills to a child.

Compared to other products currently available ‘SmartFun’ offers much more with its engaging characters and colourful design. This makes the application much less like a learning environment and more like a comic or picture book with child-

friendly appeal. SmartFun also deviates from the intensive letter practice focus of other packages, which is slightly too advanced for a very young audience with a more limited attention span. The addition of letter/number match and story-telling creates a more complete package, addressing a wider range of learning goals whilst maintaining interest. The story telling section extends the functionality of the application, adding an important new dimension by increasing interaction between the adult (parent or teacher) and the child.

The Letter Match game introduces the letters that the child has been tracing and places them into context with this simple yet highly interactive concept, which involves simply matching letters rather than identifying them. Low level numeracy tasks are also introduced in this application. The Tapfuze ‘Alphabet Fun’ has a small numeracy section which is effectively a number board covering the numerals 1-10. When the user presses the number it responds with a sound and an equivalent amount of animals are displayed. The SmartFun app takes this further through the use of Number Match and Number Trace games. ‘SmartFun’ is undoubtedly commercially viable, especially with its range of marketable, themed characters all with recognizable personalities and names. There is a major emphasis on the creation of new characters to compete with existing ranges such as Moshi Monsters which has generated a hugely profitable franchise machine. Obviously SmartFun is aimed towards the education arena and the application would be a perfect accompaniment to a classroom based book, or it could be simply integrated into a classroom based teaching programme.

The ‘SmartFun’ prototype is developed around the first four letters of the alphabet—Amy Ant, Bonny Bee, Cosy Cat and Dizzy Dog—in order to make the prototype development manageable. However, as highlighted earlier, commercially it would be possible to initially release this first set of characters for free to test the market. This seems to be a common business model on the Apple App store where, many developers release

a small amount of functionality for free—to whet the appetite before charging for the complete package. Overall the SmartFun application ticks many of the boxes required to produce a successful educational application geared towards a pre-school market, whilst carving a niche for itself in a highly competitive industry. It's simplicity of design and play-based learning tasks are created in accordance with the overall pre-school curriculum objectives and it is easy to see how this application could be useful in an interactive learning environment. As the industry advances, children are beginning their journey into the realm of technology at an increasingly early age, and it is vital that their first experiences are fun and informative. SmartFun is an easy introduction to the world of interactive learning, where education and technology work together to enhance children's learning experiences.

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## KEY TERMS AND DEFINITIONS

**Early Years Foundation Stage Framework (EYFS):** The EYFS framework emphasises the importance of linking sounds to written letters, and naming and sounding letters of the alphabet.

**HTML5:** HTML5 is a core technology markup language of the Internet used for structuring and presenting content for the World Wide Web. It is the fifth revision of the HTML standard (created in 1990) and, as of December 2012, is a candidate recommendation of the World Wide Web Consortium (W3C).

**Human Computer Interaction (HCI):** Human-computer interaction (HCI) involves the study, planning, design and uses of the interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioral sciences, design, media studies, and several other fields of study.

**Javascript:** JavaScript (is a dynamic computer programming language. It is most commonly used as part of web browsers, whose implementations allow client-side scripts to interact with the user, control the browser, communicate asynchronously, and alter the document content that is displayed.

**Leappad:** LeapPad is a range of tablet computers developed for children. Various models of the LeapPad have been developed since 1999. The latest of the range is the LeapPad Explorer, which was released in 2011.

**Mobiready:** The mobiReady testing tool is provided by the dotMobi resource centre evaluates mobile-readiness of web sites and applications using industry best practices and standards.

**Nursery Education Guidelines Curriculum:** The Nursery Education Guidelines Curriculum is a comprehensive statutory framework that sets the standards for the learning, development, and care of children from birth to five in Northern Ireland.

**W3C Consortium:** The World Wide Web Consortium (W3C) is the main international standards organization for the World Wide Web (abbreviated WWW or W3).