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Contents

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Editorial

I am delighted to introduce the tenth edition of the ITB Journal, the academic journal of the Institute of Technology Blanchardstown. The aim and purpose of the journal is to provide a forum whereby the members of ITB, visitors and guest contributors from other third level colleges can publish an article on their research in a multidisciplinary journal.

This issue contains the usual diverse and interesting selection of research papers and articles. Hugh McCabe of ITB discusses research work with interactive 2D and 3D Graphics over the World-Wide Web with ActionScript. Laura Keyes, Andrew O'Sullivan and Adam Winstanley of ITB and NUI Maynooth show how statistical NLP algorithms can be applied in the recognition of graphical objects. Ayres and Nolan of ITB present recent research on voice activated command and control of a Lego Mindstorms using speech recognition over WIFI networks

A common issue at third level is the student's ability with maths. Colm McGuinness provides a timely review on mathematical competencies of third level students at ITB and discusses concerns and trends across the 3rd level sector in this regard.

From NUI Galway we have a paper on the use and application of adaptive screen generation for mobile devices by Caoimhín O'Nualláin and Sam Redfern while Suzanne McCarthy. Of the NDTI reports on a collaborative model of service delivery for individuals with specific learning difficulties. Dawn Duffin, of the NTDI and the CLCS department in Trinity College Dublin discusses her research, within the Irish deaf community, on the access to academic english: the development of a meta-linguistic curriculum. Also on the linguistic/language area we have a very interesting paper on Catalan: The Renaissance of Europe's Stateless Language: A Paradigm for the Irish Language Revival? By Aidan Collins

Once again, we hope that you enjoy the papers in this issue of the ITB Journal.

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Interactive 2D and 3D Graphics over the World-Wide Web with ActionScript

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Abstract

Many efforts have been made to provide a mechanism for delivering interactive 3D content over the World-Wide Web. The majority of the solutions put forward require the use of a proprietary plug-in on the client browser and none of these required plug-ins have so far become part of the standard browser installation package. The Macromedia Flash player has however achieved near ubiquitous status as the standard plug-in for displaying interactive multimedia and graphics content. Flash does not provide native support for 3D graphics but the recent addition of the Shape Drawing API opens up the possibility of developers using ActionScript for this purpose. This paper describes the development of an ActionScript graphics library that consists of a set of reusable classes for adding interactive 2D and 3D graphics to Flash content. We describe these classes in detail, show examples of programs developed using them, and discuss the advantages of this approach

1 Introduction

The World-Wide Web (WWW) was initially developed as a means of providing hyperlinked textual information over wide area networks but quickly evolved into a medium that was capable of handle numerous forms of non-textual multimedia content as well; such as bitmapped images, video, and audio [2]. These are typically handled by encoding them into external files adhering to standardised formats whose goal is to ensure efficient coding and playback [11]. In the case of bitmapped images, the browser itself is capable of decoding and displaying the content, and hence the images can be directly embedded in web pages. In the case of video and audio, an external application is often invoked by the browser to handle the playback. It is increasingly common that this external application is developed as a *plug-in* for the browser. In this case seamless embedding of the content within the web page is made possible.

The nature of these content forms mean they are essentially *non-interactive*, in that user input at most comprises of choosing whether to view or play the content or not. *Interactive graphics* on the other hand is a form of multimedia content that is by definition fully interactive [8][9]. In this case the visual content is stored internally as a set of mathematical or quasi-mathematical representations[1] and the display software (or *renderer*) is responsible for generating images for display. A wide variety of interaction is now made possible as mouse and keyboard input can be used to manipulate the internal representations of the objects that make up the scene and the renderer can, in real time, display the results to the user. Interactive graphics is the technology that drives such diverse applications as games [3], computer animation [19], computer-aided design [10], architectural walkthroughs [1], and scientific visualisation [15].

For various reasons, this form of media has not made the same inroads into the World-Wide web as its non-interactive counterparts. The hypertext interface upon which the web is based is unsuited for the sorts of precise mouse and keyboard interactions required, and therefore most attempts to introduce it have revolved around the use of external plug-ins to view and interact with the content. This has been reasonably successful in the case of 2D graphics. The Macromedia Flash system for example [13], provides an effective way of delivering a form of 2D graphics over the web and the associated viewer plug-in, the Flash player, has achieved near total penetration of the browser market[2]. The various ways of delivering 3D graphics however still rely on the presence of plug-ins that the average user is extremely unlikely to have installed in their browser.

In this paper we describe how the Macromedia Flash system can be extended to handle 3D graphics as well as the 2D graphics that it is intended for. The motivations for doing this are as follows:

- Macromedia Flash is a near ubiquitous means of adding multimedia content to the web and its player is installed on the vast majority of the world's web browsers.
- The majority of web-based multimedia developers use Flash and hence they are more likely to experiment with 3D functionality if it is presented in the context of an application they are already familiar with.

[1] As opposed to bitmapped images which comprise of a two-dimensional array of pixel colour values and contain no direct representation of the content.
[2] Macromedia report that an independent survey by NPD research carried out in June 2003 found that 97.4% of web browsers had a version of the Flash player installed.

- Interactive Flash applications are built using the ActionScript language which is relatively simple to learn. From an educational point of view, this work provides an opportunity to get students to experiment with building 3D applications without having to learn complicated high-level graphics languages such as OpenGL or Java3D

This extension is made possible by building a graphics library in ActionScript that uses the Shape Drawing API to render objects on the screen in real time [6]. The rest of this paper consists of the following. Section 2 reviews the methods of delivering interactive graphics over the web and pays particular attention to those that aim to handle 3D graphics. Section 3 describes the Shape Drawing API upon which our library is built and the overall architecture of our system. Section 4 describes the extensions to the Shape Drawing API that our library includes in order to provide a full interactive 2D graphics system. Section 5 details the classes that constitute the 3D part of the graphics library. Section 6 evaluates the system by presenting some sample programs and tests. We finish in Section 7 by outlining what we see as the advantages of this approach and potential applications.

2 Web Graphics Technologies

We now examine what is currently available in terms of technologies for delivering interactive graphics over the web. We will look at technologies for 2D graphics first and then examine the options for 3D.

2.1 2D Graphics

The most important technologies that exist for delivering 2D graphics on the web are Macromedia Flash and Scalable Vector Graphics (SVG) [7]. Flash is a proprietary system developed by Macromedia that has enjoyed widespread adoption across the web. It is a vector graphics system that includes capabilities for doing animation and interactivity. The core element of most Flash content (or *movies* as the Flash system calls them) is the *movie clip*. This is a static rectangular bitmap which can be created by using drawing tools within Flash or by importing graphics or images[3]. These movie clips exist within a 2D coordinate system and can be animated or scripted to behave interactively based on mouse or keyboard input from the user. The scripting language which can be used to control the interactivity is called ActionScript and it provides a rich set of tools for building 2D interactive applications. These applications can be exported in Macromedia's proprietary SWF format and then either

embedded in web pages or else ran as standalone applications across the web. Flash has proved ideal for delivering animated content on the web and easily lends itself to more complex tasks such as implementing web-based games.

Scalable Vector Graphics (SVG) [7] has been designed as a non-proprietary alternative to Flash. It effectively defines a standardised XML format for graphical content. There are numerous advantages to encoding graphical content as XML rather than a binary format such as Macromedia SWF. The most important is that it allows developers to freely build applications to create or display this content and therefore could facilitate the development of graphics over the web in the same manner that HTML did for hypertext. SVG is a rich fully featured system but so far plug-ins to view the content have not become nearly as ubiquitous as those for the Macromedia SWF format.

2.2 3D Graphics

There are many options available for the 3D graphics case. Broadly speaking these fall into three categories: systems which convert 3D content into a 2D format such as Flash or SVG; systems which require a custom plug-in or application to view the content; and systems that are built on the basis of using Java applets embedded in web pages. We will look at each of these in turn.

A renderer that is capable of displaying 3D content effectively has to convert this content into a 2D equivalent since ultimately it has to be displayed on a 2D device (the screen). A system such as a 3D game engine has to do this approximately 40 times per second as the state of the world it is rendering is continually updated in real time. However if we are producing a piece of computer animation then there is no such speed requirement as the conversion can be carried out offline. There is no reason why we cannot create a 3D animation in some appropriate application , use another application to convert this into a sequence of 2D bitmaps or 2D vector graphics, and then use a third application to display the results.

[3] The concept of a movie clip is not unlike that of a *sprite*, which was in common usage among early 2D arcade game developers [3].

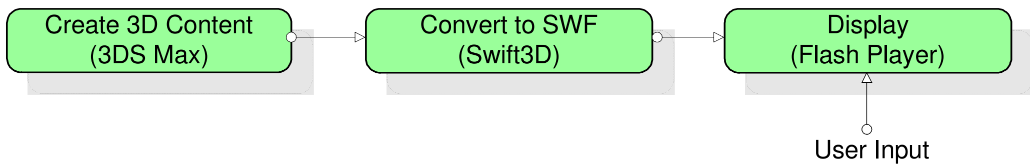

Figure 1*: The Swift3D Workflow*

This is exactly what systems such as Electric Rain's Swift3D do [5]. This allows the developer to create 3D animated content in an application such as 3DS Max [4] and then use Swift3D to convert that content into the Flash SWF file format (see Figure 1). This means it is viewable on any browser with the Flash player installed. This produces excellent results but the drawback is that since the player can only access the 2D version of the original 3D content no meaningful interaction is possible between the user and that content. Therefore it effectively produces a *non-interactive* form of 3D graphics. Numerous other products exist that work on the same basis and suffer from the same drawbacks.

The second approach involves systems that require a specialised application to view the 3D content. Because this application is built specifically for this purpose it can be designed as a 3D renderer and hence provide full interaction with the 3D content at the user end. This application can then be designed as stand-alone, in which case it is invoked by the browser when content of this form is encountered, or else it can work as a plug-in inside the browser. An early example of this approach is the Virtual Reality Modelling Language (VRML) [20]. This is a tag-based ASCII file format for describing 3D worlds. VRML content can be created by editing by hand or else by using some sort of authoring tool[4]. VRML is an open standard and hence several companies have produced VRML browsers [16] which can be invoked to view the content at the user end. Since the browser the user employs to view the graphics has direct access to the 3D content a rich array of functionality can be provided allowing users to explore 3D worlds and interact with and manipulate the objects therein (Figure 2).

[4] In fact most of the major 3D modelling software packages such as 3DS Max incorporate the functionality to export content as VRML.

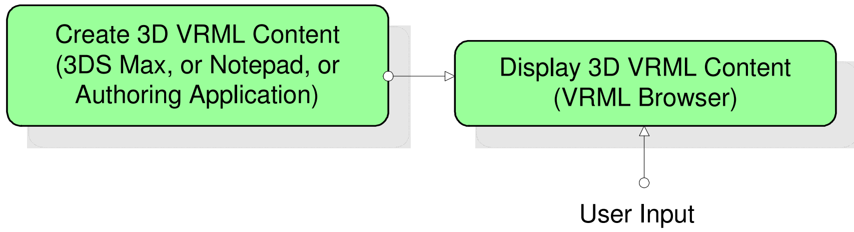

Figure 2*: The VRML Process*

Despite its technical advantages, VRML (and indeed its successor X3D [21]) has not become a widespread means of delivering 3D graphics mainly due once again to the fact that the browsers needed to access the content have not achieved sufficient market penetration. Another disadvantage of the VRML approach is that the developer has relatively little control over how the eventual viewer can interact with the content. The forms of interaction allowed come pre-packaged as it were with the browser.

Macromedia's Director software is a high-end Multimedia authoring environment that includes support for developing 3D content [12]. With the help of the Shockwave plug-in this content can be viewed and interacted with through a web browser also. Crucially the developer has full control over what form these interactions will take as the powerful Lingo scripting language can be used to specify this. Unsurprisingly the usual problem remains that the necessary Shockwave plug-in does not come as a standard component with web browsers.

The third category of web-based 3D graphics is based on the idea of using a Java applet to display the graphics content. This is a powerful idea as Java includes a 3D graphics library called Java3D [18] that can be used to program more or less any form of 3D graphics interaction we might wish for and modern web browsers are capable of handling Java applets easily. Programming graphics in Java3D is a difficult business however and requires a thorough knowledge of high-level programming concepts. It seems unlikely that multimedia practitioners or students will be willing to invest the time necessary to master these concepts. An interesting alternative is to build an application that provides some sort of straightforward graphical or programmatic interface that allows the user to create the 3D content, and then translates it into a Java 3D program for display in a web browser. An example of this is the Processing language [17] which comprises of a simple and intuitive scripting language whose output is converted into Java applets. This allows the creation of 3D objects through a set of simple classes that have much in common with the work described in this paper.

3 Graphics Library Architecture

Our graphics library is structured as shown in Figure 3.

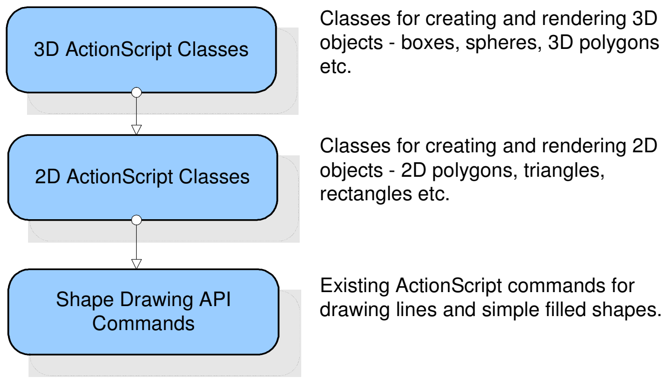

***Figure 3**: Structure of the Graphics Library*

The system is built upon the existing ActionScript Shape Drawing API commands. These were introduced in the most recent version of ActionScript (ActionScript 2.0) and represent a significant development of the language's capabilities. As mentioned earlier Flash graphics are based on the idea of manipulating predefined bitmapped shapes called movie clips. The Shape Drawing API however allows the developer to programmatically draw shapes on the screen dynamically. The commands provided in the Shape Drawing API are quite limited and are summarised in Figure 4.

`linestyle(thickness,rgb,alpha)`	Set the thickness, colour and transparency for subsequent drawing commands
`moveTo(X,Y)`	Move the current drawing position to the point (X,Y)
`lineTo(X,Y)`	Draw a line from the current drawing position to the point (X,Y)
`beginFill(rgb,alpha)`	Set the fill colour and alpha value and begin a fill
`endFill()`	Finish the fill

***Figure 4**: ActionScript Shape Drawing API Commands*

Effectively these commands allow the developer to do two things:

- Draw lines on the screen of varying thicknesses, colours and transparencies.
- Draw filled shapes on the screen of varying colours and transparencies

Lines are drawn using the `moveTo` and `lineTo` commands. Filled shapes are drawn using `beginFill` to set the fill properties, a sequence of line commands to draw a shape that encloses some space on the 2D plane, and then the `endFill` command to invoke the fill. These commands can be issued from ActionScript scripts and hence combined with all of the usual programmatic elements such as conditional statements and loops and also carried out in response to user mouse or keyboard input.

As it stands the Shape Drawing API can carry out sophisticated work but this requires a large amount of programming on the part of the developer. The first task in building our graphics library was to use the basic Shape Drawing commands to create a set of reusable classes for drawing 2D shapes on the screen (see Figure 3). This extends the functionality of the API greatly and allows developers to quickly write code to draw and manipulate 2D graphics. The second stage was to use the 2D drawing classes as a means of implementing a set of 3D classes. We now describe these two stages in more detail.

4 2D ActionScript Classes

There are three basic 2D classes in the library, each of which corresponds to a fundamental graphics primitive. These are `Point2D`, `Triangle2D`, and `Polygon2D`.

4.1 The `Point2D` class

Objects are defined in terms of their vertices and hence we need a data structure suitable for representing points on a 2D plane. The class is described in Figure 5.

Point2D
X: number Y: number
Point2D(X:number,Y:number):void examine():void drawline(point:Point2D,thickness:number, colour:string, alpha:number):void translate(tx:number,ty:number):void scale(sx:number,sy:number):void rotate(angle:number):void

***Figure 5**: Class diagram for* `Point2D`

The attributes of a `Point2D` object are `X` and `Y` coordinates. Various methods have been implemented including the normal transformations (translation, rotation and scaling), a

constructor method, and an `examine` method which prints out the values of the attributes on the screen and is primarily intended for debugging purposes. The `drawline()` method is the fundamental drawing operation of the graphics library and when invoked on a `Point2D` instance, draws a line from this to another `Point2D` instance supplied as an argument. Line thickness, colour and alpha value can also be specified. Colour is represented as a hexadecimal string in the graphics library. This may seem an unintuitive choice to graphics programmers but it is the form that web and multimedia developers are likely to be most familiar with.

```
#include "graphics.as"

p1 = new Point2D();
p2 = new Point2D();
width = _root.width // width of screen/window
height = _root.height // height of screen/window

for(i=0;i<500;i++)
{
  p1.x = Math.random()* width -  (width/2);
  p1.y = Math.random()* height - (height/2);
  p2.x = Math.random()* width -  (width/2);
  p2.y = Math.random()* height - (height/2);
  col = convert(Math.random()*255,Math.random()*255,Math.random()*255);
  thickness = Math.random()*5;
  alpha = Math.random()*100;
  p1.drawline(p2,thickness,col,alpha);
}
```

Figure 6*: Example program using the* `Point2D` *class*

Figure 6 shows an example ActionScript program that uses this class[5]. The results of running the program are shown in Figure 7.

[5] `Math.random` is the ActionScript method for generating random numbers and the `convert` function converts three integer colour component values into a single hexadecimal colour string. The class definitions are contained in the file `graphics.as`.

***Figure 7**: Results of running program in Figure 6.*

4.2 The `Triangle2D` Class

Now that we have defined points within our two-dimensional space we can construct a class to represent triangles (see Figure 8).

Triangle2D
V1: Point2D V2: Point2D V3: Point2D hexcolour: string
Triangle2D(v1:Point2D, v2:Point2D, v3:Point2D, colour:string):void examine():void draw_wireframe(thickness:number,alpha:number):void draw_filled(alpha:number):void setcolour(colour:string):void translate(tx:number,ty:number) scale(sx:number,sy:number):void rotate(angle:number):void

***Figure 8**: The `Triangle2D` Class*

The `Triangle2D` class has four attributes. Three of these represent the vertices of the triangle and each is an instance of the previously defined `Point2D` class. This means that methods to carry out transformations can be easily implemented by calling the transformation methods of the `Point2D` class. The fourth attribute represents the colour of the triangle. This can be reset at any time using the `setcolour` method. Two drawing methods are provided. One of them draws a wire-frame triangle and the other draws a filled triangle, using

the colour of the triangle as the fill colour. The fill is implemented using the ActionScript fill commands described earlier.

4.3 The `Polygon2D` class

The final 2D class provides a way of specifying and manipulating two-dimensional polygons and is shown in Figure 9. This class allows for polygons of an arbitrary number of vertices. The vertices of the polygon are represented as `Point2D` objects and the usual drawing and transformation methods have been implemented.

Polygon2D
vertices: array of Point2D objects hexcolour: string
Polygon2D(vertices:array of vertices, colour:string):void examine():void draw_wireframe(thickness:number,alpha:number):void draw_filled(alpha:number):void setcolour(colour:string):void translate(tx:number,ty:number):void scale(sx:number,sy:number):void rotate(angle:number):void

***Figure 9**: The `Polygon2D` class*

The polygon class is extremely similar to the triangle class with the only significant difference being that since a polygon has an arbitrary number of vertices we store the vertex information in an array[6].

5 3D ActionScript Classes

There are a number of classes to support 3D objects in the library. Obviously the mechanics of implementing these classes are somewhat more complex as we have to take care of issues such as projection from 3D to 2D, and lighting and shading.

5.1 The `Point3D` Class

Once again the basic unit in three-dimensional space is the point and hence we construct a class to support this. The `Point3D` class is shown in Figure 10.

[6] It is worth pointing out that in ActionScript an array is not a fixed size data structure and hence has more in common with what would be called *dynamic array* in a high-level programming language.

Point3D
X: number Y: number Z: number
Point3D(X:number, Y:number, Z:number):void examine():void drawline(point:Point3D, thickness:number,alpha:number,colour:string):void project():void normalize():void setcolour(colour:string):void translate(tx:number,ty:number,tz:number):void scale(sx:number,sy:number, sz:number):void rotatex(angle:number):void rotatey(angle:number):void rotatez(angle:number):void

Figure 10*: The `Point3D` Class*

Points in 3D space are represented as three numbers. There is a `drawline` method used for drawing a line from one point to another. Note that the implementation of this `drawline` method has to include a projection operation in order to convert from 3D coordinate space into a 2D coordinate system for screen display. The projection provided is the standard perspective projection parallel to the Z-axis of the 3D coordinate system [8]. The specifics of the projection are controlled by two parameters to a `setupcamera` function which would usually be invoked at the start of the program. These parameters are the position of the centre of projection along the Z axis and the distance from the centre of projection to the projection plane. These parameters can be used to simulate the full range of focal lengths and fields-of-view for the projection. A `project` method is also supplied which directly projects the point according to this projection. Since we are dealing with three-dimensional space we provide three rotation methods, for rotating about the three principal axes.

5.2 The Vector3D Class

A vector class is shown in Figure 11. This class contains the methods one would expect for carrying out vector arithmetic. A similar class, `Vector2D`, exists for doing 2D vector arithmetic but is omitted for brevity's sake.

Vector3D
X: number Y: number Z: number
Vector3D(X:number, Y:number, Z:number):void examine():void addition(othervector:Vector3D): result:Vector3D getlength():result:number normalize():void dotproduct(othervector:Vector3D):result:number crossproduct(othervector:Vector3D):result:Vector3D

Figure 11*: The* `Vector3D` *class*

5.3 The `Triangle3D` Class

3D triangles are at the heart of the graphics library and we support the rendering of both wire-frame and shaded triangles. Given the existence of a `Triangle2D` class the algorithms for rendering 3D triangles are quite simple. The process involves projecting the vertices of the 3D triangle and forming a 2D triangle from the results. This 2D triangle can then be drawn on the screen using the methods from the `Triangle2D` class.

We also need to take care of the problem of hidden surface removal. This involves detecting those triangles that are not visible to the viewer and declining to render them accordingly. Our library currently supports backface removal [9][8] which uses vector arithmetic to determine if a triangle is facing away from the viewer. If the triangle is facing away from the viewer then, as long as the object is convex, it must be at the back and therefore hidden. The algorithm for rendering a wire-frame 3D triangle is shown in Figure 12.

```
Algorithm: Rendering a wire-frame triangle

calculate normal vector to triangle
if (normal vector.view vector < 0)
      calculate projected vertices
      draw 2D triangle from projected vertices
```

Figure 12*: Algorithm for rendering wire-frame triangle*

The library also supports the rendering of filled 3D triangles. We use the *constant shading* [8] algorithm to calculate colour values for the projected triangles. To support this, the library allows the user to introduce an arbitrary number of point light sources into the scene. For

each light source we add a colour component to the polygon which is calculated as proportional to the strength of the light source and the cosine of the angle between the surface normal and the vector towards the light source. Effectively this technique calculates diffuse reflection from the object.

```
Algorithm: Rendering a filled triangle

calculate normal vector to triangle
set colour to (0,0,0)
if (normal vector.view vector < 0)
      calculate projected vertices
      for each light source
            calculate vector to light source
            calculate cosine of angle
            add cosine.lightsourcecolour to colour
      add ambient light term to colour
      draw 2D coloured triangle from projected vertices
```

Figure 13*: Rendering a Filled Triangle*

The complete class diagram for the Triangle3D class is shown in Figure 14.

Triangle3D
V1: Point3D V2: Point3D V3: Point3D colour: string
Triangle3D(V1:Point3D, V2:Point3D, V3:Point3D):void examine():void draw(thickness:number, alpha:number): void fill(alpha:number):void getnormalvector():result:Vector3D translate(tx:number, ty:number, tz:number) scale(sx:number, sy:number, sz:number)

Figure 14*: Class diagram for* `Triangle3D`

5.4 The `Polygon3D` Class

Once again the triangle is basically a specialisation of the polygon. A polygon contains an arbitrary number of vertices and these vertices are held in an array in our implementation.

The same methods are provided as for the `Triangle3D` class thus allowing the rendering of both wire-frame and filled polygons.

5.5 The `Mesh` Class

For convenience sake it is necessary to introduce a higher level object representation method. Our library accomplishes this by providing a mesh class. The `Mesh` class is designed to handle polygonal meshes. These are collections of polygons that approximate the surfaces of 3D objects. A mesh can be represented as an array of polygons but it is more normal to insist that these polygons are restricted to being triangles. The attributes of a mesh object are:

- An array of 3D triangles
- An array of vertices
- An array of normal vectors
- A colour attribute

The array of vertices consists of a non-repeating list of the vertices of the triangles in the triangle array and can be derived from this. This is provided to speed up the rendering process. We also store an array of normal vectors to the triangles in order to avoid having to recalculate them each time we want to do rendering or lighting calculations with them. The class diagram is shown in Figure 15.

Mesh
vertexarray: array of Point3D objects trianglerarray: array of Triangle3D objects normalarray: array of Vector3D objects colour: string
Mesh("parameters as above"):void examine():void drawwireframe(thickness:number, alpha:number): void fill(alpha:number):void translate(tx:number, ty:number, tz:number) scale(sx:number, sy:number, sz:number) rotatex(angle:number):void rotatey(angle:number):void rotatez(angle:number):void

***Figure 15**: Class diagram for the `Mesh` class*

To go with the `Mesh` class a number of functions are provided in the library for generating meshes. These include functions for primitive shapes such as spheres and octagons, and also functions to import vertex information from 3DS Max models.

6 Test Programs

We now briefly present some results of test programs that demonstrate the use of the various classes in the graphics library. The first program uses the `Triangle3D` class to create twelve 3D triangles arranged in the shape of a box. The fill method is used to render the triangles and therefore constant shading is employed. Some ActionScript code was written to respond to key presses to that the user can rotate the box on the screen around the three principal axes. A screenshot is shown in Figure 16.

***Figure 16**: 3D Box created from the `Triangle3D` class*

As can be seen the constant shading technique proves an effective method in this case. The rendering is carried out quickly and smooth motion results when the rotations are applied.. It is also possible to create a box shape from the `Polygon3D` class. In this case only six polygons would be necessary as opposed to the twelve triangles used above.

The next program serves as a demonstration of the `Mesh` class. A mesh is constructed which represents a diamond shape and is shown in. Figure 17.

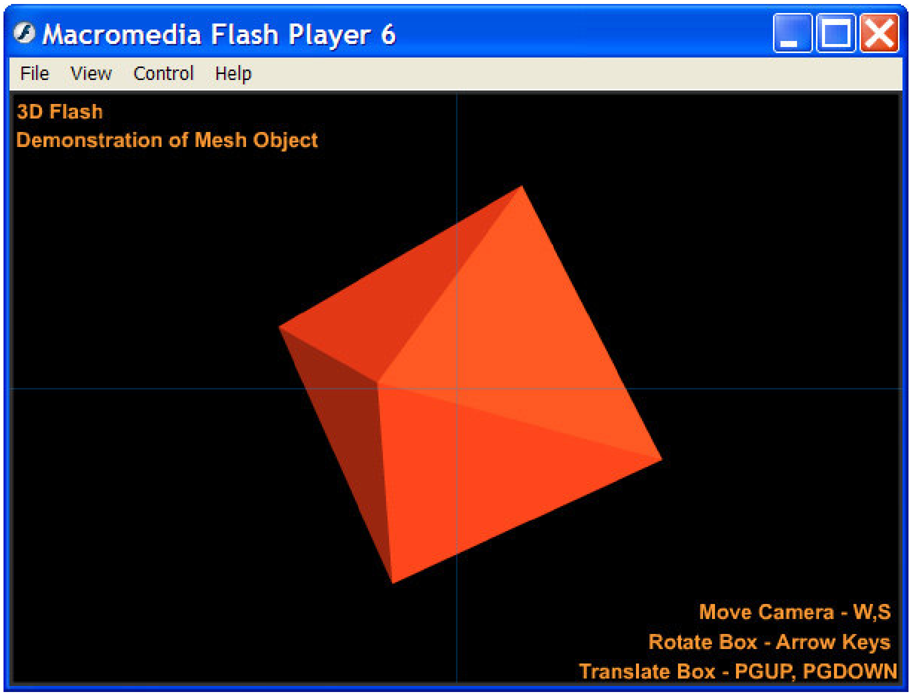

***Figure 17**: Using the `Mesh` class*

Once again a set of keyboard controls are provided which allow the user to rotate the object but also translate the object and move the camera. High frame rates and smooth motion were found to be possible in this example also.

A final example was constructed in order to test the efficiency of the rendering system when using larger numbers of polygons. In order to facilitate this a library function was written which generates a mesh approximating the surface of a sphere. The input parameters to this algorithm include the radius of the sphere and the level of recursion that the algorithm should use. A larger number of recursion levels results in a finer polygonal mesh and a greater number of polygons. The results of rendering such a spherical mesh object are shown in Figure 18. The faceted nature of the sphere is caused by the use of the constant shading algorithm which makes polygon edges visible. We discuss this issue further in the conclusions section to this paper.

As would be expected the higher number of triangles involved here places extra demands on the processor. A series of tests were carried out by instructing the sphere generation

algorithm to generate spheres of increasing polygon counts[7]. The results of this are shown in Figure 19.

Figure 18:*The sphere mesh*

Number of Poylgons	Acceptable Frame Rate
8	Yes
32	Yes
128	No
512	No

Figure 19: *Results of sphere generation test*

An acceptable frame rate was deemed to be a situation where the program responded immediately to key presses to rotate the sphere and was capable of producing smooth motion. The 128 polygon case only fell slightly short of these criteria and hence the exact number of polygons that the system can handle is closer to this upper limit than the lower one of 32.

[7] These tests were carried out on a laptop computer with a Pentium-M 1.5 GHz processor, 512MB of RAM and a 64MB graphics card.

7 Conclusions

We have demonstrated that it is possible to use the ActionScript Shape Drawing API as a basis for developing a graphics library that Flash developers can use to easily program interactive 2D and 3D graphics. We presented a set of classes that encapsulate the fundamental 2D and 3D graphics primitives and contain appropriate methods for rendering and manipulating these primitives. We conclude by discussing the advantages and disadvantages of this approach and suggesting some avenues for future work in this area.

From the point of view of programming 2D graphics, the library is extremely successful. The functionality of the Shape Drawing API is hugely increased as the developer can now easily add shapes such as triangles and polygons, and also make use of the various transformation methods to manipulate these shapes. Perhaps more importantly, it grounds the 2D graphics elements within the well understood framework of standard coordinate geometry for computer graphics, and this results in a far more powerful and flexible approach than the rather ad hoc methods of doing things which Flash developers typically employ.

The 3D part of the library also provides greatly extended functionality as at present ActionScript offers no 3D functionality at all. The library allows the developer to create various forms of 3D shapes, including a polygonal mesh. These shapes can be rendered in either wire-frame or shaded form, and the full set of transformations for manipulating these shapes interactively within the 3D space are also provided. Some limitations of this aspect of the work should be addressed however.

- **Polygon Count**. As we saw earlier polygonal objects with three figure polygon counts prove too prohibitive in terms of computational expense to render in shaded form. This is unsurprising as the nature of the Flash system means that programs written with ActionScript are unable at present to take advantage of the hardware graphics acceleration that is necessary to carry out tasks such as this. It is likely that careful optimisation of the graphics library will improve this situation somewhat.

- **Hidden Surface Removal**. The backface removal algorithm which has been implemented has the advantage of being extremely fast but it does suffer from obvious and well-known limitations. These are, that it will not correctly remove hidden surfaces in the situation where multiple objects are obscuring each other, and it will not work correctly with non-convex objects. The nature of the program that the developer is trying to write will dictate whether these limitations are important or not. If, for example, the objects are being rendered in wire-

frame mode anyway then it is likely that this will not be important. This problem could be solved by implementing a full hidden surface removal algorithm such as Z-Buffer [8]. This is only really feasible however if we can take advantage of hardware acceleration. Similar problems were grappled with in the graphics research community in the 1970's, before hardware acceleration became the norm, and the algorithms proposed are now being investigated to determine their potential suitability in the present situation.

- **Shading**. Filled objects are shaded using the constant shading technique, with the assumption that surfaces exhibit diffuse reflection only. This works perfectly well for shapes where the polygons represent the actual surfaces of the object, but less well for curved surfaces where the polygons are an *approximation* of the surface of the object. Once again this problem could be easily solved by implementing a more sophisticated algorithm, such as Gourand shading [9]. The computational demands of Gourand are not significantly higher than the present algorithm but in this case we run into a practical difficulty regarding the Shape Drawing API. Gourand shading advises that projected triangles are interpolatively shaded scan-line by scan-line but the fill methods of the Shape Drawing API do not allow for this. A form of Gourand shading could be implemented by shading on a pixel-by-pixel basis but it is likely that the computational demands of this would be so much that the visual advantages would be far outweighed by the speed disadvantages.

It should be noted that most of the issues raised above are only really important if the developer is seeking to implement realistic looking 3D graphics. Realism is not going to be achieved by a graphics library in ActionScript due to the computational limitations and the lack of it should not be regarded as a serious problem.

Perhaps the chief advantage of providing a way of doing this kind of graphics through ActionScript is that the developer can freely mix this form of media with all of the others provided by Flash. The concept of layers within the Flash movie means that on one layer we can have 3D graphics, and can then combine this with multiple other layers containing text, sprites, video, drawings, bitmaps, and so on. These layers can be overlaid and composited together with various levels of transparency perhaps, or used to provide different forms of media on different segments of the screen. Due to the ubiquity of the Flash player the results can be viewed across the World-Wide Web. We believe that creative Flash developers can potentially use this library to create exciting new forms of 2D and 3D graphics applications.

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Statistical Language Models for Graphical Object Recognition

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Abstract.

This paper explores automatic recognition and semantic capture in vector graphics for graphical information systems. The low-level graphical content of graphical documents, such as a map or architectural drawing, are often captured manually and the encoding of the semantic content seen as an extension of this. The large quantity of new and archived graphical data available on paper makes automatic structuring of such graphical data desirable. A successful method for recognising text data uses statistical language models. This work will investigate and evaluate similar and adapted statistical models (Statistical Graphical Langauge Models, SGLM) to graphical languages based on the associations between different classes of object in a drawing to automate the structuring and recognition of graphical data.

Keywords *Statistical Language Models, Semantic Modelling, CAD Drawings, Graphical Object Recognition, Statistical Graphical Langauge Models, Operation and Maintenance Information System*

1. Introduction

Graphical information systems are computerised systems used for storing, representing, manipulating, analysing and displaying graphical data. The increased used of graphical information systems has motivated research in the automatic structuring of graphical data and developing and applying graphical object recognition. That is, a vast amount of data archived by organisations is in graphical form (for example, diagrams, maps, technical drawings, and architectural plans). For this to be searched, analysed and synthesised automatically, it must be parsed and converted from simple graphics (points, lines, symbols, polygons) to semantically rich graphical information ("circuit-breaker", "building", "spark-plug", "extractor fan"). For computer systems to process such graphical data not only the geometry but also attribute data, describing the nature of the objects depicted must be stored.

This manual structuring into composite objects and addition of labelling attributes is a labour-intensive, expensive and error prone process. The successful automation of raster-vector conversion plus the large quantity of new and archived graphical data available on paper makes the automation of feature extraction and structuring of graphical data desirable. Automation of the structuring and recognition of objects through statistical modelling for efficient and complete input into graphical information systems can form a solution to this complex problem.

Statistical language models are a successful method for recognising text data. These models are derived from corpora of language-examples using the frequency and associations between words. This work will apply and evaluate similar and adapted statistical models *(Statistical Graphical Langauge Models, SGLM)* to graphical languages based on the associations between different classes of object in a drawing to automate the structuring and recognition of graphical data.

This paper describes the proposed research into the use and adaptation of SLM techniques to aid in the semantic analysis of graphical data for the purposes of recognition, indexing and retrieval. The derived graphical recognition system will be used for the development of an operation and maintenance information system for architectural plans within buildings and other facilities (Entropic Ltd)[*].

2. Operation and Maintenance Information System

An Operation and Maintenance (O&M) information system holds centrally all relevant information pertaining to the operation and maintenance of plant and equipment within buildings and other facilities. This information is presented through a multi-media web interface and consists of drawings, data sheets, operating instructions, parts listings, suppliers, installers, manufacturers and other details of all the service utilities. The information on each component is comprehensively cross-referenced using links between corresponding items in drawings, data sheets, photographs and so on. The system can be implemented for all sizes of installations but comes particularly suited for the infrastructure

[*] Entropic Ltd, are a SME located in County Kildare, Ireland and are exploring the provision of multimedia operation and maintenance information systems for building and plant facilities management.

management of large industrial or service sites. Current use includes a sports complex and large private dwellings.

The Operation and Maintenance Information System allows a user to select an example object (simple or composite) and the software finds similar objects in the same or other drawings. The tool generates data structures that can be used to build multimedia linkages between objects, drawings and related information. The information is accessed through a standard web browser interface including navigation through hot-links and key-word search facilities. CAD drawings showing the location of utilities and services also act as browser navigational maps. In operation, the system's main use concerns day-to-day operation and maintenance tasks**,** for example**:**

- Retrieving plant operating and servicing instructions
- Scheduling of maintenance tasks
- Keeping records of maintenance done
- Listing of spare parts
- Locating rarely accessed equipment, plant and components
- Generating service reports

2.1. Problems of Data Capture and Construction

A typical O&M system has to be compiled from information supplied by many manufacturers, architects, designers and contractors in a wide variety of formats: CAD drawings, data sheets, operating instructions, parts listings, details of suppliers, installers and manufacturers. Some are available digitally but many are paper documents. O&M systems commissioned so far have been constructed manually through digitising, structuring and linking this information appropriately.

For the system to be economic, it is desirable to automate as much as possible of this compilation process. Automation possibilities include:

- Recognition and labelling objects/components on drawings
- Generating links through string matching
- Compilation of databases of information from scanned text/drawings

Once recognised and classified, these objects can be assigned unique identifiers in the system. This allows their inclusion in the search and navigation functions. Previous work evaluated the recognition and labelling of objects and components and drawings using shape [11] and structural descriptors [14]. As part of this project, for the automatic structuring and

recognition of technical data for a web-based multimedia O&M information system, an adapted SLM technique will be used. This work will also investigate if SGLM can be applied to improve recognition performance of shape and structural methods to provide an optimal solution to the problem of graphics recognition for architectural and engineering graphical domains.

3. Graphical Object Recognition and SLMs

Graphics recognition involves the recognition and structuring of geometry such as points, lines, text, symbols on graphical documents into meaningful objects for use in graphical information systems. Graphics recognition is a sub-field of pattern recognition and includes classification and recognition of graphical data based on shape description of primitive components, structure matching of composite objects and semantic analysis of whole documents. A sub-field of semantic analysis is to treat the graphical notation as analogous to textual language by, for example, constructing a graphics parser based on a formally defined grammar.

Statistical language models have been used with natural language processing applications such as speech recognition and spoken language understanding. They are based on the analysis of a large corpus of text to construct a probabilistic contextual model for the occurrence of words (and/or larger structures). The model is used to increase the effectiveness of other recognisers.

This work will investigate the use and adaptation of SLM techniques to aid in the semantic analysis of graphical data for the purposes of recognition, indexing and retrieval. A number of techniques (n-gram models, hidden Markov models, part-of-speech tagging) will be adapted and evaluated for graphical data. A rational for their use will be formulated. A categorisation of the different domains of graphical data by form and content will be made. Software modules will be created to test and illustrate Statistical Graphical Language Model (SGLM) techniques' effectiveness on the architecture and engineering domain.

The suggestion that this may be a valid approach is re-enforced by the similarities between textual and graphical notations [1]:

- Both consist of discrete objects (words, graphical objects)
- Objects have a physical form (spelling/pronunciation, shape)
- Objects have a semantic component (meaning, graphical object label)

- Objects are classified according to function (part of speech, object class)
- Objects are formed into larger components (sentences/paragraphs etc., regions/diagrams etc.).

Depending on the nature of the graphical notation, this analogy can be very strong. For example, at one extreme, visual programming languages have precise grammars that can be used to create well-formed software tools to edit, check and translate valid programs. Other notations, while containing conventional symbols, are depictions of the real-world configuration of objects that has a much less structured syntax, although there is usually some underlying structure. For example [18], on a map a building needs access to a road that has connections to other roads, and so on. Part of the proposed research is to characterise the applicability of SLMs to each subject domain according to this underlying structure. Of course, there are differences between natural language and graphical notations:

- Natural language is one-dimensional; graphics are usually two-dimensional.
- Natural language is sequential - the meanings of sentences are determined by the order of their component words; graphical notations use more complex spatial relationships.
- The vocabularies in natural language texts are generally larger than the symbol vocabulary of most graphical notations.

The proposed research will assess how these differences affect the applicability of SLMs and how they can be incorporated into a SGLM. Also, SLMs will be investigated and evaluated on the problem of automatically recognising and interpreting graphical data on technical drawings for the development of an operation and maintenance information system for plans within buildings and other facilities.

3.1 Statistical Language Models

Statistical Language Models are estimates of probability distributions over natural language phenomena such as sequences of letters, words, sentences or whole documents. They were first used by Andrei A. Markov at the beginning of the 20th century to model letter sequences in Russian literature [13]. While this was a linguistic task, these methods were then developed as a general statistical tool. They have been primarily developed for natural language processing. Automatic speech recognition is arguably the area that has benefited the most from SLMs where they have proved quite successful [7]. A possible system architecture (to improve speech recognition) is shown in figure 1. SLMs have also been used in the fields

of machine translation, optical character recognition, handwriting recognition, information retrieval, augmentative communication systems and many more [8].

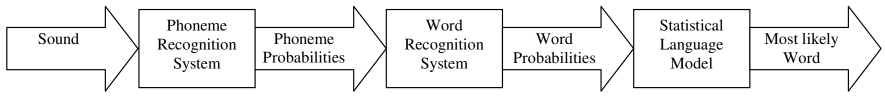

Figure 20 Typical speech recogniser.

SLMs employ statistical estimation methods that make use of large corpuses of training data in the form of text. These corpuses can consist of thousands or millions of words from a language. In order to be as representative as possible of a language, a corpus usually has text from a wide variety of sources. For example, the derived *Brown Corpus* [13] consists of one million words taken from fifteen different categories such as legal text, scientific text and press reportage. A corpus can however be built to just include a particular sub-set of language, if so required for a particular task. Generally the larger the corpus the better it will be for statistical language modelling.

3.1.1 N-gram models for SLM

A SLM is simply a probability distribution *P(s)* over a sequence of words (or sentences or whole documents and so on). In practice it is impossible to know the probability so instead the estimate of the probability is used. This estimate is found by using the frequency of text within the training data. Generally a language model is represented as a conditional probability distribution of the next words to be seen, given the previous words, that is:

$P(w_i \mid h_i)$, where $h_i = (w_1, w_2, ..., w_{i-1})$ and w_i is the i^{th} word (1)

The purpose of a SLM is to assign high probabilities to likely word sequences and low probabilities to unlikely ones. Different SLM models can be combined using techniques such as linear interpolation. N-gram models are the most widely used SLM technique. They use the previous *n*-1 words to predict the next word. Generally *n* is either 2 (a bi-gram), 3 (a tri-gram) or 4 (a four-gram). A bi-gram model is looking for the probability $P(w_i \mid w_{i-1})$ and a tri-gram model is looking for the probability $P(w_i \mid w_{i-1}, w_{i-2})$. These probabilities are estimated by using relative frequency:

$$P(w_i \mid w_{i-1}) = C(w_{i-1}w_i) / C(w_{i-1}) \quad (2)$$

and

$$P(w_i \mid w_{i-1}, w_{i-2}) = C(w_{i-2}, w_{i-1}w_i) / C(w_{i-1}, w_i) \quad (3)$$

where *C* is the frequency of the enclosed words in the training corpus. For example if a sentence starts with “I was walking the” a tri-gram model would use the two words “walking the” to predict the next word. This prediction is done using the training data corpus. The corpus is analysed for co-occurrences of words, in this case triples that start with “walking the”. The triples are sorted in terms of the frequency they appear in the training data, with the most frequent triple the one used for the prediction. To use this example, the training data may have the triple “walking the dog” as the most frequent triple that starts with “walking the” so the word “dog” is given as the prediction.

There are other SLM techniques which are also used [15]. These include *Decision Tree* models [2] which assign probabilities to each of a number of choices based on the context of decisions. Some SLM techniques are derived from grammars commonly used by linguists. For example Sjilman et al. [16] uses a declarative grammar to generate a language model in order to recognise hand-sketched digital ink. Other methods include *Exponential* models and *Adaptive* models. [15] suggests that some other SLM models such as *Dependency* models, *Dimensionality* reduction and *Whole Sentence* models show significant promise. However this research will focus on the most powerful of these models the N-gram and its variants [18].

There are problems that affect SLMs. One problem is the data sparseness problem. This problem is simply that a training corpus, no matter how big cannot cover all probabilities. These probabilities are then automatically assigned a zero value. So when a phrase occurs that has not been seen before, that is, it is not in the training data, its probability is zero. To solve this problem techniques are used that assign a 'non-zero probability' to 'zero probability'. This process is called *Smoothing* [13,7,8].

3.1.2 Evaluation of SLM

In order to compare SLMs common measures used. These are based on the concepts of relative entropy, cross entropy and perplexity [13]. Combined with the use of standard corpora and test data sets, they provide for the calculation of objective metrics for SLMs.

Entropy is a measure of information in a random variable. It can be used as a metric to measure how much information there is in a particular grammar, and also to measure how well a given N-gram model will be able to predict the next object. Computing entropy requires that we establish a random variable *X* that ranges over a sequence of objects (the set

of which we will call χ) and that has a particular probability function, call it $p(x)$ the entropy of this random variable X is then

$$H(X) = -\sum_{x \in X} p(x) \log_2 p(x) \quad (4)$$

Entropy is measured in bits. The lower amount of the entropy we get the best model we have. The value of 2^H is the perplexity. Perplexity can be thought of as the weighted average number of choices a random variable has to make [8]. It can be seen as a measure of the size of the set of words from which the next word is chosen from. Generally the lower the perplexity the better the model.

3.2 Applying SLMs to Graphics

The success of statistical language models has been due to the efficiency of these models and to the linear structure of natural language utterances and the underlying grammar (the semantic and syntactic relationships between adjacent words). In graphical data, there is no rigid grammatical structure. However, a quasi-grammatical pattern does exist (for example, vent-duct-fan or witch-wire-socket) and this suggests that the language model approach may have some validity. However, unlike natural language, these sequences have no inherent direction.

Given the similarities between graphics and natural language, it seems reasonable that SLMs may have applicability to improve the classification of graphic objects as they do for natural language processing applications. On major difference is that, whereas language is naturally a one- dimensional sequence of symbols, graphics are inherently multiple-dimensional. Therefore, for direct application, it is necessary to extract one-dimensional sequence from the graphical data. One approach of doing that is to use adjacency relationships between objects on a drawing/document. Alternatively, the SLM theory can be extended to deal with two-dimensional "sequences".

Within this work SLMs will be used to measure the frequency of each graphical objects context allowing a graphics recognition system to be constructed in a similar way used for a speech recognition system (figure 2). In figure 2 the system depicted would be used to extend the classification capabilities of other recognition methods for example, based on an object's shape. The image is vectorised, cleaned and topologically corrected to form polygons. A

recognition system produces probabilities for candidate classes of each object based in this case on their shape [11]. The SLM, built from analysis of another data set, uses the probabilities to construct “phrases” of objects. A shape recognition system produces probabilities for the candidate classes of each object. The statistical language model uses these probabilities to construct candidate “phrases” of objects and use the n-gram model built from a corpus to select the most likely candidate object class.

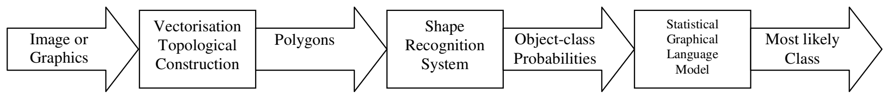

Figure 21 Possible graphical object recognition system with SGLM (see figure 1)

4. Graphical Recognition System

A main outcome of this work will be a software module that can be used and evaluated in the production process of O&M systems. Figure 3 shows the software configuration envisaged and the role of SGLM within this system. Digitised CAD drawings of the building/plant services will be processed to extract their component objects from which shape and structural descriptions are built. These feed into several description and matching algorithms, each of which produces one or more candidate categories to which each object may belong. A fusion algorithm produces an overall consensus decision giving a ranked list of candidate types. The SGLM module can then be used to improve the performance of the recognisers.

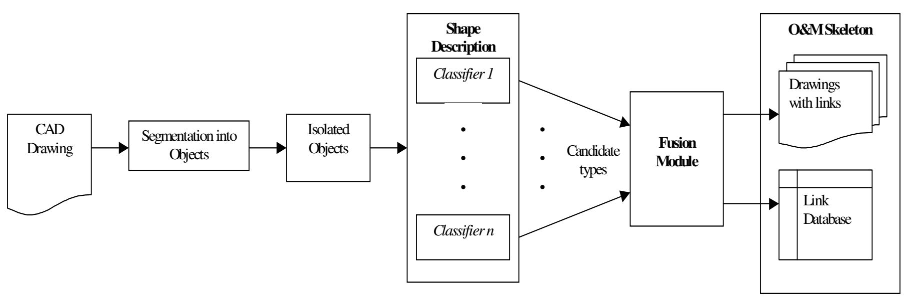

Figure 22 Graphical Shape Recognition System configuration

4.1 Evaluating the SGLM system

To evaluate the classification performance, *precision*, *recall* and *accuracy* (defined below) will be used. These notations are frequently used in information retrieval (IR) applications to evaluate statistical NLP models, and their use has crossed over into work on evaluating SLMs for many problems. Precision is defined as a measure of selected objects that the classification system got right.

$$precision = \frac{tp}{tp + fp} \quad (5)$$

Where *tp* (true positive) and *tn* (true negative) account for the cases the classification system got right and the wrongly selected cases in *fp* are called false positive. The cases in *fn* that failed to be selected are called false negative.

Recall is defined as, the proportion of the target objects that the system selected.

$$Recall = \frac{tp}{tp + fn} \quad (6)$$

Accuracy is defined as, the proportion of correctly classified objects.

$$Accuracy = \frac{tp + tn}{tp + fp + fn + tn} \quad (7)$$

Fallout is a less frequently used measure. It is defined as the proportion of non-targeted items that were mistakenly selected and is defined as follows:

$$fallout = \frac{fp}{fp + tn} \quad (8)$$

Intense evaluation of the system forms part of the overall research goal.

5. Conclusion and Future Work

Treating graphical notations as examples of language is well established and the use of syntactic grammars to generate or parse graphical is well known. Similarly, the development of statistical natural language models is advanced. However, the aim of this work is the application of statistical language models to graphical notations. By identifying graphical notations properties that make them suitable for these models, this research will offer a theoretical foundation for new methods of capturing, searching and analysing graphical data.

This work has relevance to sectors that collect, supply or use graphical data in digital form. There are enormous amounts of data in paper form, examples come from surveying, mapping, architecture, engineering and multimedia systems. Aside from the architectural and engineering domains identified for use in this work, it is envisaged that this research will result in software modules that can be used in various configurations for different application domains. For example, recognition and retrieval of graphical data for multimedia operations, automatically structuring geometry, detection and correction of errors in structure for graphics recognition.

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Voice Activated Command and Control with Speech Recognition over Wireless Networks

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Abstract

This paper presents work conducted to date on the development of a voice activated command and control framework specifically for the control of remote devices in a ubiquitous computing environment. The prototype device is a Java controlled Lego Mindstorm robot. The research considers three different scenario configurations. A recognition grammar for command and control of the robot has been created and implemented in Java, in part in the recognition engine and in part on the robot. The physical topology involves Java at each node endpoint, that is, at the handheld PC (iPaq), the PC workstation, the Linux server and onboard the robot (including its Java based Lejos OS). Network communications is primarily WLAN with an element of IR where the robot is concerned. The speech recognition software used includes Sphinx4, Microsoft SAPI and the Java Speech API. We compare these speech technologies and present their benefits in the context of this research. For each given scenario we present and discuss the implementation challenges encountered and their corresponding solutions. We outline our future plans to create additional grammars to extend the frameworks range of devices.

1. Introduction

This research project is concerned with building a framework with applications for command and control of a remote device by voice activation with speech recognition from a local control station over a wireless network in three different scenario configurations. In each scenario Java plays a critical role.

The first of these scenarios or configurations is based on a PC workstation under the Windows operating system connected via a wireless network to a PC-based server. The server issues commands to a remote device. The second scenario will involve developing a distributed speech recognition engine, between an iPaq pocket PC and a PC based server which will issue the commands to the remote device. The third scenario will involve a mobile device, specifically an iPaq Pocket PC that will connect over a wireless network to a PC-based server. The server will, again, issue commands to the remote device.

For purposes of this research project the remote device will be a Java controlled Lego MindStorms robot that will move and undertake certain actions under instructions relayed to it over a wireless interface. The robot could be replaced with practically any computing or electronic device which has a Java Virtual Machine installed. As part of this research it is our intention to develop a speech recognition engine using the Java programming language.

2. Technology Review

2.1 Applications of Speech Technology

The applications for speech recognition can be grouped into three distinct categories; these are command and control, dictation and authentication

Command and Control applications are concerned with providing the user of these systems the means to control items within their environment with voice commands appropriate to the domain. The appliance of command and control technology may manifest itself in the control of user interface menus in personal computing desktop applications or the control of large scale mechanical or electronic and computing devices.

Dictation applications allow the user to speak to the system and have it generate a transcript of what has been said. This is particularly useful in legal or medical arenas where information is recorded in real time and making written notes would be too slow. Specialized dictation grammars exist for application domains such as this. Furthermore dictation and command/control functionality can be combined in word processing applications such as Microsoft Word.

Speech technology can also be used for authentication purposes as part of a security system. The signal analysis algorithms employed as part of a speech recognition front end generate a feature vectors which can be matched to a pre recorded sample of a users voice. Given that each person has a unique voice print this can be used for authentication purposes.

2.2 Types of Speech Recognition Systems

Speech Recognition systems can be classified according to whether they are speaker dependent or speaker independent. Speaker dependent speech recognition engines require the user to train a profile of their voice for the engine to use when performing recognition. This process typically involves reading sample passages of text to the engine. Conversely speaker

independent systems do not require the user to train them before achieving high recognition accuracy. In this instance a pre recorded corpus of words is compared to the input speech vectors to generate recognition result.

In general terms speaker dependent systems achieve greater recognition accuracy given that the engine will be customized for a specific users voice, however speaker independent systems can achieve comparable accuracy levels where the grammar is constrained and as such are ideally suited for applications which may have a large number of users.

2.3 Process of Speech Recognition

The components of speech recognition systems include a speech corpus (database), a frontend processing system and a speech decoding unit. The frontend is responsible for analyzing the speech input and extracting feature vectors which will be used in the decoding process (figure 1). The speech corpus, in the case of speaker independent recognition engines will contain acoustic information for all the words and phonemes which the corpus contains. The speech decoding process compares input features generated by the frontend with those in the corpus, the result is usually a probability score, representing the engines confidence in the accuracy of any match found.

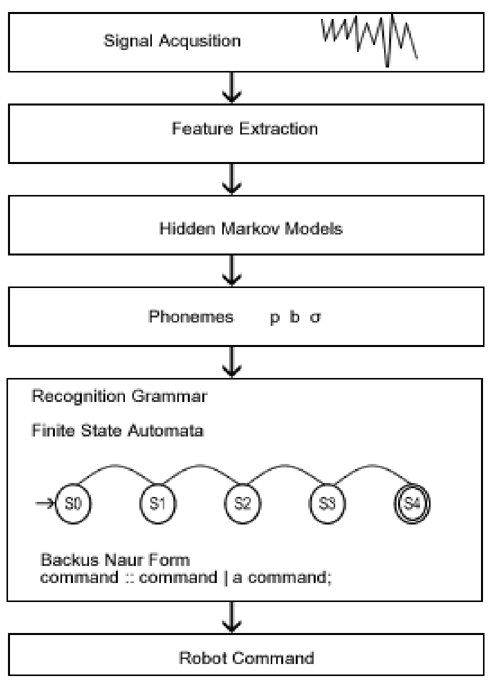

Figure 23 Speech Recognition Process

Modern speech recognition systems use stochastic techniques to model and decode speech signal data. Hidden Markov Models (HMM) have become the most successful statistical method for speech recognition. The HMM phase of speech recognition comes after an initial analysis and feature extraction process on the incoming speech signal. The feature extraction process generates feature vectors which are used as the input to the HMM.

A Markov model is specified by the states Q, the set of transition probabilities A, defined start and end states and a set of observation likelihood's B. A Hidden Markov Model formally differs from a Markov model by adding two other requirements. Firstly it has a set of observation symbols which is not drawn the from the same alphabet as the state Q. Secondly the observation likelihood function B is not limited to the values 1 and 0, in the HMM the probability can take any value between 0 and 1. The parameters needed to define a HMM are as follows:

- o A set of states
- o Transition probabilities
- o Observation likelihood's
- o Initial distribution
- o Accepting States

In order to extract a suitable output for speech recognition we must parse the representation which the markov model contains.

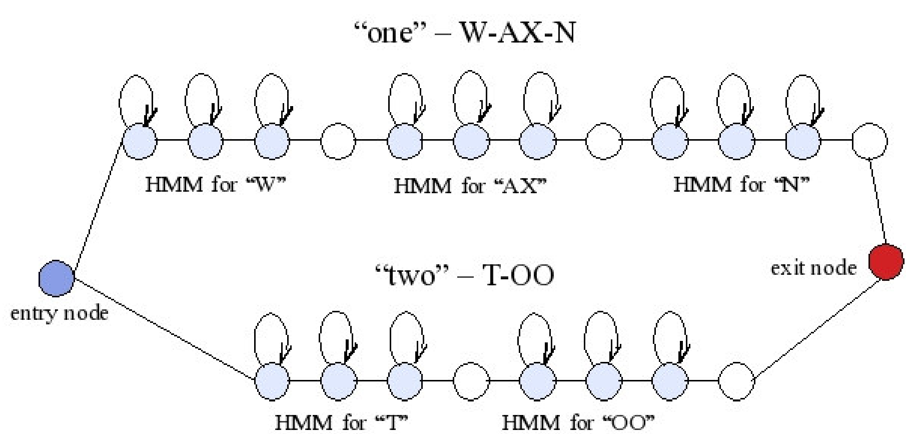

Figure 24 HMM Decoding of Phones (Taken From Sphinx4)

Figure 2 shows the HMM graph for the words "one" and "two" according to the Sphinx4 speech decoder. HMMs are generated for each phoneme that constitutes a word. Each HMM has a transition from to various nodes in the graph and to itself. The Viterbi [1] algorithm is used to find the best path through the graph based on the highest score of each transition.

2.4 Selecting a Speech Engine

The Java Speech API [2] is used to provide a platform independent speech recognition and synthesis interface for Java applications. Sun Microsystems supply a reference standard for the Java Speech API, but they do not provide an implementation. The Java Speech API implements no speech processing functionality of its own but allows Java applications to plug into functionality available on the host operating system.

Recent advances in signal processing algorithms coupled with the development of HMM based decoding techniques, has led to the development of many highly accurate speech recognition engines. The majority of these speech engines are commercial products which include text to speech capabilities in tandem with their recognition functionality. These products include Microsoft Speech API version 5 [3] (SAPI5), IBM Via Voice [4] and Dragon Naturally Speaking [5]. One defining characteristic of all these engines is that they are speaker dependent.

In the open source domain the Sphinx project is the only suitably large candidate. The Sphinx project is concerned with developing HMM based speaker independent recognition systems. The project has 3 engines available as source code downloads, namely Sphinx2, Sphinx3 and Sphinx4. Sphinx2 is a real time speech decoder, its feature include continuous speech decoding, can provide a single best or several alternative recognition's, support for bigram, trigram, or finite-state grammar language models. Sphinx3 is a state of the art speech decoder written in C. While it has a slower decoding speed than Sphinx 2, it provides more accurate recognition. Initially it was developed to perform batch speech decoding from audio files but is now capable of live decoding.

Sphinx4 is the latest speech decoder to be released by the project, initially it started as a port of Sphinx3 to the Java programming language; however the engine evolved to become more flexible than Sphinx3. A defining characteristic of Sphinx4 is the configuration of the engine, which is achieved through an XML configuration file. Each Java object in the Sphinx4 system can be instantiated through this file, this helps keep application code which implement Sphinx4 clear of Sphinx4 code which makes for easier debugging. Sphinx4 also includes an implementation of the Java Speech API. Its object oriented structure and easy XML configuration make it an ideal choice for conducting research

This research project defines a number of application scenarios [section 3]. A different speech engine is implemented in each of the scenarios, Scenario 1 uses Microsoft SAPI5 with

the Cloudgarden JSAPI [6] implementation; Scenario 2 uses the Sphinx4 speech recognition engine which includes its own JSAPI implementation, Scenario 3 which is still in development, will use a lightweight Java/C++ based speech decoder based on the Sphinx engine.

We tested the performance of the Java Speech API with Sphinx4 and SAPI5 in the context of developing this framework for command and control. The test provided an insight into the characteristics of speaker dependent and speaker independent recognition engine and presented and opportunity to compare the current state of the art of both approaches to speech recognition.

2.4.1 Performance Analysis under the Java Speech API

Under Windows XP, the setup time for a JSAPI recognizer under both speech engines is in a similar range, although SAPI5 is marginally faster. Most notable is the length of time Sphinx takes to process the first command; after this initial command has been processed the time drops back to just over 3 seconds for each subsequent command. The SAPI5 configuration is extremely quick for all commands; although SAPI could be prone to a high number of errors, this occurred under JDK1.4 where the average error rate was 1.5 (accuracy of 63%). The graph shown in Figure 2 highlights the speed of the SAPI engine in processing the commands.

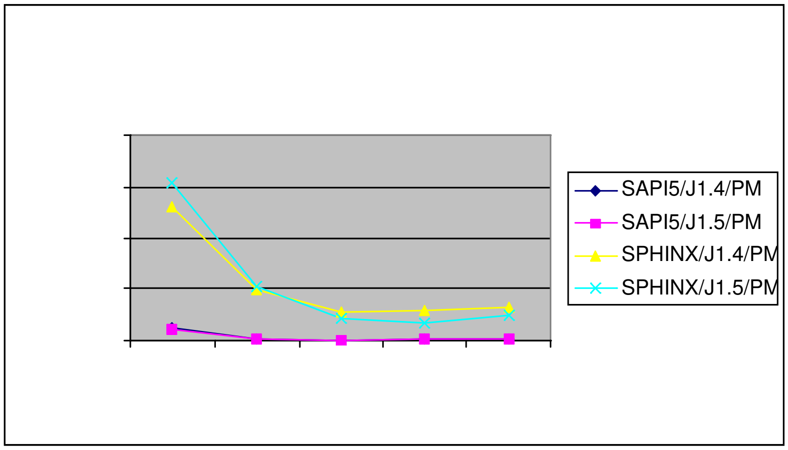

Figure 3 SAPI VS Sphinx Windows XP

Figure 3 also shows that Java 1.5 is faster than 1.4; this is most noticeable with the Sphinx4 test. While the setup times are almost identical, the time recognition time drops to around 2 seconds in comparison to 3 seconds with 1.4. The SAPI5 test also ran faster with JDK1.5, although the difference is marginal when compared to performance gain Sphinx4 achieves.

Sphinx encountered a trough in recognition accuracy with the Pentium IV/1.4 configuration, with at least one error occurring in the majority of tests, thus yielding an average of 1.4 errors which translates to an accuracy of 65%. In addition, the recognizer setup time was much longer than those on the Windows XP test machine. With JDK 1.5 Sphinx4 yielded a recognition accuracy of 93%, with only 0.2 errors. One noticeable difference is the recognition times under JDK 1.5, we encountered numerous spikes where decoding of commands took between 8 and 30 seconds, this occurred on 3 occasions while issuing the "Backward" command. As a result the average command time for JDK1.5 on the Windows 2000 machine is slower than JDK1.4. In figure 3 the graph shows the sharp peaks and troughs in the Sphinx performance under JDK1.5.

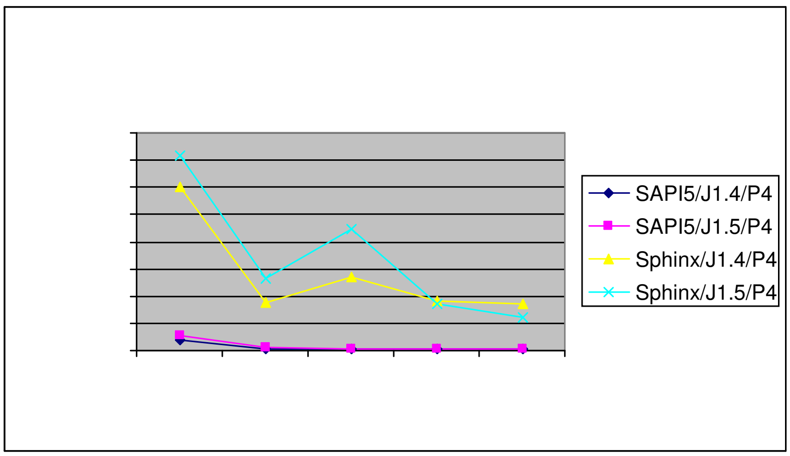

Figure 4 SAPI VS Sphinx on Windows 2000

The SAPI5 results on this machine were inline with the previous test, recognition time averages below 500ms and the setup time averages around 1 second. As with the Sphinx tests on this machine, the SAPI performance under JDK1.5 was not faster than JDK1.4.2.

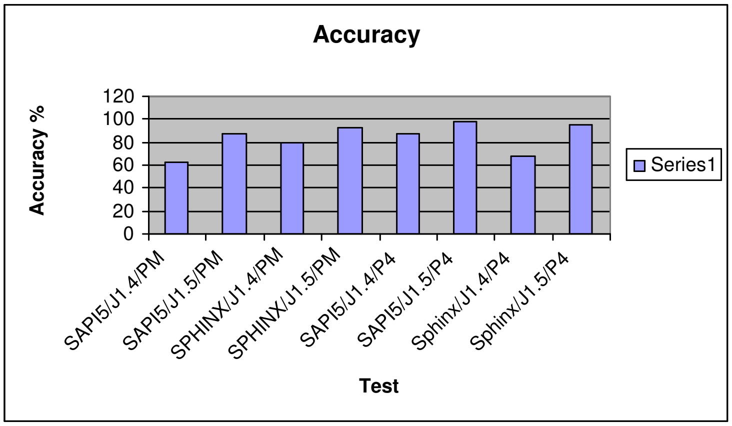

Figure 5 Accuracy Percentage

Figure 5 presents a bar graph indicating the recognition accuracy of test configuration. SAPI5 under Windows 2000 under JDK1.5 was the most accurate with a score of 98%, Sphinx4 on the same system and the same JDK received the second highest score with 95%. SAPI also holds the lowest score of 63% on Windows XP with JDK1.4. The average accuracy for both engines was 84%. Both engines had one trough of poor performance where the accuracy dropped considerably and as a result both engines received the same average accuracy percentage. If we ignore the trough values, then SAPI5 achieves the highest average score of 91% with Sphinx scoring 89%.

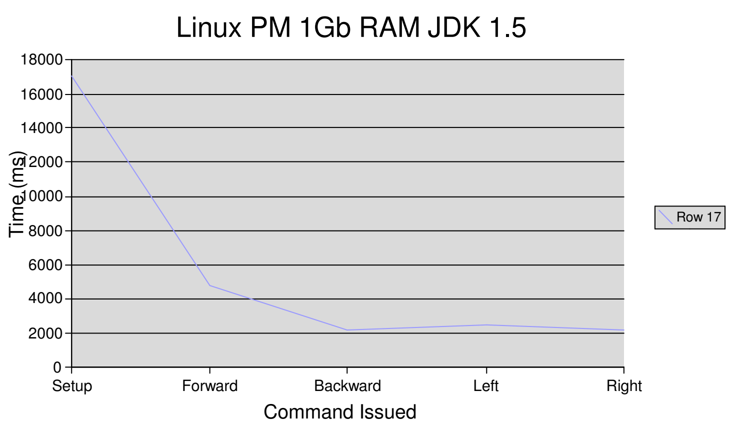

Figure 6 Linux Performance Results

We tested the Sphinx4 engine under Mandrake Linux 10.1 running the release version of JDK 1.5. This allows us to compare the performance of the Java runtime environment on a second operating environment for the purposes of speech recognition. Furthermore, Sphinx4 is one of the few large scale speech recognition engines available for the Linux operating system. In comparison to the Windows based tests the Linux test achieved the greatest accuracy with a score of 97%. Again the initial engine setup time is longer than

SAPI5/Windows, however it does perform better than Sphinx4 on Windows in both recognition processing time and accuracy.

The results of these tests show the relative strengths of both speech engines, performance wise there is little to separate them. There are significant differences between them, SAPI5 as a speaker dependent engine using a speech profile to decode speech input has the ability to recognize any speech utterance from the user who trained the profile. Sphinx4 is limited to recognizing only those words which are contained within the language model. This limitation in Sphinx4 makes it less suitable for dictation applications, but its high accuracy and open source code make it excellent for conducting research and building command and control applications. SAPI5 is an excellent engine for both dictation and command and control, but it is less adaptable for research purposes as it a closed system.

3. Application Topology

3.1 Scenario One

To date we have been developing the overall system architecture and evaluating speech technologies which will meet our requirements. Figure 1, illustrates the architecture of scenario one. In scenario one, we propose to develop a speech recognition application in Java using the Cloudgarden implementation of the Java Speech API. Cloudgarden provides JSAPI functionality in conjunction with a SAPI 4/5 compliant speech engine on the host operating system, supported SAPI speech engines include Microsoft SAPI, IBM Via Voice and Dragon Naturally Speaking.

The client application accepts speech input via microphone and performs speech recognition using the JSAPI. A successful output from the speech recognition process is one or more string tokens. The application delivers the recognized speech strings to a Java based server application over TCP/IP via a wireless network. The server application is running on a Linux operating system. The server processes the recognized speech strings in order to determine if they match terms in the robot control grammar. If a match is found, that particular command is issued to the robot over a wireless network.

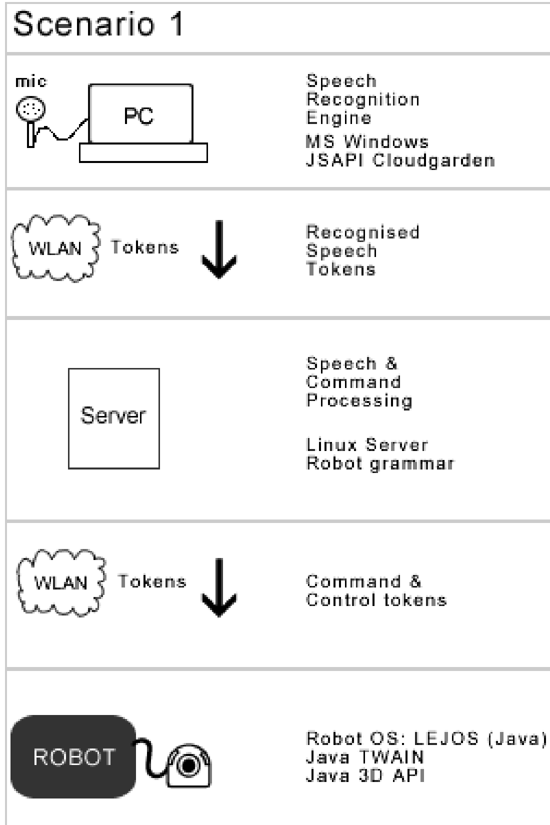

Figure 7 Scenario One

The robot will be fitted with a camera and we are investigating the possibility of using Java API's including the Java Twain and the Java 3D API to capture and process images returned to the client application from the robot.

3.2 Scenario Two

Scenario two offers an alternative approach. The PC workstation is replaced by a PDA with wireless networking capabilities, in this case an HP iPaq 5550 running Pocket PC 2003. The configuration of the HP iPaq Pocket PC 5550 is:

Processor	Intel XScale 400mhz
Memory	128mb RAM
ROM	48mb ROM
Networking	802.11b WLAN and Bluetooth
Operating System	Pocket PC 2003

The application on the PDA is concerned with capturing a speech input signal and sending it through the wireless interface to the server. The server hosts a processing engine for the robot

grammar as in scenario one, however it also has an additional layer of functionality, namely, the speech recognition engine.

The PDA provides mobility but has limited processing power. In order to lessen the load on the PDA the speech recognition engine is distributed between the server and PDA. The PDA has the Jeode runtime environment installed on it. Jeode is a Personal Java compatible runtime environment.

Personal Java [7] is fully compatible with JDK 1.1, however JDK 1.1 does not have sufficient libraries to perform signal capture or speech recognition. To circumvent this obstacle, the Java Native Interface will be used to plug into the sound capture functionality of the PDA hardware; a digitized speech signal will be returned. This digitized speech will be sent to the server application where the remainder of the speech recognition process will take place.

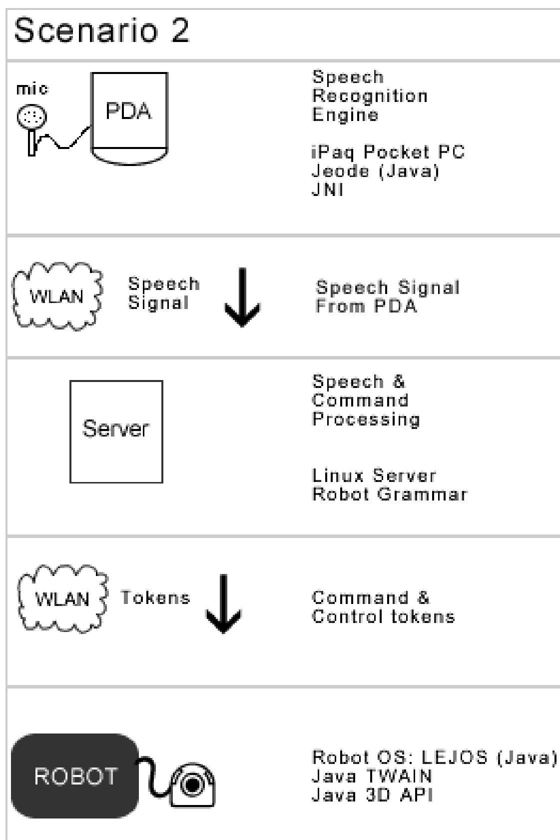

Figure 8 Scenario Two

Processing of the speech signal is the most processor intensive activity in the recognition process, therefore this function is assigned to the server, thus memory and processing power on the mobile device become of less importance. This approach presents greater complexity

in acquiring the signal, sending it over the network and reading it back into the speech processing engine.

3.3 Scenario Three

In scenario three we port the speech recognition engine from the PC workstation in scenario one to the PDA. Given the resources of the PDA, a simple copy of the speech engine from scenario one is not feasible. The Cloudgarden JSAPI implementation requires a SAPI compliant engine and Java Development Kit 1.3 or better, as these are not available on the PDA an alternative is needed. The open source Sphinx 2 can be used to provide speech recognition functionality on the device. Sphinx2 is written in C, therefore the Java client application will use the Java Native Interface to plug into the methods which are provided by Sphinx.

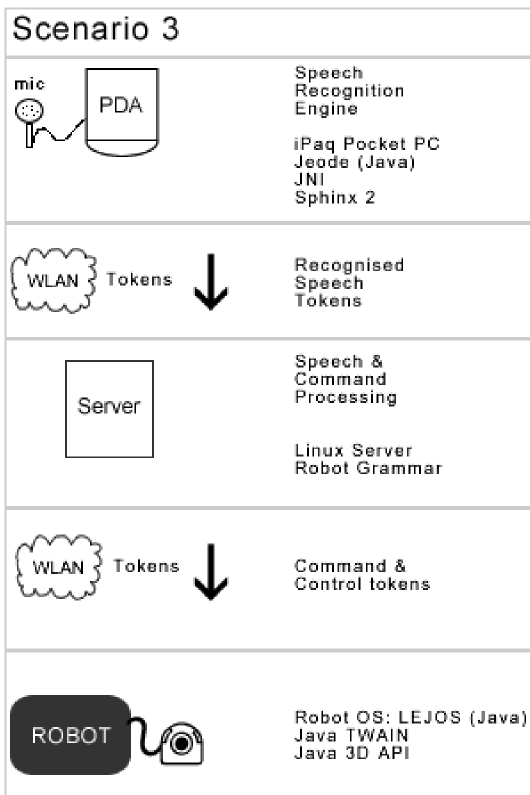

Figure 9 Scenario Three

The recognized speech will be sent over a WLAN link (TCP/IP) to the server application. As with Scenario 1 the server processes the recognized speech strings in order to determine if they match terms in the robot control grammar. If a match is found, the command is issued to the robot over a wireless network.

4. Design

4.1 Distributed Speech Recognition under Scenario 2

Scenario 2 requires a distributed speech recognition application topology. The architecture of this design is shown in figure 10.

The process begins with the client application installed on the iPaq, presently the client is written in C#, but will be converted to Java in due course. The application records and streams speech audio data from the client over the iPaqs wireless network interface to the server application.

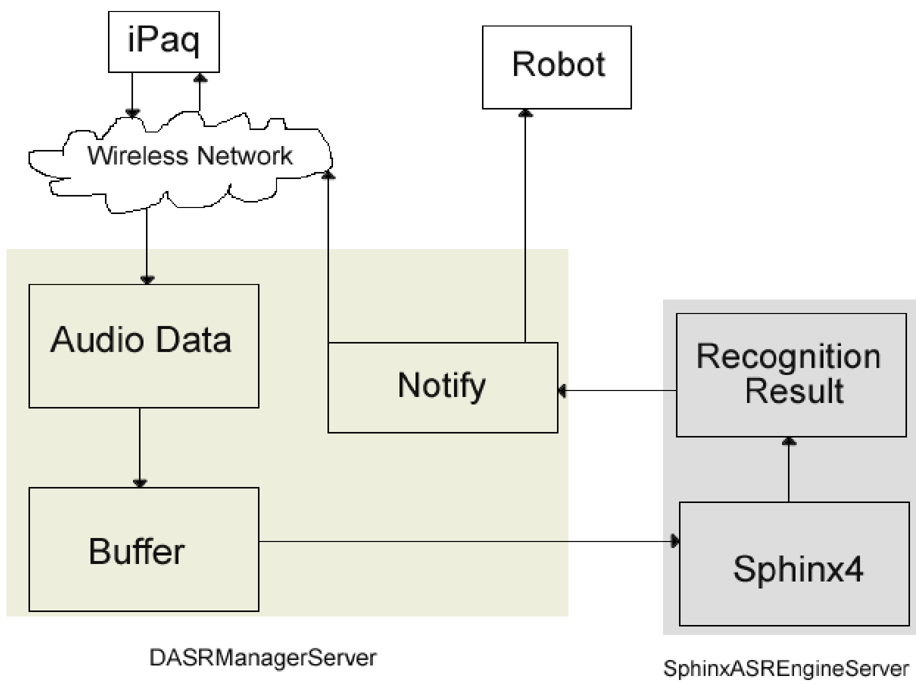

Figure 10 Distributed Speech Recognition under Scenario Two

The server application consists of two Java classes namely DASRManagerServer and SphinxASREngineServer. DASRManagerServer is responsible for receiving client connections and subsequently audio data send from the client. The class buffers the audio data before sending it to SphinxASEngineServer for speech recognition processing. The recognition result is send back to the Manager class and the notification process begins. If a command has been detected in the speech, this is sent to the robot (or other end device) a notification of the command is returned to the client.

4.2 Grammar Design

The commands appropriate to the target device are defined in a JSGF grammar file; this is used by the speech recognition engine to define what words the application can recognize.

```
#JSGF V1.0;
/**
 * JSGF Robot Grammar
 */
grammar robots;
public <forward> = forward | forward <distance>;
public <backward> = backward | reverse;
public <turn_left> = (turn left <distance>) | (left <distance>);
public <turn_right> = (turn right <distance>) | (right <distance>);
public <distance> = (five {five}) | (fifty {fifty}) | (ninety {ninety});

public interface RobotGrammarInterface {
    public int moveForward();
    public int moveBackward();
    public int moveForward(int distance);
    public int moveBackward(int distance);
    public int turnLeft();
    public int turnRight();
    public double turnLeft(int degrees);
    public double turnRight(int degrees);
    public void stop();
}
```

Code 1 JSGF Grammar and Java Interface

These commands are also built as methods into a Java interface. The interface is used by classes which wish to implement the real world functionality of a particular device.

The prototype device for this is a Lego Mindstorm [8] robot and we have devised a grammar which maps its functionality to software. The robots range of movements include forward, backward, left turn and right turn. We can enhance this further by specifying a distance or a number of degrees for the robot to move, the grammar is robust enough to cater for this. Code fragment 1 shows the JSGF grammar and the Java interface which defines the methods in code.

The implementation of the methods will vary depending on the application of the robot device, but the range of motions will be the same for the any application involving this robot.

5. Implementation Challenges

5.1 Ipaq Audio Capture

A suitable Java runtime environment must be installed on the Ipaq in order to run Java applications. The environment used in this research is Jeode, which provides JDK 1.1.8 compatibility and support for Java applets. The sand box security model implemented in Java prevents code from access to underlying system hardware, this has many security advantages but creates problems for application developers wishing to use low level device functionality, in our case access to the sound card. More recent versions of Java(1.3 and better) include the Java Sound API [9] which provides access to this functionality on more powerful desktop computers.

In order to gain access and record audio from the sound card the Java Media Framework (JMF) [10] was downloaded and a customized Java only version was built specifically for the device. The ability to customize the JMF is a relatively unknown and at this time, poorly documented feature of the software. Following numerous unsuccessfully attempts to record audio through the JMF, it was ascertained from other users that the sound functionality was not available to the JMF on the iPaq.

A pure Java solution to this problem does not currently exist. Under Scenario 2 the client is developed using C# and the Microsoft .NET Compact Framework [11] which includes low level access to the iPaq audio capabilities. The C# code is similar to Java and the runtime characteristics are identical i.e. the code is interpreted not compiled as is the case with Java.

Scenario 3 which is currently being developed, will use C++ code to capture the audio and populate a Java object with the data, this will be returned to a Java program using the Java Native Interface.

5.2 Robot Movement

The robots movement is controlled by timers which activate the motors for a specified time before stopping. In order to move the robot accurately, the timings of the motor movements must be synchronized properly. The robot moves on two caterpillar tracks each controlled by a separate motor, therefore in order to move forward both motors must be engaged in the forward direction, the same is true for reversing.

Formula:

```
(Degrees_To_Turn / 360) * Robot 360 Time
```

Code Implementation

```
public double turnRight(int degrees)
{
      return (degrees / 360) * FULL_CIRCLE_TIME;
}
```

Equation 1 Calculating the turning of the robot to left or right

Turning is more complicated, in order to turn left, the left motor must be stopped while the right motor continues to move forward and vice versa when dealing with right turns. To allow for a greater degree of control, a distance to turn can also be specified, to execute such a command the time to pause the motor must be calculated. The equation to calculate this is show equation 1.

The time it takes the robot to complete a 360 degree turn was measured and found to be a 10000ms (10 seconds), this is set as a constant value in the code.

5.3 Robot Communication Protocol

The Java control program installed on the Lego Mindstorm robot acts a server which listens for incoming data packets from its control PC. The control program simply uses the built in data port functionality to do this. In order to send commands successfully to the robot a protocol for communication needed to be designed and implemented.

Specific byte values within the RCX computer are allocated to perform certain tasks related to motor and sensor control , therefore these values needed to be avoided to ensure interoperability between the RCX and the Java control program. The byte range of values from 70 to 79 were found to be free for external use.

Binary Value	Byte Value	Function
1000110	70	Turn Right
1000111	71	Turn Left
1001000	72	Move Forward
1001001	73	Reverse

Table 1Robot Communication Protocol Functions

In the case of each function an additional value can be follow the function value, this value indicates a distance or degree parameter for the function. If this value is not present the execution continues with the default values. This allows the protocol to comply with the application grammar.

6. Conclusions and Future Work

The successful implementation of scenario one indicates that a framework for the command and control of remote devices is both feasible and practical when considerable computing power is available. The distributed speech recognition and command and control model described in scenario two is almost complete, upon completion it will be clear how the framework fits within the ubiquitous computing paradigm, however the initial results during development are positive that the distributed model of speech recognition will be succeful in the context of the overall application. Scenario two will also be developed further to incorporate a Java client to augment the current C# client implementation.

The framework can be easily extended and moulded to suit a variety of devices or applications. We propose to conduct further development of the framework utilizing additional software and hardware end devices specifically the voice activated remote control of a web camera. Incorporating additional devices will demonstrate the flexibility of the command and control framework and extensibility of the grammar.

The development scenario three will move the speech recognition even closer to the ubiquitous computing paradigm. A usable and easily programmable speech recognition engine which can run efficiently on a mobile device with limited resources will spawn endless possibilities for the development of mobile command and control applications.

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Mathematical Competencies of Third Level Students: A Review

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Abstract

Many lecturers of mathematics and related disciplines in Ireland and internationally believe there has been a gradual decline in mathematical competencies of students presenting for first year at third level educational establishments. Some of the evidence to support this view is reviewed, along with the types of solutions being applied in Ireland and the UK. Attention is drawn to the explicit and implicit decline in standards potentially associated with some of the solutions, particularly for short courses involving mathematics.

1 Introduction

The primary stimulus for this paper is the author's increasing sense over the last few years that while 3rd level student's inherent ability has been relatively constant[8], their capacity to apply such abilities to "basic business mathematics" (BBM) has been diminishing. The author has been teaching the basic business mathematics modules within the School of Business and Humanities across three courses since the opening of Institute of Technology Blanchardstown (ITB) in September 1999. These are two semester modules with 30% of marks allocated to continuous assessment and 70% to a 2 hour final examination, per semester.

This paper is essentially a review of both some worrying potential "trends in the making" at ITB and of supporting evidence for there being a decline in the mathematical competencies in Ireland, along with some suggested solutions, and a review of solutions both in Ireland and the UK. Counteracting any such problems is clearly a strategic issue for an institution due to the wider effects on general student retention.

One area of concern is the indirect potential lowering of standards associated with many student support schemes particularly for short courses, e.g. one year or two semester. While 3rd level institutions must service the society within which they find themselves it is important that employers and society are informed and aware of the actual capacity of

graduates. O'Grady et al (2004) depicts the type of results that may occur if cognizance is not taken of the effect of some student "supports", although O'Grady et al (2004) is directed at a broader set of issues.

In addition improved standards may in fact be what is required. From Forfás (2004):

> *Forfás is of the view that the overall standard of the Irish education system must be raised; Ireland must strive for continuous improvement and ensure that it achieves, and maintains, a high ranking among OECD states.*

where the report goes on to say:

> *The problem in relation to mathematics is underscored by Ireland's poor ranking of 16th, out of 28 OECD states, for mathematical literacy among 15 year-olds.*

1.1 Experience at ITB on the Higher Certificate in Business (BN003)

Initial evidence of a potential problem in BBM is shown by Figure 1 with relevant information shown in Tables 1 and 2 in Appendix A. While ITB is at an early stage of development there are potentially worrying signs in these BBM results. It should be realized that there are many factors which could in fact account for the decline in pass rates. The initial intake of students in 1999 got a lot of attention and had a special relationship with lecturers. Subsequent years have had other changes, although the main syllabi and the lecturer have remained constant throughout. A computer based practical component was introduced in the academic year 2000/01, and subsequently for 2001/02. This was temporarily suspended for 2002/03 and 2003/04 due to resource constraints. In years where the practical was given the number of lectures was reduced by one, with this being replaced by a laboratory session.

Of key importance will be the results at ITB for BN003 for 2004/05 and perhaps 2005/06 in order to establish whether the particularly poor outcome for 2003/04 is part of a trend or an anomaly.

[8] Based on simple introductory surveys of students looking at 3 basic business maths skills: Use of a scientific calculator, ability to draw a chart, and ability to follow a procedure. Also based on a

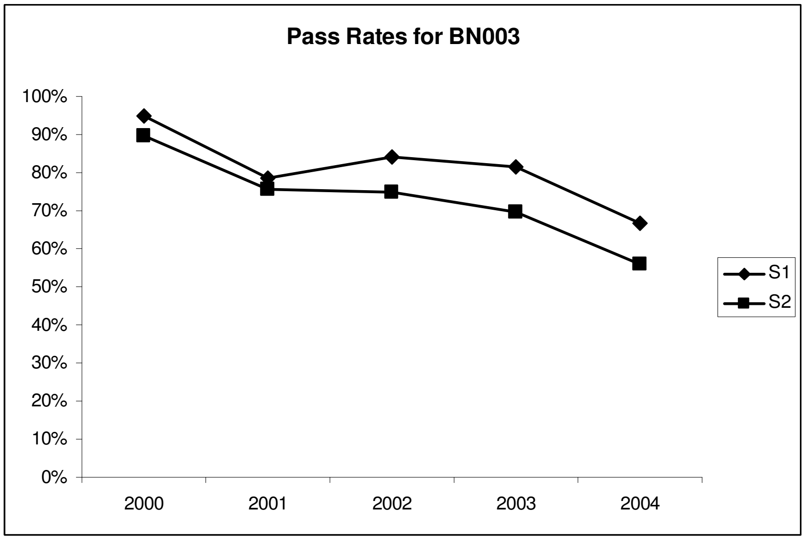

Figure 25: Business maths pass rates for Higher Certificate in Business Studies (BN003) since ITB opened. The year values refer to the end of the relevant academic year.

Notwithstanding the 2004/05 results there is a probable downward trend, which is more evident from the semester 2 results. Calculating the least squares slope for the semester 1 results: Slope b=–5.32%, and using a one tailed t-test shows that P($\beta_1 < 0$) = 96.0%, ie the probability that the population slope is negative[9] is 96.0%. For semester 2: Slope b = –7.31% and P($\beta_1 < 0$) = 99.5%.

This evidence is further reinforced by Figure 2, which looks at grade point values (GPV) of passing students. For semester 1 the correlation coefficient r = –0.58, slope b = –0.1126 and P($\beta_1 < 0$) = 84.5%. For semester 2: r = –0.93, b = –0.2868 and P($\beta_1 < 0$) = 98.8%.

Adjusting the GPV figures[10] to take account of changing entry points per year produces Figure 3, which shows less correlation now for semester 1 with r = –0.32, b = –2.3494 and P($\beta_1 < 0$) = 70.0%, and semester 2 r = –0.91, b = –8.1211 and P($\beta_1 < 0$) = 98.5%.

---

subjective sense after dealing with the students.

[9] This was done using a one tailed t-Test to construct a confidence interval that had an upper limit of 0. The associated p value gives the level of significance, and 1-p gives the probability that the population slope is indeed negative.

[10] See Appendix A.

The adjusted semester 1 analysis is suggesting that a relatively significant part of the downward trend for semester 1 GPVs may be accounted for by changes in CAO entry points. Of course in the current context that is again indicative of overall declining competency in mathematics. Figure 2 is more relevant to this paper.

Figure 2 is consistent with the anecdotal view of lecturing staff of disimproving standards in analytical and mathematical abilities of the associated students.

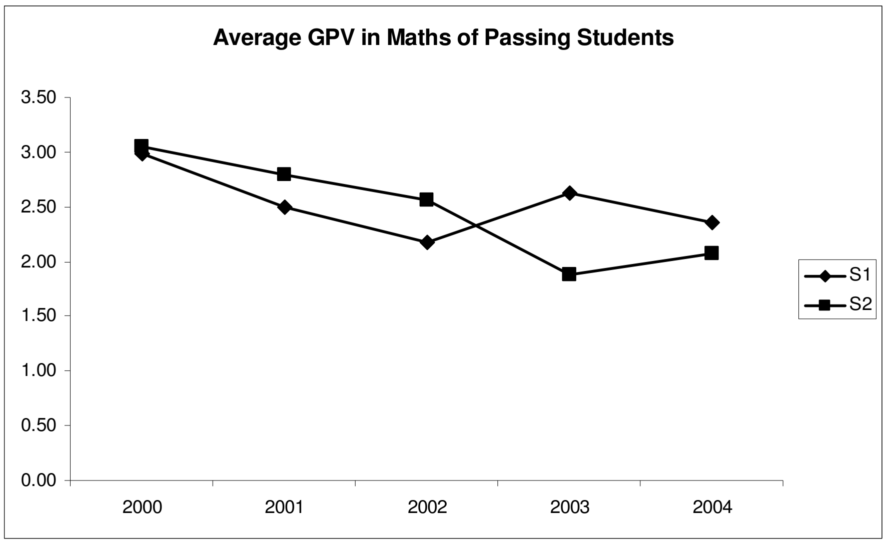

Figure 26: Average grade point value (GPV[11]) for BN003.

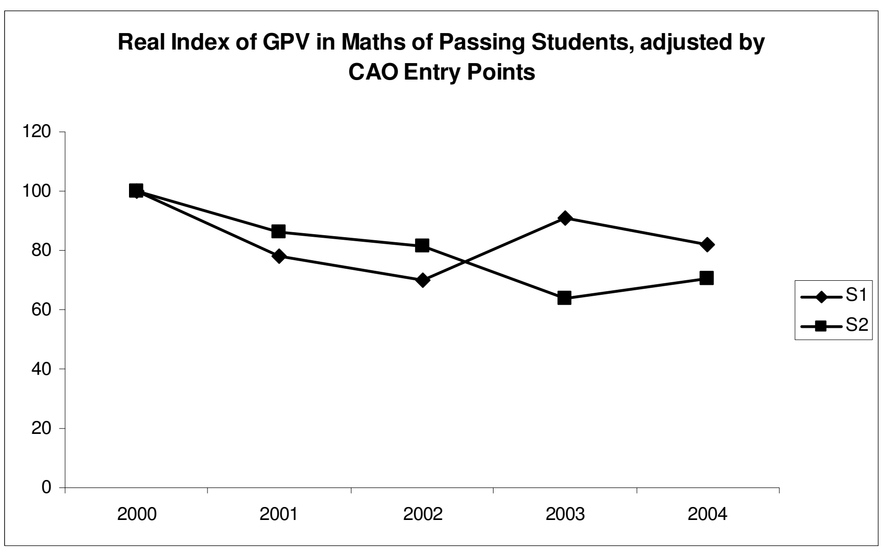

Figure 27: Adjusted GPV values by CAO entry points[12] using a real value index.

[11] GPV calculations as used at ITB are show in Appendix B.
[12] See Appendix A.

These results from BN003 are certainly not definitive. As yet there is insufficient data to draw strong conclusions. For example if the 2004/05 and 2005/06 semester 1 average GPV outcomes are 2.8 then we'd have b = +0.0084 and P($\beta_1 > 0$) = 55.4%, which is a complete turnaround. However allying the current results with the anecdotal sense of student standards from the lecturing staff, and the wider national and international perspective, would suggest that these trends, if unmanaged, will likely in fact go on to replicate the experiences verified elsewhere. Some form of intervention/support seems justified by the current analysis.

Current (2004/05) students have the same syllabus, lecturer, and overall resources as previous years. While a survey of the 2003/04 or previous cohorts is not available, a November 2004 survey of those who had missed or failed a continuous assessment worth 10% of overall marks, from two first year classes (BN003 and BN010[13]), gave the following results[14]:

Question: In relation to maths which of these apply
(students could check one or more from a list of options).

Option	**Number of Students**
Between the lectures, tutorials and notes I have plenty to help me master the subject	11
I think lectures are a waste of my time	1
I think tutorials are a waste of my time	0
I think the notes are very good	9
I think the notes are poor	2

These results would suggest that students are not identifying problems, from their perspective, as being caused by their current learning environment.

1.2 Experience at ITB on other courses

BN003 was specifically chosen above since it has displayed the most worrying of the pass rates within the three business mathematics related courses, so this does present a worst case scenario. In addition, analysis for example of the Higher Certificate in Engineering (BN001) is at some variance with the above. This could be for a number of reasons with an apparent

[13] Bachelor of Business in Information Technology.
[14] Total number included in the survey was 40, but some of these had likely in fact left without informing administration. Total responses was 18.

increasing pass rate trend within the BN001 mathematics results depicted in Figure 4: For BN001 Semester 1: b = +6.14% and P($\beta_1 > 0$) = 96.2% and Semester 2: b = +6.19% and P($\beta_1 > 0$) = 93.2%. It is certainly true that the syllabus content is quite different between the two courses. The absence of sufficiently many time points within the data make it hard to suggest anything definitively different is going on here between BN001 and BN003 that wouldn't be subject to possible significant change depending on the next few year's results.

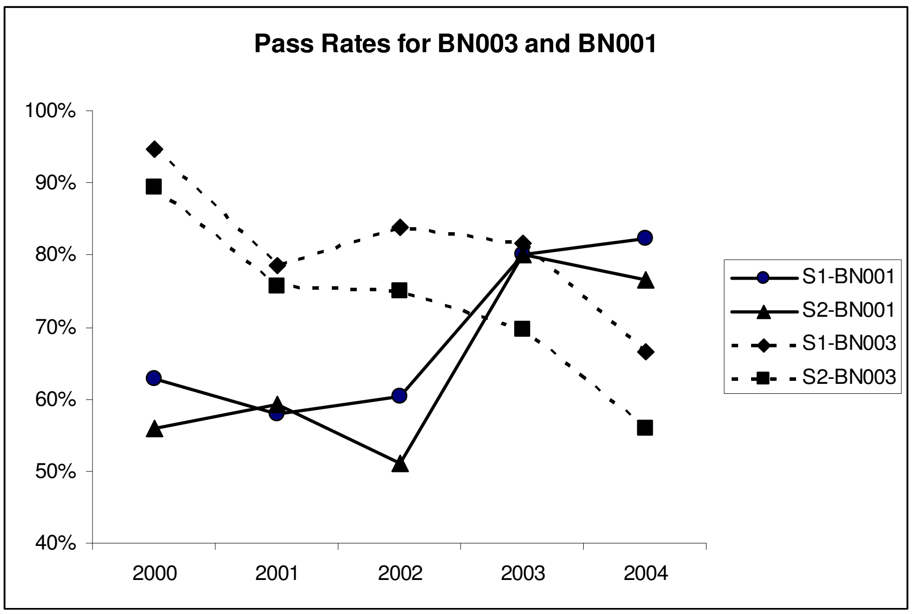

Figure 28: Comparison of pass rates for BN001 and BN003.

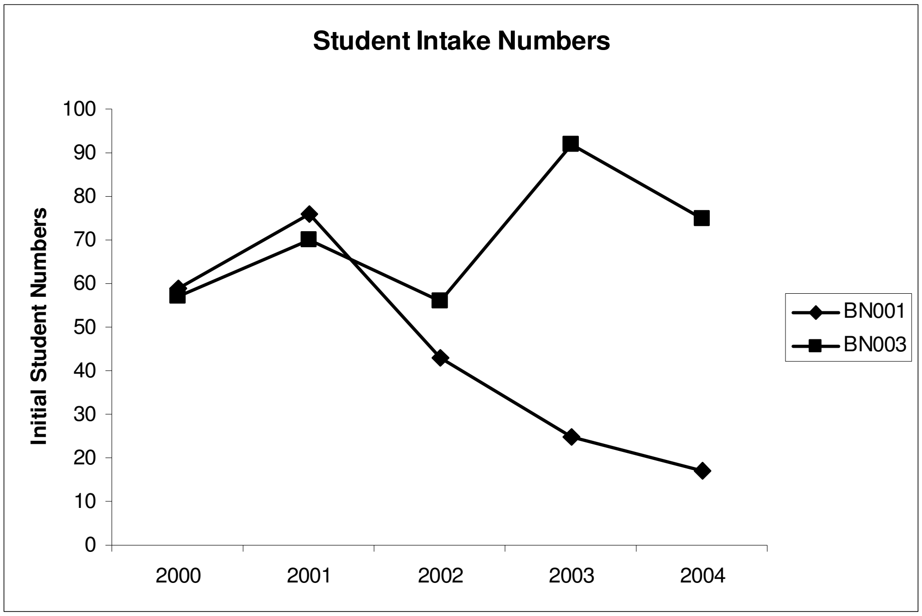

Figure 29: Total student intake on BN001 and BN003. This includes all students who initially registered for a course, but some may never have attended classes, and others will have withdrawn before examinations.

It must also be stated that two potentially significant changes on BN001 occurred in 2002/03 which continued in 2003/04. These where: a) the number of students admitted was significantly reduced, and b) the number of student support hours changed from 2 tutorial hour per week to 3 tutorial hours per week.

1.3 Evidence from Ireland

There is much anecdotal opinion that mathematical (and other) competencies are decreasing. This has been the subject of Oireachtas committees (Dáil 2003) and government reports. For example from O'Hare (2002):

> *Serious concern about the mathematical competence of students in schools and in higher education permeates the debate on the declining uptake of the sciences. The decline in performance in mathematics at second level was highlighted by the highest-ever failure rate (17%) in ordinary level Leaving Certificate Mathematics in 2001.*

From Forfás (2004):

> *There is a significant body of opinion, both in the enterprise community and among academics that standards have declined in the Irish education system over the past decade, both at second and*

> *third level. Empirical evidence to support this perception is contained in an earlier submission to the YES review*[15].

The employer's body IBEC in a press release from 18th August 2004 (IBEC 2004), state:

> *IBEC, the business and employers organisation, has responded to today's Leaving Certificate results by expressing major concern at the ongoing decline in the number of students taking science related subjects and the increasing failure rate in some of these disciplines.*

They go on to suggest that "*…consideration should be given to introducing bonus points in the Leaving Certificate for people who take science subjects.*"

On the same day the Irish Times had an article titled: "*Leaving results show high failure rates in maths, science*".

The Irish Times education editor writing for www.skoool.ie (Flynn 2004) wrote:

> *The chief examiner in the subjects has said that students are too preoccupied with part-time work, and their hectic social lives to give maths the concentrated attention it requires.*

Again commenting on the 2004 leaving certificate results, the Director General, Paddy Purcell, of The Institution of Engineers of Ireland (IEI 2004) comments:

> *… this years high failure rate in Maths and Science subjects mirrors a most worrying trend in recent years …*

Indirect evidence is provided by the provision of supports for mathematics by many third level educational institutions. From Flanagan & Morgan (2004):

[15] Reference to O'Grady et al (2004).

	UCD	UCC	NUI G	TCD	NUI M	UL	DCU
Science and Maths interventions	Faculty care team **learning support unit*	Pre-entry Science programme Easter revision programme ** peer tutoring*	Mathematics support ** peer tutoring*	**peer tutoring*	Mathematics support ** orientation*	Mathematics Learning Centre (Engineering / Technology)	**orientation & peer mentoring*

Initiatives funded under Targeted Funding for Special Initiatives: Student Retention

Some details on the University of Limerick's (UL) support centre are available at http://www.ul.ie/~mlc/About.html.

1.4 Evidence from UK

Hawkes & Savage (2000) state:

> *"There is strong evidence from diagnostic tests of a steady decline over the past decade of fluency in basic mathematical skills and of the level of mathematical preparation of students accepted onto degree courses."*

See also Gordon (2004), Perkin & Croft (2004) and Pyle (2001), for example. According to Savage (2003): "*... 200+ Departments of Mathematics, Physics and Engineering now give their new students a diagnostic test and provide some form of mathematics support.*"

2 Current solutions

According to HEA (2004):

> *A number of trends are evident in the types of student retention initiatives:*
>
> o *The provision of support to students in specific subject areas, notably in the areas of mathematics, science or languages.*

In terms of BN003 various supports have been tried on an ad-hoc basis to date, with the most "sophisticated" of these being Macromedia Flash based audio-visual animations of syllabus content. Other supports include or have included: Excel based automated question and detailed answer software, online access to all lecture notes, problem sheets and detailed

solutions, extra tutorial/clinic supports, and some provision of personal one-on-one support as requirements arise and resources permit.

Interestingly while the Macromedia Flash based material, which had been a large body of work to complete, was widely welcomed by students it did not have any obvious effect on final grades. This support was in place for the 2003/04 students on BN003.

Given the high level of student satisfaction expressed with this support material the only conclusion to date has been that students viewed the material without subsequently carrying out personal practice. This would be consistent with experience over the academic year with many students who view material as "easy enough", then fail to put in sufficient time and practice, only to find that they cannot in fact apply techniques come examination time. However, research is required to substantiate this, or any other explanation.

In the November 2004 survey (referred to previously) the following question and answers perhaps give some ideas:

What are the main reasons that you think that you didn't do so well in the maths CA?
(Students could select one or more options)

Option	**Number of Students**
I did little or no practice	9
I missed more classes than was good for me!	5
I did a fair bit of practice, but not enough with hindsight	2
I did a lot of practice, but I had problems on the day	0
The exam was harder than I expected	1
I'm lazy and find it hard to get started	5
I'm confused and find it hard to get started	6
There are personal circumstances which are taking up my time, and college is low priority at present	2
Other reasons	1

Lawson et al (2001) reported that CAL is the 2nd least used resource with 33% of respondents saying that the resource was "barely used". CAL was second after videos which had a 70%

"barely used" response rate. The most popular resources were "staff", with 48% reporting considerable use was made of the resource; and handouts with 31%.

Lawson et al (2001) provides an extensive review of supports available in the UK. Lawson et al (2003) "*distils the findings*" of Lawson et al (2001) giving more details related specifically to maths supports centres, with a chapter on dyslexia. Perkin & Croft (2004) updates Lawson et al (2001). Perkin & Croft (2004) state that of the 48 old polytechnics surveyed 35 (72.9%) had some form of learning support, with the following breakdown:

Number	35
Learning Support/ Drop-in Centre	25
Maths Clinic-Drop in with limited hours	4
Numeracy Support	3
Learning Support Tutor	2
Postgraduate Support	1

The old polytechnics perhaps represent the closest match to Ireland's Institute of Technology (IoT) sector.

Many initiatives aimed at the broader issue of student retention in Irish Universities are reported in Flanagan & Morgan (2004). This includes some of the student supports provided in Ireland. See MathsTeam for a series of case studies on student supports provided in various UK universities and colleges.

Other possible support examples/ideas include:

- **Extra/longer tutorial class times** – A key part of the learning process in mathematics is personal practice. In light of the chief examiner's comments reported in Flynn (2004) combined with local experience at ITB it is felt that more student "management", particularly at 1st year/entry level, may improve their performance. Longer tutorials would provide a better opportunity for both interactive parallel problem solving (students solve a similar, but not identical problem, as one is solved for them) and managed/directed time, when students could attempt problems under direction, and in addition avail of readily available support. Extra and longer tutorials are currently in place on BN001 at ITB, with a total of 3 hours per week, allocated in a single 2 hour class, followed later in the week by a 1 hour class. Anecdotal evidence suggests this is working well, but it has only been in place two years, so it is too early to tell.

- **Streaming of students within an existing syllabus** – Similar to an honours and pass two level system, the idea here is to avoid exposing weaker students to more advanced

material, which can negatively impact their overall perception. Students would have the option to skip certain lecture classes and associated materials and then sit a simpler set of examinations, on the reduced content. Maximum grade available is lowered pro-rata to reflect the reduced content. While it is a somewhat defeatist approach, since it accepts the lower standard, it is perhaps relatively simple to implement, and is at least better than doing nothing. This approach is not in use at ITB nor has it been reported anywhere to date. It would most likely meet with opposition from lecturers whose own subjects would be impacted negatively by the omitted content. However the question of whether knowing 60% of a course well is preferable to know 100% poorly must be posed.

- **"Struggling student" manager** – Surveys of students performing poorly in BBM at ITB have regularly reported that they "need help but don't like to ask questions"[16]. In addition when extra time slots have been made available, for one-on-one support that are reservable by students, little use has been made of these. Similarly optional additional and targeted tutorial ("clinic") support has been met with decreasing attendance levels. See also Lawson et al (2003) under "Student Engagement".

In contrast most students have been found to have little difficulty looking for assistance once contact is made by the lecturer. This gives rise to the idea of having a suitable resource who would actively "pursue" a range of students who are found to be having difficulties by course lecturing staff, across all first year classes. This is basically a more proactive drop-in centre, perhaps more aptly it might be called a "called-in centre". Once the guidelines from Lawson et al (2001 & 2003) are followed then such a proactive service might be what these students would most benefit from to get them started.

A key aspect of support provision is identification of students who will benefit from such support. Due to "grade inflation" (see O'Grady et al 2004) required entry standards for third level courses are no longer necessarily consistently indicative of expected competencies in mathematics. The solution adapted most generally in the UK appears to be early diagnostic testing. This is at an earlier stage of development overall in Ireland but Flanagan & Morgan (2004) reports that several institutions have systems in place or are working towards implementation of such diagnostic testing. As sufficient data becomes available from such testing any further "grade inflation" should be detected.

[16] 9 out of 18 responses in a November 2004 survey of students who had failed a continuous assessment BBM examination. Survey was of a potential 40 students, across two first year classes, BN003 and BN010, with some of these 40 probably having left the course without notifying administration.

3 The standards dilemma

Evidence of a problem has been provided here and is widely accepted in general. Possible support options have just been outlined in section 2, but there is a further aspect to consider, and it is a problem encompassed by the term "grade inflation", see O'Grady et al (2004). The concept of "grade inflation" addresses a wider range of issues.

If person A can learn to complete a task unsupported, have they a higher standard at this task than person B who needs support? Having provided supports for person B to the extent that now A and B can complete that task equally, then are they of the same standard?

It can be argued that, in terms of the specific outcome of completing the task, A and B are of equivalent standard. However academics also sometimes argue that in academic terms A has a higher standard than B, and the questions above are regarded as too narrow in determining the "standard" of the individuals. For example, in Gordon (2004) the fact that students took longer to answer questions was regarded as indicative of lower performance:

> *… however, the 2001 cohort did take an average of 2 min longer than the 2000 students, and the 2002 cohort took a further 2 min. Since Diagnosys does not have a fixed time, nor fixed question bank, this would indicate a decrease in performance, that is, they take longer to get the same mark.*

The "academic standard" can be hard to pin down in measurable terms as required learning outcomes may have been fully achieved by both individuals, and based on a range of imaginable examinations these two will be awarded the same grade … But perhaps business in particular might value and benefit from the additional information based on the path to the grade in addition to the grade itself; or benefit from a grading system that could take such additional factors into account.

Certainly some levels of business would be quite satisfied with either individual as task completion is all that is required, but there are also areas of business where variation on the original task is a key component of the business, and in such contexts there is probably benefit in hiring A over B.

Within this context the more supports that students require, or are provided with, the more the academic standard is potentially reduced, or at least becomes shrouded by the provision

of the supports. Of those receiving supports who are the ones who in fact have a high task specific and broader “academic” standard? Who are the A’s and who are the B's?

The other side of this business focused standards argument is that 3rd level education should service the needs of the current cohort of students and thus society, within some reasonable degree of year to year variation. Standards or approaches to education that exclude many people are not of much real value.

The issue is further complicated by the fact that there are certainly students with high ability, effectively A’s, who need, for a variety of possible reasons, some support to bring out this ability. The suggested new grading system from above incorrectly labels this type of person.

The dilemma of providing supports with consequential grade inflation, or no support, with consequential student attrition, can be resolved, once it is recognized and managed, or for that matter possibly accepted. For a 3 or 4 year degree program supports provided in year 1 only should not be expected to inflate grades obtained in the final year. More susceptible to grade inflation are shorter courses, such as the 2 year Higher Certificate offered in Ireland, or in general where supports are provided up to and including award years. Perhaps government, society and business will need to explicitly make clear their preference: Grade inflation, lowering competency, and consistent or improving pass rates, or consistent standards possibly associated with increased fail rates.

4 Conclusions

There is clearly a problem nationally and internationally, which is being actively assessed and addressed by many institutions in many different ways. It is still too early to say if a corner has been obviously turned due to specific and repeatable interventions.

ITB is still in its early years. Possible trends mirroring national and international experience may be present, but more data is required to decide to a reasonable level of confidence. However, it would be naïve to expect that ITB will be that much different in terms of the students it receives. Initial supports at ITB at any given year for BN003 and BN001 have included one or more of: Macromedia Flash based audio-visual material, Excel based visual basic Q&A support, online notes and practice questions and answers, extra class tutorials, and one-on-one or small group meetings with lecturing staff. The most desired support from a student point of view seems to be one-on-one contact, with many struggling students reporting that they do not like to ask questions. This is consistent with research in the

UK.There are a wide range of supports possible, but only time will tell which work best in general, or in specific contexts. Implementation of some form of diagnostic testing seems essential to appropriately and accurately manage the subsequent provision of supports.

The potentially parallel and broader issue of grade inflation, both at pre-entry and subsequent award levels, needs national inquiry, review and direction. Through better student course choice along with better options and management for students if problems do arise, it would seem possible to maintain standards, but perhaps provide more appropriate exit points consistent with each student's displayed ability. There are palatable alternatives to grade inflation.

5 Thanks

This paper was motivated by personal experience and consequent discussions with many staff and students at the Institute of Technology Blanchardstown (www.itb.ie), and various and repeated visits to materials available from the UK's Learning and Teaching Support Network, LTSN. As of October 2004 LTSN has moved to the Higher Education Academy website http://www.heacademy.ac.uk.

6 Appendix A – Basic Business Mathematics (BBM) Results and analysis for Higher Certificate in Business (BN003) since ITB opened.

Semester 1

Grade	2000		2001		2002		2003		2004	
A	5	9%	0	0%	2	4%	4	4%	2	3%
B+	11	19%	4	6%	1	2%	9	10%	3	4%
B	17	30%	9	13%	7	13%	15	16%	9	12%
B-	8	14%	12	17%	2	4%	12	13%	4	5%
C+	8	14%	12	17%	5	9%	10	11%	5	7%
C	5	9%	12	17%	13	23%	18	20%	17	23%
D	0	0%	6	9%	17	30%	7	8%	10	13%
F	3	5%	6	9%	9	16%	12	13%	12	16%
NP	0	0%	3	4%	0	0%	1	1%	7	9%
EXE	0	0%	2	3%	0	0%	0	0%	1	1%
DEF	0	0%	1	1%	0	0%	1	1%	2	3%
W	0	0%	3	4%	0	0%	0	0%	0	0%
NA	0	0%	0	0%	0	0%	3	3%	3	4%
Other	0	0%	0	0%	0	0%	0	0%	0	0%
Total	57		70		56		92		75	
Passes	54	95%	55	79%	47	84%	75	82%	50	67%
Fails	3	5%	6	9%	9	16%	12	13%	12	16%
Avg GPV of those who pass	2.99		2.49		2.17		2.63		2.36	
Adjusted GPV of those who pass	100		77.9		70.1		91.0		81.7	

Table 2: Grades and analysis for BN003 semester 1 since ITB opened.

For marks ranges associated with grades A to F see Appendix B. The grades in tables 1 and 2 include any repeat examinations taken with the academic year, so represent the best performance of the associated students within that year. They did not take into account results obtained in any subsequent repeats. The meaning of the other rows are as follows:

Row Label	Meaning at ITB
NP	Not present – Means student is registered on course, but sat no examinations, including no continuous assessments.
EXE	Exempt – Student has an exemption for some reason.
DEF	Deferred – Student has deferred their course for now. May come back later.
W	Withdrawn – Student has officially withdrawn from the course.
NA	NA – No information available on the corresponding students.
Other	Other – Counts anything "strange", which is different from all of the other available "grades".
Total	Total number of "grades", excluding "other".
Passes	Number of grades ≥ D
Fails	Number of grades = F
Avg GPV of those who pass	Average Grade Point Value (GPV[17]) of those with grade D or higher.
Adjusted GPV of those who pass	A "Real Value Index" is calculated as: $\frac{GPV_n}{GPV_{2000}} \div \frac{CAO_n}{CAO_{2000}} \times 100$, where n=2000, 2001, …, 2004, and CAO values are given in Table 3. This formula basically compares changes in the GPV's compared with 2000 against changes in the CAO points. Values below 100 indicate that changes in GPV since 2000 have been smaller than changes in the CAO. Conversely values above 100 indicate that changes in GPV since 2000 have been larger than changes in the CAO. It is thus a simple way to attempt to adjust the GPV values to allow for changes in entry standards.

[17] See Appendix B.

Semester 2

Grade	2000		2001		2002		2003		2004	
A	5	9%	3	4%	5	9%	1	1%	1	1%
B+	10	18%	11	16%	3	5%	0	0%	2	3%
B	23	40%	13	19%	6	11%	3	3%	4	5%
B-	3	5%	9	13%	6	11%	2	2%	4	5%
C+	6	11%	6	9%	6	11%	5	5%	2	3%
C	4	7%	5	7%	8	14%	19	21%	9	12%
D	0	0%	6	9%	8	14%	34	37%	20	27%
F	4	7%	3	4%	7	13%	15	16%	18	24%
NP	0	0%	7	10%	6	11%	9	10%	12	16%
EXE	0	0%	2	3%	1	2%	0	0%	0	0%
DEF	0	0%	1	1%	0	0%	1	1%	3	4%
W	1	2%	4	6%	0	0%	1	1%	0	0%
NA	1	2%	0	0%	0	0%	2	2%	0	0%
Other	0	0%	0	0%	0	0%	0	0%	0	0%
Total	57		70		56		92		75	
Passes	51	89%	53	76%	42	75%	64	70%	42	56%
Fails	4	7%	3	4%	7	13%	15	16%	18	24%
Avg GPV of those who pass	3.04		2.80		2.57		1.88		2.07	
Adjusted GPV of those who pass	100		86.0		81.7		63.8		70.5	

Table 3: Grades and analysis for BN003 semester 2 since ITB opened.

Year	BN003 Entry Points	Index of Entry Points with 1999 as base
1999	290	100.0
2000	310	106.9
2001	300	103.4
2002	280	96.6
2003	280	96.6
2004	280	96.6

Table 4: BN003 entry points

7 Appendix B – Grade Point Value (GPV)

Mark Range	Alpha Grade	GPV
80 and over	A	4.0
70 and < 80	B+	3.5
60 and < 70	B	3.0
55 and < 60	B-	2.75
50 and < 55	C+	2.5
40 and < 50	C	2.0
35 and < 40	D	1.5
< 35	F	0.0

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Adaptive Screen Generation for Mobile devices

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Abstract:

When one looks at any learning software - eLearning based or not - one cannot sometims help but think why the authors could not have organized the screens (or the means of navigation) in a way similar to some other piece of software which the user has used or come accustomed to using. In this paper it is hoped to be able to achieve just that. That is, to accommodate the adaptive screen design by building up a profile about the user which can capture the learning styles of the user and personal preferences, and to be able to have the same navigation process over multiple devices and transmission types. With this as the design backbone it is also planned to offer user driven material so as to be able to take full advantage of the user requirements

Keywords:

Dynamic screen generation, blended learning, blended screen generation, user centred, assessment, effective learning, WiFi, user profiling.

Statement of problem

The ability and usefulness of having a mobile device with which to study and learn new skills has been long established and recognised [Soloway E., Norris C., Brumenfelt P., Fishman B.,Krajcik J.,Marx R]. In the case of the Virtual Learning Environment (VLE) the aim is to improve learning effectiveness. This is an aspect that must be addressed, if only to justify the cost of development, maintenance and provision of varied curriculum for such an environment. The typical multiple choice tests, which in themselves present a unique means of automating assessments for large classes, have both advantages and disadvantages. For example, by random selection of one of four answers a student would score about 25% in a test. By using multiple choice assessment we are not examining deeply the knowledge of the student or getting a feel for their understanding of the subject: only a broad examination of the course is possible [Masters, K., et al (1999)]. In designing and managing multiple-choice questions [online], Deming also advanced approaches to assessment with his "decision wheel" [Deming W.E. (1986), "Out of the crisis" New York: Wiley]. Chambers [1998] points out that "self assessment is an efficient and effective learning tool in that students are required to identify their own strengths and weaknesses". There is definitely some merit in

self-assessment and feedback following on from such assessment, especially timely feedback. [Sadler (1998)]

In our model for a learning environment (initially outlined in O'Nuallain, Brennan, Mlearn (2004)), we propose a different approach to virtual learning, which has many implications for screen design, assessment, tracking and profiling for future courseware. Some of these aspects will be discussed and described in this article.

Learning

We all learn in different ways and we all have different preferences for how we learn, the student profile [Fig 2 Listing of profile categories] segmentation is a technique which performs some preliminary probing of the student, requiring them to do a pre-test to establish information regarding such things as their learning styles, preferred environment, device(s) used, and problem solving skills. This serves to establish a baseline for a student's profile.

Many of the pre-test questions relate to how students prefer information to be presented on the screen, whether on a desktop PC, laptop, PDA, or phone. This allows us to blend material so as to be suitable to the device type and the user (there is little point, for example, in trying to deliver streaming video to a desktop computer or PDA if the required bandwidth or screen resolution is not available: in such a situation this could lead to the computer hanging and/or loss of synchronisation with the rest of the learning material, which in due course leads to student disillusion and, ultimately, possible withdrawal from the course).

Student retention was one of the initial driving forces in advancing the research into this area [May&Bousted, (2002), Retention project final report, Kingston University, internal paper. ISBN 0 10 2178011]. We have already established the effectiveness of the approach with gaming devices which can be used to motivate and hold a child's attention [O'Nuallain, ITTE02]. Our current research hopes to achieve similar results with adult learners, with particular emphasis on a well designed engaging curriculum which can be effectively displayed and utilised on different devices. Various studies have been carried out in the other areas of learning that are relevant to our project, with the ultimate aim of optimising the learning potential of our system through the use of accepted learning theory and methodology. Having examined :

- Behaviourism [Skinner, B. F. 1969],
- Cognitivism [Mergel, B.1998]
- Constructivism [Mergel, B.1998]

and taken what we considered to be the best of the three, together with some aspects of :

- Gardner's Multiple Intelligences [Gardner, H. 1983/1993]
- Kolb and Honey and Mumfords Learning style models [Henke, H. 2001]

- Blooms Taxonomy [Bloom , 56]

a coherent picture started to emerge which, when combined with Blended Learning [Centra software (2003)], allowed for the development of a number of matrices which ultimately formed part of our user profile. This profile improves the delivery of material and enables the creation of a personalised learning environment that is appropriate to the user's preferred learning needs. Ultimately, having taken into consideration user preferences and attributes, and identifying their "current" learning style, we believe we have taken the first steps in being able to fill the profile and be on a pedagogically sound footing.

Motivation

Research by Dunn, Dunn, Barbara (2000) suggests that:

- Only 30% of students remember at least 75% of what they hear in class
- Only 40% of students retain at least 75% of what they read in class

Furthermore Holland, [1998], reported that boys in school spend 25-75% of their time listening passively to teachers. All of the above reveals very poor overall statistics for learning, and indicates that children are given few opportunities to learn effectively (as defined by the higher levels of Bloom's Taxonomy). It is clear that a deeper level of understanding is required which can then be reused in different situations and domains. This is the kind of learning which we should strive for in all learning situations. The core problem is that in schools, VLEs and curriculum are typically not presented in a way that is interesting, engaging, or stimulating the student to think. In this body of research it is our objective to produce an environment that tackles this core problem, and furthermore to prove its effectiveness by presenting curriculum to students and obtaining statistics which relate to levels of achievement and satisfaction with the (highly personalised) material presented. It is known that, through the use of collaboration with tutors, mentors and fellow students, the motivation and quality of learning is increased Edwards M.A.(2000).The International Standards Organisation (ISO) has formulated a number internationally accepted standards one of these Sc36 is for "IT for learning and technology training" and part of this standard is a workgroup 2 (WG2) which is involved with Collaborative technology.

By applying ISO 36 WG2 standard [http://collab-tech.jtc1sc36.org/index.html] it is hoped that we can build on a standard collaborative framework and in doing so take advantage of other material which conforms to this standard. we hope to improve our goals in obtaining higher satisfaction from the students, and deeper understanding through brain storming in collaborative discussions. Such collaborative aspects are also part of the dynamic screen makeup, which depends on the bandwidth available, memory, and validity for the material being delivered. [Zen of Palm]

Student Profiling

The student profile in its current state (at the time of writing this article) contains twenty-one sub categories; each category contains approximately ten parameters. Through the use of such extensive data on a user, it becomes possible to deliver material that the student wants. Furthermore, as discussed in the article O'Nuallain C., Brennan A. in Mlearn 2004, all aspects of the course are assessed, with particular emphasis on the user's learning characteristics allowing us to structure the curriculum appropriately.

Our approach is cognisant of the fact that learning styles (like many other aspects of a young person's personality) change as they develop and evolve. Having established a preferred learning style, we also aim to strengthen the user's other styles of learning: the ultimate goal is to assist students in becoming comfortable with all learning styles. When this is achieved we have a situation where effective learning can occur, similar to Blooms upper levels of his taxonomy Bloom, B.S. (Ed.) (1956). This we acknowledge and build into our profile base.

This is achieved through the use of reusable learning objects which have various ways of being used and displayed. This depends on aspects of a users profile which indicate ways of optimising the means of learning for various devices to suit the users specific style.

Dynamic Screen Generation

Currently, with a learning curriculum, whether it is delivered to multiple devices or not, the user must typically adjust to the graphical user interface style, and also to the approach used to present the curriculum. This forces the learner to adjust their learning style to the interface, and is at odds with our profile based curriculum which instead adjusts the GUI to the learners style. In studies carried out by Inkpen (1992) it was found that because different environments and GUIs were being used, students needed time to adjust to the different GUIs and to how to interact with them. This is clearly undesirable and should be minimised.

In our model, all screens are initially created blank - we create a "blank slate". On this blank slate we draw from information stored in the various matrices of our student profile, in order to create screens that present information appropriate for display on the current device being used, but also with functional aspects (e.g. collaboration tools, assessments) which are suitable for the device and more importantly the user. Then, suitable collaboration aspects, screen layout, button location, size, and overall "look and feel" are applied. The area where curriculum can be presented is therefore optimised and the dexterity of the user taken into consideration together with their learning context. When a student has paused their study or changed devices, our system automatically detects this and resumes at the appropriate position in the learning material, and with presentation characteristics that are appropriate to the current device. The profile detects the device type, or can be set by the user, and can adjust all aspects of the screen generation so as to cater for this and not diminish the resulting quality of

the material delivery due to a change of device. Such a change of device is seamless and, as much as is possible, does not lead to a modified "look and feel" or altered navigation process which will help the student focus on the curriculum rather than how to navigate there way around the device and find out how to do things that were possibly more accessable on the previous device.

When a user does decide to change some aspect of their screen layout, (for example, by adding scroll bars where previously they had specified they were not required), they are able to do so. The student's profile is then updated and the change becomes permanent. The user has effectively changed their style and the system allows them to change that aspect of the screen as they see fit. It allows the change, learns the change and implements it permanently for all further curriculum delivery on any device. Typical scenarios will be examined in the following section.

CATEGORIES (that go to make up the profile): User age grouping

1. Gender
2. Background
3. Colour preferences
4. Layout preference (Style Guides)
5. Environment
6. Pre-Test Post-Test

7. Device Type
8. Protocol Type
9. Remoteness
10. Type of Group
11. Speed of use/delivery
12. Quality of Service (QOS)
13. Timings
14. Audio Assess
15. History from last use (Pebble Trail)
16. Tracking aspects (what the user has done and how they got there)
17. Input Methods
18. Output Methods

19. Collaboration Types
20. Integration of Devices
21. Feedback Assessment/Mentor
22. Assess. Complexity vs Difficulty
23. Server or Peer
24. Internet Access type and parameters
25. GUI Design

26. Learning Style
27. Multiple Intelligence
28. Blended Approach
29. Viewing Assess
30. Left right brain style
31. Lateral thinking

32. Assessment

Figure 1: Categories in the Profile

The above category list shows areas of the profile being developed. Each category has within it in the order of twenty parameters which can facilitate all aspects of that category to the required detail of the reporting of the main application. Through the capturing of data for these parameters significant data mining can lead to the establishment of detecting possible student behaviour such as dropping out or changes in the way the student is learning.

COLLABORATION TYPES

1. White board
2. Text message
3. E-mail
4. Chat
5. Discussion board
6. Audio chat
7. Video chat
8. Video conferencing
9. Live face to face discussion

Figure 2: Collaboration Types

Through the use of the above collaboration types the teachers and mentors can communicate with the user to establish how they are getting on, provide further tuition, signal further areas of study or alarms is the student is not achieving targets. Through the use of these collaboration methods the student need not feel isolated. The above methods can also be used by the student to contact other members of their class and peer group to discuss material and brain storm each other. Through talking to members of their peer group the student is not under the same pressure as if talking to the teacher as such the learning is more informal and open. Through the assessment methods built into this system to assess the user the effectiveness of the curriculum and the software it is possible for the application to assign individual user marks on the basis their input into a collaboration and on how they may have progressed in follow on assessments. It is hoped that such collaborations lead to higher order learning (as indicated by the upper three layers of Blooms Taxonomy) for the individual and the group which would not be possible with students working in isolation.

Test and click Trailing

The author intends to build on the excellent research carried out by O Suibhne, (2004), in which the amount of data collected provided the author with a great insight into K12 students' thinking when interacting with his courseware. In his journal article, "Using ICT as a Tool to Monitor how children read Multi Media Material", regarding user interaction with the screen and timings, he has provided an impressive depth of knowledge into how children interact with ICT. It is this depth of knowledge that

we are capitalising on and further extending in terms of how to capture and analyse user data. Unlike our approach, O Suibhne's delivery was not based on a profile or on multiple device types but, nevertheless, his evaluation of the user interaction and timings can be applied to our project and much information drawn from it - especially where "guessing and testing" analysis is to be carried out (see [Salomon, 1979a] [Healy, 1998] [Burbules, 1998] [Heppell, S, 1995]).

Through the use of profiling, we embrace many of the findings presented while also building a more complete picture of what is going on when a particular student interacts with information on a particular device. The aim is for the material to be intuitive, presented in a way that is suitable to the user's background, age, learning style, colour preferences, and so on. The chance of the user randomly clicking will therefore be reduced considerably and, if it does occur, it will be identified via interaction timings. Certainly all actions and timings will be tracked and more evaluation of the data and findings will be dynamically fed into the profile and the resulting assessments, screen options, learning objects and collaboration options will change.

The article by O Suibhne provides us with an excellent test bed from which to go forward and allows more in depth evaluation to be carried out. However a number of important questions must be asked, namely:

1. Will the personalisation of the material and environment improve the way users interact with the media and reduce "test and click"?

2. A great deal of research goes into the development of a dynamic, customisable interface. Do the results gained justify the cost in man-hours and research?

3. What else can we deduce from the interactions?

4. Can we learn much about the thought process having provided such extensive rich media and collaboration features? (In this application framework the aim is to have built in many ways through which the user can get feedback from mentors and discuss issues with fellow students over an array of mobile devices such as laptops and Personal Digital Assistants (PDA.), which have different characterises and feature lists. These lists and characteristics can, through the Blended Learning methodology, optimise the learning experience through the ability to adapt what collaboration aspects are available based on the users preferences and the features for the devices.)

We have collected data from the curriculum-interactions of approximately 150 students with the Blackboard virtual learning environment, using the same learning material as we intend to use on with mobile curriculum. This will allow us to compare the data from all the environments. Blackboard, just like the environment used by O Suibhne, is static and does not adjust itself to the user's preferences. The comparison with Blackboard, O Suibhne's environment, and our own, will enable a detailed evaluation as to how best to utilise technology so as to optimise the learning experience. It should be

restated that one of the initial driving forces for this body of research was to make material more appealing, engaging and challenging to the users, with the overall result being to increase the level of effective learning, reduce drop out rates, increase high order learning and instil curiosity in all learning.

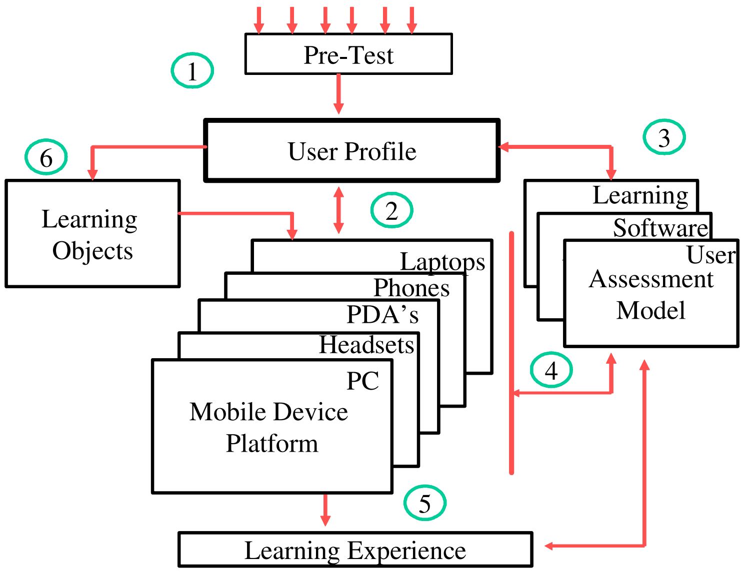

Figure 3: MODCA Model

From the current MODCA[18] model (Figure 3) there are several dynamic aspects to a system, including screen design and layout for individual users and devices, as well as dynamic assessment of the software over the three sub models (i.e., assessment of the user, of the curriculum, and of the presentation of the curriculum).

Example Scenario

We will now consider a scenario by which we can illustrate the dynamic aspects of our software. User one, John, logs onto the system for the first time. He is offered an initial questionnaire presented in a multi media format. As the questionnaire is on the computer it can be evaluated immediately, and the original entries are entered into John's profile on that device. If he connects to the server or the Internet the information will automatically be distributed, thereby enabling a constantly available and up to date representation of his profile. The second part of the pre-test then takes place: an initially blank screen is presented, and screen aspects immediately begin to form based on the initial information gathered from the questionnaire. Once the screen has formed, some novel curriculum is presented with John's characteristics embedded. Through the use of this material, the interaction type and

[18] **Mo**bile **D**evice **C**ollaboration and **A**ssessment

timings are recorded and measured. Any changes he makes to the screen layout are noted in his profile, and his screen navigation is analysed in order to provide for optimisation, for example depending on whether he is identified as being left handed or right handed. Through the delivery of this part of the pre-test, several aspects of John's learning potential are tested, in order to assess the optimum conditions and compare the results with data gathered from the more formal questionnaire that formed the earlier pre-test. It should again be noted that adjustments to John's profile are constantly being made, just as John himself is developing and changing with each new experience. We hope that by the end of both pre-tests, a high degree of accuracy can be guaranteed in delivering curriculum and assessing the user at that moment of time.

From here, if John then changes to a different device type, for example a PDA, which may have a smaller screen and different characteristics, the profile detects the device change and continues gathering information of his interactions with curriculum in this new environment. It will optimise the experience with all aspects that are both suitable for him and that are available on the device at that time. For example, if the PDA connects to the Internet via a blue tooth connection to John's phone, the system is aware of the bandwidth and what can be delivered with the limitations available. The smaller screen would also be taken into account, while providing, as far as possible, the same "look and feel" and navigation process. John would undergo a minimised learning cycle having moved to the other device and would continue with the curriculum at the point where he left the previous device.

Conclusion

It is only now with the abundance of wireless mobile devices and increasing bandwidth capabilities that mobile wireless ubiquitous learning environments can be realistically considered as a solution to the existing problems involving the capture and challenge of students while providing a high degree of feedback and collaboration and assessment.

The subject matter of the research is very current and can be applied to all but a few curriculum, however there a few particular domains: for example, computer programming and Maths, which we would like to see this model applied to first, as these are seen as the most important areas with regard to student problem solving and areas that are of most difficulty for students, especially first year students where we aim to target the retention. The impact of losing first year students has many follow-on issues, [Ohio University (2003)] for example, being unable to provide highly skilled staff to meet the country's demand for highly skilled technical staff. Our initial assessments indicate that this may be a very effective model, or at the very least a solid starting point for other research. In either case, our model represents a significant jump forward in terms of delivery, pedagogy, assessment and mobile learning.

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A Collaborative Model of Service Delivery for Individuals with Specific Learning Difficulties

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Abstract

This paper will discuss a collaborative, multidisciplinary approach to service delivery for young people and adults with specific learning difficulties. Influenced by research findings and a gap in service provision, the BUA service has been set up to provide screening, assessment, training and support to young people and adults with specific learning difficulties. The paper will consider the etiology of specific learning difficulties and current practices with particular reference to service provision and best practice models in the delivery of services. The paper will also discuss the BUA Centre's innovative approach with the Institute of Technology, Blanchardstown and the Dyscovery Centre, Wales in the areas of screening, assessment and training, and in developing best practice teaching methods.

The essence of education is becoming*, the gradual discovery of what it means to be human, the search for a personal identity, an identity which brings individual autonomy within a community structure (Ó Súilleabháin, 1986, p.91).*

Introduction

Above are the words expressed by the Irish educationalist, Professor Séamus Ó Súilleabháin (1986), which was used in The Task Force on Autism in 2001, to describe its approach to education. This paper will define specific learning difficulties (SPLDs), identify the etiology and prevalence of the difficulties, and discuss the existence of overlap. It will also look at the advantages and disadvantages of attaching labels to individuals. The current services for people with SPLDs will be described before moving on to look at the type of service that the National BUA Centre offers, which is a multi-disciplinary collaborative model of service for post 16-year-olds. The BUA Centre provides a range of assessment services for adolescents and adults from varying walks of life. The development of a unique screening tool is currently being developed and is being piloted in a range of different settings. The paper will then give some examples of collaborative projects that are currently taking place. A brief

description of a cross border project on specific learning difficulties between Ireland and Wales will be provided before concluding the paper.

Definitions and Etiology

In Ireland, the Disabilities Bill (2004) states that:

> *"special educational needs means, in relation to a person, a restriction in the capacity of the person to participate in and benefit from education on account of an enduring physical, sensory, mental health or learning disability, or any other condition which results in a person learning differently from a person without that condition and cognate expressions shall be construed accordingly"*

'This Act will have implications for' individuals with specific learning difficulties, 'as it includes those who learn differently. This Act, when activated, will have resource and funding implications for all educational services' (National Adult Literacy Agency, 2004).

The term "specific learning difficulties" (SPLDs) is commonly used to refer to Dyslexia. It is not always used to refer to other difficulties, which include:

- Dyspraxia (also known as Developmental Co-ordination Disorder (DCD)) – co-ordination difficulties
- Attention Deficit (Hyperactivity) Disorder (AD (H) D) – attention and concentration difficulties
- Asperger's Syndrome – social and communication difficulties

Individuals who have an SPLD have a specific difficulty in the way they process information which impacts on their ability to achieve their true potential. They learn differently which means that, often, the traditional teaching methods that are used in the classroom may not always work for these individuals.

The Irish Government Task Force on Dyslexia (2002) definition is as follows:

> ***Dyslexia*** *is manifested in a continuum of specific learning difficulties related to the acquisition of basic skills in reading, spelling and/or writing, such difficulties being unexplained in relation to an individual's other abilities and educational experiences. Dyslexia can be described at the neurological, cognitive and behavioural levels. It is typically characterised by inefficient information processing, including difficulties in phonological processing, working memory, rapid naming*

> *and automaticity of basic skills. Difficulties in organisation, sequencing and motor skills may also be present. (p.31)*

In recent years the genetic predisposition for reading difficulties has become increasingly clear. Although the first molecular genetic studies appeared in 1983, specific predisposing genes for dyslexia have not yet been isolated. However, several chromosomal regions have been intensively studied, particularly chromosomes 6, 1, 2, and 15 (Kirby & Kaplan, 2003).

At the BUA Centre, we find that many people still believe Dyslexia is only weakness and lack of ability, but such beliefs are unsubstantiated. "They are myths that have evolved as myths always do when a phenomenon is not well defined" (Fitzgibbon & O'Connor, 2002). As outlined in the definition above, dyslexia is a specific difficulty and it is not caused by lack of intelligence, laziness, or motivation. Dyslexia can cause difficulties in any one or more of the following, reading, spelling, writing, copying, organisation, time management, and direction among others. Often there can be other associated difficulties, which include underachievement, lack of self-esteem, withdrawal, dropping out, disruptive behaviour, bullying, and immaturity. Many adults have learned to hide their difficulties over the years, and have come up with some excellent strategies to overcome the barriers that they face in their everyday lives. If the right or appropriate supports are put in place for individuals with dyslexia, they will be able to succeed and indeed contribute to the success of any college or organisation.

The Report of the Task Force on Autism (2001), defines **Asperger's Syndrome**:

> Asperger's Syndrome *'shows the same kind of qualitative abnormalities of reciprocal social interaction as autistic disorder does with a restricted, stereotyped, repetitive repertoire of interests and activities. In international diagnostic terms, the main difference from autistic disorder has been that there is no clinically significant delay or retardation in cognitive development or in language acquisition (DSM-IV-TR* - an American diagnostic tool that is widely used internationally as a benchmark for specific difficulties). *More importantly, persons with AS have communication difficulties (regardless of structural language skill). The pragmatic aspects of their language are affected, as are all of the paralinguistic features of gestures, facial expressions, intonation meaning and even personal space regulation.*

The difficulties described above affect socialisation of the individual in all situations and result in him or her lacking adaptability and flexibility, especially in new situations. There have been many theories over the years to explain the cause of Asperger's syndrome. One such theory is based on the notion that the male brain is significantly better at systematising than at empathising, whereas the female brain has the opposite cognitive profile. Simon-Baron Cohen (1999) refers to Asperger's syndrome as being an extreme of the normal male brain. Although there is evidence for genetic factors playing a part in Asperger's syndrome, family studies have suggested that the expression and penetrance of the phenotype are variable. However, when examined along with autism and the autistic spectrum, Asperger's syndrome appears in the same families (Kirby & Kaplan, 2003).

The Irish association, HADD (Hyperactivity Attention Deficit Disorder) Family Support Group, **AD(H)D (Attention Deficit Hyperactivity Disorder)** is defined:

> *as a neurobiological disability. It is characterised by inappropriate degrees of inattention, impulsivity and sometimes hyperactivity. (p.2)*

The label for this behavioural syndrome has varied enormously through the ages. The current label from the American Psychiatric Association DSM-IV is ADHD, although the public often continue to use the term ADD. The DSM-IV specifies three subtypes of ADHD:

- Primarily inattentive
- Hyperactive-impulsive
- Combined inattentive and hyperactive-impulsive

ADHD is part of a spectrum of SPLDs. There is no correlation between ADHD and intelligence, and IQ is normally distributed in individuals with ADHD. Memory is not weak in individuals with ADHD. If people with ADHD attend to information, then they can remember it just as well as others do.

ADHD appears to run in families. Strong evidence of genetic involvement has been derived from twin and adoption studies, in which about 50% of parents who themselves had ADHD have a child with the disorder, and 10-35% of children with ADHD have a first-degree relative with ADHD. Although there have been no individual predisposing genes identified for ADHD, molecular genetic studies have focused on chromosomal regions associated with dopamine pathways in the brain (Kirby & Kaplan, 2003). Most symptoms of children with ADHD tend to improve with age, perhaps simply because people learn coping skills, and direct themselves into fields where their attention problems are less of an obstacle. Research

indicates that from 50-80% of children diagnosed with ADHD continue to experience symptoms into adulthood. For many adults with ADHD, as they get older the signs of hyperactivity diminish and they are left with the attention, concentration and organisational difficulties (Kirby & Drew, 2003)

The DSM-IV outlines the diagnostic features of **Developmental Coordination Disorder** as follows:

- **(Criterion A)** A marked impairment in the development of motor coordination.
- **(Criterion B)** The diagnosis is made only if this impairment significantly interferes with academic achievement or activities of daily living.
- **(Criterion C)** The diagnosis is made if the coordination difficulties are not due to a general medical condition (e.g. cerebral palsy, hemiplegia, or muscular dystrophy) and the criteria are not met for Pervasive Developmental Disorder.
- **(Criterion D)** If mental retardation is present, the motor difficulties are in excess of those usually associated with it.

This means that individuals with DCD will have coordination difficulties, which can manifest itself in many activities of daily living. The most typical difficulties identified are with the following: dressing, eating, doing activities under time pressure, riding a bike, and driving a car. In the school or college setting, the most typical problems mentioned include: writing (either copying from the board or taking notes dictated by the teacher), using scissors, and team sports. Many individuals with DCD have insight into their difficulties and feel frustrated at their inability to do tasks that others take for granted. The activities that many of us take for granted require large amounts of attentional resources from an individual with DCD. This often leads to a misdiagnosis of the individual's difficulties. In the past people have been labelled as having ADHD when in fact they had coordination difficulties. Other children were labelled as being disruptive in class when the real issue was that they were unable to hold their attention on a task for the same length of time as another chid in the same class.

The underlying etiology for motor coordination difficulties is not known, although some children who are given the label of DCD may have a neuromuscular or hypotonic problem, and/or a myotonic, myopathic or connective tissue disorder (Kirby & Kaplan, 2003)

Having looked at the various definitions and etiology of specific learning difficulties, the paper will now describe the prevalence of each of these difficulties.

Prevalence of specific learning difficulties

The Dyslexia Association of Ireland estimates that, while no conclusive research has been carried out in Ireland to determine how prevalent dyslexia is, studies in other countries would suggest that 6% to 8% of the population are likely to be affected. The British Dyslexia Association (BDA) in 1989 estimated that there were 10% (4% severe and 6% mild to moderate) of children who have some degree of dyslexia. Some reports suggest that up to four times as many boys as girls are dyslexic. This ratio is questionable, as more recent research appears to suggest that this may be because of the method of referral; for example, when failing, boys tend to be more disruptive in class, and therefore are recognised as needing support from the learning support teacher or psychologist. Asperger's syndrome occurs in approximately 4 per 1000 population, affecting at least four times as many boys as girls. ADHD is one of the most common neurodevelopmental disorders, affecting 3-5% of school-age children. At least three times as many boys as girls are affected, and in clinically referred samples the ratio is often as high as 6:1. 'Developmental Coordination Disorder is a common condition, present in about 5% of school-age children, though a recent comprehensive study suggests that moderate-to-severe DCD may be present in over 7% of 7-year-olds, with a boy: girl ratio of 5.3:1' (Kadesjo & Gillberg, 1998). In considering the type of support required, individuals are often labelled artificially and are placed in a convenient 'box' in order for services to be delivered. It is important to recognise that the functional difficulties seen may commonly overlap for many different conditions.

Overlap

There is evidence to suggest that there is considerable overlap between each of the specific learning difficulties outlined above (Kirby & Kaplan 2003). Too often in Ireland individuals with SPLDs are passed from one organisation to another in order to acquire the help they need, and even still they do not receive the appropriate support. This can take considerable time, energy, and conviction from the individual.

Gillberg's (1998) research alerts us to the fact that conditions on the continuum of specific learning disabilities are more likely to co-exist as the norm with much lower numbers existing with only one label than previously thought. This makes the possibility of a singular diagnosis even more complex. Gillberg states that 50% of those with DCD have ADHD and 87% of children with ADHD have one additional DSM-IV diagnosis with 67% with two. Kirby & Kaplan (2003) report on a population study which showed that 23% of children showed signs of DCD, 8% met the criteria for ADHD, and 19% were categorised as dyslexic.

Nearly 25% of the affected children were found to have all three, while 10% had both ADHD and DCD, and 22% had dyslexia and DCD. Kaplan et al. (1998) sums up this overlap by saying that "co-morbidity (a medical term for overlap) is the rule rather than the exception". Given the diagnostic overlap in SPLDs it would seem important that services be delivered in a model that addresses all of the specific learning disabilities. Research indicates that the numbers of adults exhibiting symptoms that could be attributable to any one diagnosis under the SPLDs umbrella are very small. The SPLD norm is more likely to be that people have a cluster of characteristics with considerable overlap between conditions. Therefore, identification under one heading may lead to other needs not being met.

Labelling

The use of diagnostic labels to characterise a person makes many people uncomfortable. In relation to funding, however, labelling has become a necessity and can be beneficial. For adults in particular, a label often provides a certain amount of relief and allows that person to give an explanation as to why they underachieved in education in the past. A diagnostic label allows for the acknowledgment for some parents that there is a genuine reason for their worries and concerns. It can assist others who work with the individual to focus on the appropriate type of intervention.

On the other hand, labels can be quite harmful, especially for children. Some people may have preconceived ideas about a particular disorder based on their previous experiences of others with the same label, such as a child with ADHD who may have been seen as a difficult child rather than a child with difficulties. Labelling can be particularly harmful if the wrong label is given, or if a person 'views this label as a stigma for life that implies a disability rather than a difficulty that can improve' (Kirby & Kaplan, 2003).

In view of the disadvantages of labelling, and because people do not fit neatly into boxes, people would be better served if we abandoned diagnostic labels and instead provided functional descriptions of a person's strengths and weaknesses. This would probably give parents and others more support in knowing how they can support the individual with their difficulties, for example see table (Kirby & Kaplan, 2003) below:

Examples of diagnostic and functional labels for specific learning difficulties

Diagnostic Label	Functional label
DCD	Difficulty with ball skills, handwriting, dressing, organisation
ADHD	Difficulty staying on task, impulsive behaviour
Dyslexia	Spelling, reading, writing, organisation, time management difficulties
Asperger's syndrome	Difficulty with social relationships, literal interpretation of words and phrases

The labelling debate will continue and there are certainly very good reasons to look at both sides of the argument. Henderson & Barnett (1998) suggest that in spite of recent attempts to standardise the terminology used, variation continues to compromise inter-professional communication and interpretation of research. There seems to have been little change in this since Dewey (1995) spoke about the lack of consensus in relation to developmental dyspraxia in both its definition and description.

Services for people with SPLDs

Services in Ireland in relation to SPLDs have generally been provided and developed by the voluntary sector. Services have almost entirely been in respect of children and there has been little if no provision for adolescents / adults in this area. Services for children are still in the process of development with long waiting lists, huge variability based on geographical location and little integration of service delivery. It has long been thought that children with SPLDs grow out of these difficulties, as they get older. Unfortunately, this is not the case. They still remain to have difficulties but the types of difficulties may change as they move from one educational level to the next.

In recent years there has been an increased recognition of SPLDs in children by health, educational professionals and parents in Ireland. However there remain significant barriers to delivery for appropriate support. Some of the barriers include lack of determination of the specific difficulties, long waits for any support, shortages of professionally trained staff and lack of interdisciplinary communication. In addition to this, there is no central key worker to work with the individual themselves, the family, educators, and vocational supports through a system that straddles different services and uses different terminology. Service provision - if available at all - often varies from place to place magnifying the problems further.

In the past many individuals with Dyslexia, Dyspraxia, (also known as Developmental Co-ordination Disorder), ADHD and Asperger's Syndrome were not recognised as requiring support into adulthood. These conditions affect both children and adults in their activities of daily living and often result in serious barriers to their full integration into society if not recognised and appropriately supported. In addition the labels are used inconsistently by professionals, and this can cause a great deal of confusion, misunderstanding and frustration to both individuals diagnosed, parents and indeed amongst professionals themselves.

While some services exist for adults diagnosed with or seeking assessment in relation to dyslexia, there are currently no services in existence for adults with Dyspraxia (DCD) in particular and little available to those with ADHD and Asperger's Syndrome. In relation to the area of dyslexia, a small number of adults are catered for in specialised adult training. Private assessments are also available through the Dyslexia Association of Ireland.

The National BUA Centre

The National Training and Development Institute (NTDI) has been aware for a long time that there is a gap in service provision for adolescents and adults over the age of 16 years who have specific learning difficulties. Many individuals who train with NTDI encounter difficulties progressing to further education, training, or employment within a mainstream setting because of their specific learning difficulties and the lack of services to cater for their needs. The Institute of Technology Blanchardstown (ITB) encountered similar difficulties in the past, with regards to providing comprehensive services to students with specific learning difficulties who attend courses there.

The National BUA Centre represents the realisation of a long desired goal. Discussions between the Chief Executive Officer of the National Training and Development Institute and the Director of The Institute of Technology, Blanchardstown began three years ago. These discussions took on a tighter and more coherent focus when the Dyscovery Centre Cardiff joined the partnership, with the shared aim of providing a comprehensive and effective service for individuals with SPLDs.

A core staff comprising a Project Coordinator and part-time Administrator moved into premises on The Blanchardstown Campus in May 2003. An interdisciplinary team was sourced, initially on a part-time basis and a full-time Trainee Educational Psychologist joined the staff in August 2003. The appointment of an Educational Support Officer/Dyslexia Tutor has now been formalised so that students entering the college can gain access to

specialist supports immediately after they are identified, rather than waiting for funding approval, which can take a full term, as currently happens in many colleges. The BUA team therefore is made up of a project coordinator, two part-time administrators, an educational psychologist (trainee), an occupational therapist, a speech and language therapist, a medical director, and a clinical manager. All members of the team assess the individuals in order to identify their strengths and areas of difficulty. They then provide practical advice and strategies, which will help the individual to reduce their difficulties and improve their life skills. Where appropriate, blocks of intervention/treatment may be offered in order to give additional and on going help and guidance.

An essential component of the development of the BUA service has been relationship building between mainstream and specialist education providers. The main objectives of this relationship between NTDI and the Institute of Technology, Blanchardstown are:

- To support individual students
- To raise awareness and to support staff in pursuit of the above
- To raise awareness and create a positive ethos towards students with disabilities.

This type of collaboration between a mainstream and a specialist provider is somewhat unique in Ireland and aspires to operate more and more closely within the capacity building model as the service continues to develop.

The BUA Centre aims to create a much-needed model for adults with specific processing issues that involves the individual fully in the process and will, it is hoped, be a more acceptable future vehicle for funding applications. BUA is a centre with expertise in Specific Learning Difficulties for individuals with living and learning difficulties such as: Development Co-ordination Disorder, Dyspraxia, Dyslexia, Attention Deficit Hyperactivity Disorder and Asperger's Syndrome. Individuals may have difficulties in some or several of the following areas:
Reading, Spelling, Handwriting, Study skills, Concentration, Time management, Self-organisation, Prioritising and organising workload, Co-ordination, Social skills and communication, Personal care, Domestic tasks, and Budgeting.

The BUA Centre provides specialist and high quality services, which are tailor-made to suit individual and/or organisational requirements. The approach is very practical and helps people reduce the difficulties they experience in carrying out everyday living tasks, whether

they are home, work or social and communication difficulties. The range of services offered include:

- Assessment / Support
- Transition Planning
- Consultation
- Training

Assessment / Support

The assessment may or may not lead to a diagnosis. However during the assessment a detailed profile of the individual's strengths and weaknesses is built up. Practical, functional solutions, advice and strategies that will help them to improve their living and learning skills are then given and explored.

Transition Planning

Transition planning assists the young person with their move from secondary school to further education or employment, or from further education into the workplace. Practical strategies for planning and dealing with the difficulties encountered are discussed and explored with the individual and their family.

Consultation

This service is offered to meet the needs of those who may have been seen by other professionals in the past and require an opportunity to discuss learning or living problems further.

Training

The Centre offers seminars, as well as tailor-made training and in-service days for employers, educational institutions and health professionals on a variety of topics, e.g. identification and support of individuals with Dyslexia, Dyspraxia, Asperger's Syndrome and Attention Deficit Disorder.

Screening and screening tools

Currently there is no universal system for assessing all individuals for potential difficulties as they enter into training, Further Education (FE) or Higher Education (HE) Colleges.

Individuals may present in four main ways:

- They have already identified difficulties and may have a “label”
- They may think they have problems and want them identified
- They start in the training setting and then others identify they have difficulties
- They start in the training and then they find they are having difficulties

In FE and HE colleges and universities student services may provide a support structure. However obtaining assessments can take time because of a shortage of suitably qualified professionals to undertake the assessments that are required. Until recently these assessments have only looked at the area of Dyslexia and not at the other specific learning difficulties.

Is screening a valuable process?

If suitable support should be put in place an initial screening tool could offer a baseline of information for both the tutor and the student to allow them to have an opportunity to see where strengths and difficulties lie.

There are already computerised screening tools in existence such as ***QuickScan,*** which generates a report highlighting the individual clients’ learning style. ***The Dyslexia Adult Screening Test*** offers a batch of sub-tests, which will test possible areas of weakness but is restricted to delivery by trained teachers only. ***The Bangor Dyslexia Test*** runs on a similar vein to DAST. It is a simpler version and requires a teacher with some training for delivery. ***Lucid Adult Dyslexia Screening*** (LADS) tests phonological processing, working memory and lexical access. However none look across all the specific learning difficulties and can be self-administered and the response tailored to the setting (Kirby, 2004).

> *‘The Dyscovery Centre has developed an innovative screening tool to identify individuals who may be “ at risk” of having difficulties in a training or employment situation and has been developed for post 16 years. It is a computerised programme, which can be used on large numbers of individuals to recognise where difficulties may be occurring and allows guidance for the individual or can be used for planning services within a setting to make sure that all students are having their needs best met.*
>
> *Once screening has been completed looking across all developmental areas, then those individuals requiring a more in depth assessment are offered this service. This one stop screening is potentially both more cost and time effective. This only*

identifies individuals that have been "missed "in their school days. Obviously the best route would be screening at transition points such as school entry and also when starting in secondary school in a way that doesn't make the person feel that they are somehow "lacking" or different in a way that effects their confidence. The child may not have been identified earlier because his needs may have been partially met and it is only when he or she starts to flounder once in a larger school with greater expectation on him or her such as writing at speed, playing sports, and greater need for self organisation that he "tips over" and begins to have problems.

There may also be a need to screen at other stages in life as well, where the adult enters a different type of setting such as into the workplace, or in training settings to identify the type of support required' (Gunne et al. 2003).

Referrals to BUA

There are three referral routes at the BUA Centre, ITB students, NTDI trainees, and a private referral service for anyone over the age of 16 years. In each situation the student meets with a member of the BUA Centre team. This is the initial consultation where information is gathered through a semi-structured interview with the individual. This information usually includes the person's medical, educational, and social and communication history. This gives the BUA staff member a chance to build up a rapport with the individual. When the information is gathered, the clinical team at BUA evaluate the information and decide on the most appropriate type of assessment that will be of the utmost benefit to the person in question. This might be a full psychological assessment, a speech & language assessment, or an occupational therapy assessment. In some cases it might be a multi-disciplinary assessment.

In each individual case, the team focuses on the functional difficulties that the person is experiencing rather than simply attaching a label. What is it that the individual cannot do and what can be done to help the person overcome some of the barriers that they face in their everyday lives whether at home, in college, at work etc? However, in some situations a label is required in order to access funding from the Department of Education & Science.

At ITB students are referred to BUA through a number of different ways:

1. Through the Access Office at ITB
2. Students drop into BUA themselves suspecting that they have a learning difficulty
3. Lecturers can advise students to call into the BUA Centre when they feel that a particular student is not achieving their full potential.

After an assessment, relevant information is passed onto the lecturers so that they can make learning a more enjoyable experience for the student.

NTDI trainees are referred to the BUA Centre through their Regional Psychologist. After the assessment, information and practical recommendations are provided for the resource teachers and instructors who are working with that individual.

Individuals who make enquiries through the private service are sent information about the BUA Centre along with questionnaires. Having read this information she or he may wish to access the service. The centre aims to obtain an accurate and comprehensive picture of an individual, their difficulties and their strengths in a range of settings. Once the questionnaires and supporting documentation are received the team will discuss the information and identify the most appropriate service, which will meet the individual's needs. A team member will then contact the person making the referral to discuss the service being recommended.

With regard to each of the three types of referrals outlined above, all assessments are conducted in a sensitive and client-focused manner and every effort is made to help the individual feel at ease. Generally an assessment at the Centre, per team member may take up to two hours depending on the needs of the individual. The experience may be tiring and some people find it difficult to absorb and retain the information during and after the appointment. Following the appointment a comprehensive report is produced that summarises the assessment findings and outlines practical advice, strategies, and useful information that can help the individual to reduce their difficulties and to improve their living and learning skills.

Collaborative work between BUA & ITB

Collaboration across a variety of disciplines offers potential for new thinking and innovative approaches. Having an interdisciplinary team means that the service user can benefit from a range of skills, knowledge, training and experience of the members of that team. 'People with disabilities should expect nothing less than the highest level of skill and experience from the team. Consequently it should be considered a core function of collaborative teams to build upon the experience of "all" staff members in order to assure that services are delivered with an increasing level of quality, skill and expertise (Sax, Duffin, & Boyle, 2003).

An important policy that BUA has adopted since it opened in August 2003, is that it takes an inclusive approach to education. Members of the BUA team have always been particular about the language they use in reports about individual people. Many different terms and phrases have been used to describe people's difficulties in the past, and most of these have had very negative connotations to them. More recently, the terms 'disability' and 'special needs' have been used to describe people. However, these types of terms direct the focus towards the person rather than towards professional practices or organisational structures. No matter how many times the language has changed over the past hundreds of years '*the focus of attention remains fixed on the particularities of the individual's body or mind rather than on the marginalising and exclusionary practices and structures of society'* (Mc Donnell, 2003).

> *'By defining pupils in terms of 'given' problems, educationalists are then predisposed to regard educational development as having definite limits with certain kinds of pupils. The search for solutions is focused on individual deficits rather than on inequitable social structures'* (Drudy & Lynch, 1993, 59)

Since the BUA Centre opened on the ITB campus in August 2003, it has been working in close collaboration with ITB staff including the academic staff, the Access Officer, and the administration staff. Training sessions are held at regular intervals throughout the academic year. The training depends on requests from particular staff members, for example, 'Dyslexia in the Classroom' or 'Assistive Technology', but the focus is on how the teacher can adapt their teaching styles to meet the needs of each individual learner in the class. From time to time academic staff seek advice from BUA about particular issues that arise within their lectures in relation to students with reading, spelling, writing, language, or communication difficulties among many others. The advice provided by BUA is always one of inclusion. For example, if one student has difficulty taking notes in a lecture, then it is important that he or she is provided with copies of each lecturer's notes in advance of the lecture. But why not provide notes for every student in the class so that no one student stands out as being 'different'. Corbett (2001) asks the question, 'is there a pedagogy for inclusion? If there is, then it needs to be one that connects with the individual learner and their own way of learning, and that then can connect them into the curriculum'. When Lewis & Norwich (2000) investigated the commonality and differentiation of pedagogy for children with learning difficulties, they concluded that what works with most pupils would also work with all pupils.

In light of the above, the Apprentice tutors in particular were very interested in this approach to teaching and learning and requested the BUA team to work collaboratively with them in endeavouring to develop a best practice teaching model within their department.

The Apprentice School in ITB takes on apprentices in carpentry, electrical, brick and stone and plumbing for Phase 4 of their apprenticeship. There are 32 apprentices in each trade and they are only at ITB for 10 weeks. Through interviews and screening of these apprentices, it was acknowledged that many of them had had negative experiences in their previous education. They reported that they did not like the classroom environment and they were not looking forward to being back in a classroom situation for 7 hours each day for 10 weeks. The tutors also find it difficult to motivate the students to learn, and to support students who have particular difficulties in relation to literacy and numeracy. The tutors also expressed concern about getting the course covered in time so that the apprentices are able to sit their exams at the end of the 10 weeks.

Ways of dealing with the above issues are currently being explored between the staff at BUA and the teaching staff of the Apprentice School. This collaborative project is ongoing and there will be a report on the outcome of it at the end of 2005.

Three important questions that are being looked at with the tutors are:

1. How are the learners connected into the curriculum?
2. What strategies are used to ensure that each student learns in a meaningful way?
3. What kind of knowledge or learning is examined at the end of the ten weeks?

Corbett (2001) discussed a case study of a particular school in Tower Hamlets, East London, which had been working at inclusion for about 15 years and has been hugely successful in achieving it's goals. Corbett (2001) talks about the negativity around the issue of inclusion. People are always able to give reasons to explain why inclusion could/would not work, for example, teacher apathy, curriculum rigidity, a competitive market, parental prejudices, shortage of staffing, limited resources, among others. After exploring the school culture, policies and practice, Corbett concludes that there is no great mystery to having an inclusive school. It is all about a shared vision by the school/college team (teachers/tutors/lecturers, students etc.), enthusiastic leadership by committed, experienced and skilled teachers and heads of schools, appropriate levels of resourcing, and an openness to learning new skills and trying out whatever strategies seem useful. Corbett goes on to say that 'an effectively inclusive school can be assessed through comparing the levels of achievement of its learners

with those in comparable schools. In relation to the Apprentice School in ITB, this comparison could be made with other IT colleges who have Phase 4 apprentices attending them. In Corbett's case study school, the average levels of achievement in National Curriculum tests by 11 year-olds showed performance in English below average (D) compared with all schools, but well above average (A) compared with similar schools. Similar results were found with other subjects including Maths and Science. These results are true indicators of the value of inclusive teaching, and there is no reason why this approach would not work in other educational institutions.

Partnership

The partnership, which has been mentioned above, between NTDI, ITB and the Dyscovery Centre teamed together to write a proposal for EU funding, an INTERREG funded project. The agreed name of this project became known as P.A.C.T.S. (Partners Collaborating in Training for Individuals with Specific Learning Difficulties). The PACTS Project has partners from Ireland and Wales. The partners have come together to provide a strong partnership to look at ways of supporting adults with specific learning difficulties and those working with them in the East of Ireland and West Wales areas. In Ireland the Institute of Technology Blanchardstown in Dublin, The BUA Centre, are leading the project. In Wales the Dyscovery Trust is the lead partner.

The aim of the project is to empower individuals with Specific Learning Difficulties, who are increasingly disenfranchised in a society which is ever more dependent on literacy and numeracy, to achieve their potential. This project will increase access to third level education for individuals who may have conditions, which preclude them from achieving their goals academically. The project will focus on developing linkages between Ireland and Wales to build expertise and encourage the transfer of knowledge through joint collaboration.

Specifically, the project aims to ensure the provision of an assessment, remediation and support service for individuals with Specific Learning Difficulties in the designated areas in Ireland and Wales, to assist them in achieving their potential in mainstream education, training and employment settings.

Conclusion

The paper has looked at what the term, specific learning difficulties, means, and how different people have described the different labels that come under this umbrella term. The etiology and prevalence of the conditions were examined which led to discussions around the

impact of labelling, and the fact that there are huge numbers of individuals who have overlapping conditions. People do not fit neatly into boxes and therefore it is important to look at the diagnostic label, but more importantly to look at the functional difficulties that the person is experiencing. In this way the most appropriate remediation and supports can be provided for the individual. With all of these factors in mind the paper goes on to look at how services have developed in Ireland, and in particular the National BUA Centre. The centre provides an inclusive multi-disciplinary approach to education and the living and learning skills of people. It is currently involved in a number of projects and aspires to continue working in this manner. The aim is to continue building its services in a way that respects every individual. The emphasis is on listening to and valuing what people have to say, which is a fundamental aspect of an inclusive model. As Mittler (2000) says,

> *'Inclusion is about everyone having opportunities for choice and self-determination. In education, it means listening to and valuing what children (and adults) have to say,* regardless of age or labels'.

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Access to Academic English: The Development of a Meta-Linguistic Curriculum

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Abstract

One of the greatest barriers to the deaf student's continuing and further education is the accessing of course texts and research papers. A native ISL user will not necessarily have acquired fluency in accessing written information in English during the course of his or her previous educational experience. At university the deaf student cannot hope that more than a percentage of course materials will be translated into ISL onto video tape and so often loses insight into the chosen course normally gained through the range of reading of text required by third level study if her or she lacks skill in accessing written English.

My research is a response to this need for deaf students to be able to access academic text and takes a 'meta-linguistic' approach to reconciling the grammatical differences between English and ISL. I am developing a curriculum that 'bridges' the two languages by deconstructing the grammars of both under a Chomskian model of universal grammar. This paper gives examples of possible solutions to aid reconciliation of the grammatical differences of these languages from my prototype curriculum. The course components are presented as a series of easily learned tools, yet are underpinned by contemporary linguistic theory.

Introduction

One of the greatest barriers to the deaf student's continuing and further education in Ireland is the accessing of academic course texts and research papers. A native Irish Sign Language (ISL) user or a deaf person whose preferred language is ISL will not necessarily have acquired fluency in accessing written information in English during the course of his or her previous educational experience. As well as being hindered by a lack of knowledge about English the deaf student is very likely to lack confidence in his or her ability with the subject.

This paper will set the context and demonstrate the rationale for the need for the development of a curriculum that will allow deaf third level students to access academic English with greater efficacy. In addition to making reference to a number of disciplines this will

necessitate detailed explanation of the modality and grammatical differences that exist between English and Irish Sign Language (ISL). We will also need to examine some psycholinguistic processes in order to posit that a meta-linguistic approach is essential to the development of an effective curriculum. The curriculum will then be described from both theoretical and pragmatic perspectives with some examples from the prototype curriculum. Finally, assessment and ethical elements will be discussed before suggesting options for future development and application.

Language Acquisition and Education of Deaf Children and Adults.

The complexities and difficulties surrounding the language acquisition and education of deaf students have been discussed and documented extensively over the past thirty years. More recently the understanding of the theoretical implications of language acquisition of deaf children has produced evidence that has consequences for mainstream linguistics research (Emmorey 2002, Chamberlain, Mayberry and Morford. 2000, Duffin 1998, Duffin 1999, McDonnell and Saunders 1993) and so will be referred to rather than fully described again here due to space constraints.

Although deaf studies in Ireland (McDonnell 2004) is a relatively new and recent discipline it is now more generally understood that ninety percent of deaf children are born to hearing parents with either little or no ISL and some may never acquire a sign language unless they either attend a deaf school or have contact with deaf people. Some deaf students experience mainstream education and do not ever acquire a sign language unless they seek or make contact with the local deaf community. Deaf children of deaf parents/siblings are ‘native’ sign language users (ie those who acquire their first language from birth onwards and in a natural pattern of language development.

The Centre for Deaf Studies at Trinity College Dublin has now taken in its fourth year cohort of students and is committed to providing an ISL language environment for learning as well as supporting the development of maximal English reading skills.

The Centre for Deaf Studies offers courses in Deaf Studies, ISL Tutoring and ISL Interpreting and students are given the option of submitting assignments either in written English or as a signed ISL presentation. This means that deaf students do not have to demonstrate proficiency in English in order to demonstrate their knowledge. This fact along with the strict policy that language use in the Centre must be this ISL means that linguistic and educational equality exists for all students studying at the Centre.

It is sufficient for the purpose of this discussion to acknowledge that there is great diversity in both deaf people's language access and education access both in terms of methodologies and experiences and that this most frequently leads to deaf people not being able to achieve or demonstrate educational achievement concomitant with cognitive ability despite the advances in theoretical research over the past 30 years (Powers, Gregory and Thoughtenhoofd. 1998. Conrad 1979).

Context

At university the deaf student cannot hope that more than a very small percentage of course materials will be translated into ISL either onto video tape or onto a DVD and so she or he often loses much of the insight into the chosen course normally gained through the range of reading of text required by third level study if he or she lacks skill in accessing written English. It is this fact that has led me to research and develop alternative teaching and curriculum methodologies that will improve deaf students access to academic English from a perspective that will be both confidence building and empowering. I would like to thank the National Training and Development Institute and Trinity College for the support I have received in this endeavour over the past decade.

My research is now at the stage where I have developed a prototype curriculum and have received positive quantitative feedback from students who have completed it. I am now collecting data for the more difficult task of publishing the results of qualitative research study. Having set the historical context for my research I will now discuss the linguistic rationale on which the curriculum development has been based.

Modality and Grammatical Differences between English and ISL

Whilst many educators realise that English is difficult for deaf people to access, few appreciate that this difficulty arises from two related reasons; one of these is linguistic modality difference and the other is its relationship to language processing.

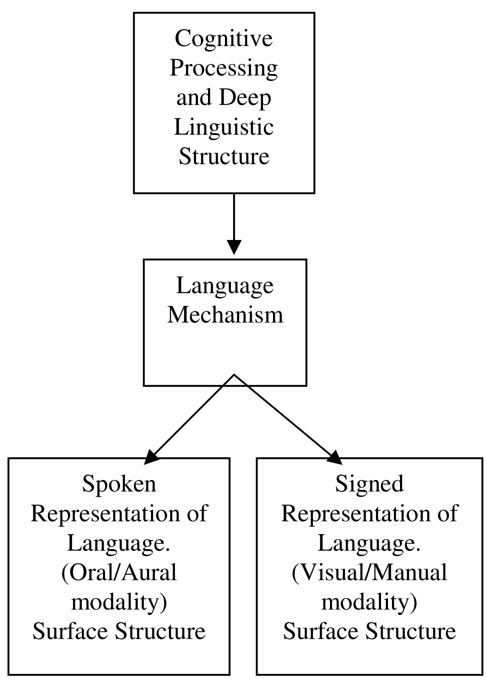
Deaf people have a natural pre-disposition to use visual processing rather than auditory processing, because they all have either a partial or total difficulty with accessing auditory input language.

We will now look at linguistic modality in order to appreciate the differences between signed and spoken language phonologies.

Linguistic Modality.

Linguistic modality is the term we used to describe the manner of our language performance. The majority of people assume (quite unconsciously) that the spoken form for language output and a heard form for language input forms *the* universal language model. By this I mean we believe the auditory channel is used for language access and delivery. We also make unconscious assumptions about the way language is processed at a cognitive level in terms of assuming that all processing is based on the fact that language performances makes use of an auditory channel (Duffin, 2004).

Models of language production and perception (Eysenck and Keane 2000), generally agree that there are non-verbal levels of processing that do not employ words or components of words as well as levels of processing where words and parts of words are employed. These processing levels apply when both encoding and decoding messages and are known as language production and language perception.



Representations of Language (Duffin 1998, p16)

It is also generally agreed that there is a level of processing that identifies semantic and pragmatic relationships. These levels of processing are interconnected and also draw on other types of cognitive information such as memory, perception and attention to allow

meaning to be attributed to communications. The following diagram describes this in the simplest terms in order to demonstrate that there is a deep processing structure as well as a surface processing structure.

In summary, the components of processing operate on a number of levels including the following:

1. Elements that are purely cognitive without any language like elements including items such as memory, attention and perception.
2. Elements within which language is being either constructed or deconstructed at a deeper level of language processing in terms of semantic relations, morphological relations and pragmatic relations.
3. Elements within which language is being either constructed or deconstructed at a surface or performance level in terms of phonemes and groups of phonemes.

From the late 1990's sign language linguists such as Diane Brentari and Vivienne Tartter have described models of sign language processing where research has shown that the manner and nature of the deepest levels of signed language processing is most similar to the deepest levels of spoken language processing. They have also shown that the processing is most different at the phonological or surface levels and that this is because the modality of the two languages is very different. This means that instead of using a phonology and morphology made up of combinations of sounds in a heard and spoken form, signed languages use a phonology, composed of handshapes, movements, locations and non-manual features in a visual or kinesthetic form (Brentari, 1998.Tartter 1998).

This understanding that signed languages behave in a similar way to spoken languages but that they employ a different modality of performance which has led to the development of very different phonological, morphological and semantic relationships is not yet generally known or, indeed, understood by mainstream linguists. This is because it is very difficult to move out of the assumptions we all hold which are based on our own spoken language experiences. Additionally the vast majority of mainstream theoretical linguistic research focuses on spoken language models as can be seen when examining most linguistic texts. One instance of this can be seen in the Trevor Harley's Psychology of Language 2001 a well-known third level linguistic and psychology textbook where scant reference is made to sign languages and the reference that is made is incomplete and inaccurate (Duffin 2004). Irish professionals and teachers working with deaf children and adults in Ireland in pursuit of the

development of good reading skills in English are at an even greater disadvantage because is no legal requirement for persons working or training to work with deaf people to have any knowledge or fluency in Irish Sign Language.

The following diagram summarises the basic differences between the two modalities and to phonologies of English and ISL described above:

English	**Irish Sign Language**
Spoken form Information through **SOUND** **Linguistic Data** In ear Out mouth **Phonemes** • vowels (lips) • consonants (mouth, lips, tongue, teeth) Multiple combinations of the above phonemes form parts of' 'words' and 'words'.	**Signed form** Information through **VISION** **SHAPE** **MOVEMENT** **Linguistic Data** In eyes Out hands/body/face/head **Phonemes** •Handshapes (hands) •Movements (hand, body, head, face) •Orientations (hands) •Locations (upper body, head, face, arms, hands) •NMF's (face, head) Multiple combinations of the above phonemes form parts of 'signs' and 'signs'

From: Comparison of English and ISL Phonologies: Spoken and Signed Forms

English and ISL Phonology

As we all know an alphabet consisting of 26 letters is generally considered to represent the sounds of spoken English. However, the actual number of separate sounds that can be articulated is significantly larger than 26. (Crystal 1997). In terms of ISL phonology the number of legal handshapes shown in Pat Matthews (2002) first comprehensive written description of ISL is 65, numbers of movements, locations, orientations and non-manual features have not yet been recorded. But it can be clearly seen that a very large number of individual phonemes exist in ISL and other sign languages (Brentari 1998).

Having now summarised the main differences between signed and spoken phonologies, we will briefly discuss the implications of the grammatical differences between the two modes of language.

Grammar

One consequence of the lack of knowledge about sign languages is the historic and ongoing development of English teaching materials based on English grammar only. Many of these take a second language approach to the teaching of English. A large Department of Education study in England conclusively demonstrated that deaf students continued to perform poorly in school in English and in other subjects when compared to hearing peers (Powers, Gregory and Thoughtenhoofd. 1998).

Whether or not the deaf student is a sign language user, his or her language processing will have either a predisposition or preference for visually inputted communication information.

In the case of the native, fluent and late sign language users for whom this curriculum has been developed, previous educational experience will not have included any teaching to support, develop or describe the grammar of the sign language user. The teaching of grammar is part of the curriculum for speakers of English.

As has already been said, as the first linguistic descriptive grammar of ISL was published in 2000 and as the first qualified ISL tutors only graduated in 2002 young Irish deaf school pupils could only now begin to receive tuition on the grammar of ISL.

The differences between ISL and English grammars and behaviours have been described in detail elsewhere (McDonnell 1998, Leeson 2001, Duffin 2004), One or two examples used in the curriculum are shown in the table below.

Grammatical Role (Grammar Job)	**English**	**ISL**
Time marking/Tense	Time words exist (yesterday) Past, present or future time is usually set by or added to the verb	Time sign exist (YESTERDAY) Time is indicated at start of communication in one of a number of ways.
Pronouns	A finite number of words exist to describe simple pronouns.	Index referent indicates one or more persons Placement can be used to describe persons not present
Adjectives	Separate lexical items	Separate lexical items Inflected into the noun

From: Comparison of English and ISL Grammars by Role. Duffin forthcoming

For deaf people, learning English is predominantly a metacognitive exercise as their experiential knowledge of English can only be either partial or minimal and they have to work hard to construct its grammar using the hearing they have, using lip reading and using contextual guess work (Paul.1998, 2001) For hearing people both metacognitive and experiential perspectives can be brought to the task.

In practice what this means is that when deaf people are reading English they cannot rely on the vast store of information on words and arrangements for words known covertly by hearing people as part of their functioning grammars which allows them to know if something written *looks or sounds* right.

Presenting grammar as a linguistic concept allows a description of the components of communication in terms of roles (or grammar jobs) in theoretical terms this means we deconstruct our notion of grammar into a model containing all the jobs that need to be done in order for complex communication to be understood between speakers. Thus, the curriculum is able to describe and demonstrate the way the roles within communication manifest themselves in the performance of ISL and in the written form of English. This is a particularly empowering approach for deaf students as the understanding of English grammar that is required doesn't come from immersion in the language or by teaching English grammar as a subject on its own, but by application of the student's own growing knowledge on how languages behave.

The use of plain English and plain language to describe complex abstract concepts is also a particularly important feature of the curriculum. Students do not need to learn about linguistics at bachelor degree level, but they do need to have a sense of language behaviours in general in order that each individual can construct his or her own internal models of how these behaviours (or grammars) apply to ISL and English. Examples of ' grammar jobs' referred to in the curriculum include:

Action
- **Information about the action**
  - Identification
  - Information about the noun
  - Pronouns
- **Time marking**
  - Tense
  - Aspect
- **Reference**
- **Relationships**
  - Initiator of action
  - Recipient of action

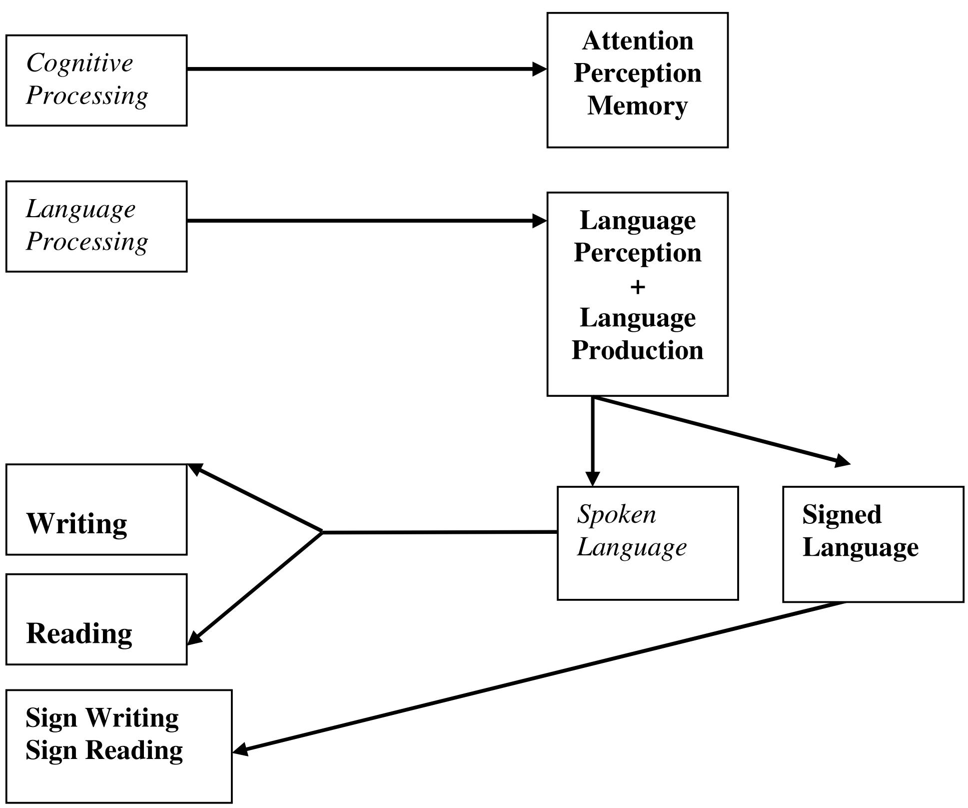
From: Duffin D. forthcoming

We have now examined the factors that must be taught in order to understand the differing English and ISL phonologies and we have also shown that many differences exist between the two respective grammars. It is not possible in this paper to describe the differences in grammar fully, a more detailed discussion can be found in Pat Donnell's 'Introduction to Deaf Studies in Ireland' (Duffin 2004).

We will now look at a particular element of the relationship of the written form of English by making in an addition to the language representation model discussed earlier. This will highlight the fact that the written form of English doesn't have an explicit concrete relationship to language processing as the spoken and signed forms do, being as it is an abstraction from the spoken form (Paul 1998, 2001) and will demonstrate more precisely the nature of the difficulties experienced by deaf people learning to read.

The Relationship Reading and Writing Skills to Cognitive and Language Processing.

This diagram captures the relationship between comprehension and speech and queries the relationship of the written and read forms of English to the spoken form.



Model of Written Forms of English and ISL: Duffin forthcoming

It shows that for all who learn to read English the spoken form of English must be associated with the arrangements of the 26 letters of the English alphabet that we all know as words and sentences. It also demonstrates that for deaf children who use a sign language the there is no clear route through which access to reading and writing skills in English can be gained as there is no guaranteed route to spoken language fluency. It will be of further interest to mention the existence of written forms of sign languages in the following discussion about acquiring reading skills.

English Reading and Writing

Children learn to read after they have learned to talk. As we have already explained that spoken languages use the medium of sound for both production and perception is easy to see that there is no automatic transference from the spoken sounds of English to its written or orthographic form. It is simply not possible to place a number of sounds on a sheet of paper. All forms of written spoken languages employ symbolic representation. English uses the Arabic alphabet as symbols to represent the sounds of spoken English (Crystal 1997). The alphabet is familiar to us because we know it and because we have long ago learned to associate its characters with the words we speak. It is difficult for us to acknowledge that the alphabet is a purely arbitrary system of symbols for representing a series of sounds on a two-dimensional surface.

In learning to read the child goes through a very complex process in learning to associate the written symbols with the spoken language he is used to hearing and using. This is why there have been such a large number of reading programmes developed and why there is such variation in the way that children learn to read and in the ages at which the individual gains mastery of the task (Paul 1998, Paul 2001).

In presenting the means to best support deaf people in accessing written English text there are two main historic schools of thought to consider (Padden and Ramsey, 2000, Hoffemeister 2000).

1. Deaf children with the greatest levels of hearing will learn to read English with the greatest ease because they have greatest access to the spoken language form of English and therefore can be expected to experience the least difficulty in making the transference to an abstracted written form.

Difficulties with this point of view centre on the variation of spoken language input access between one deaf person and another resulting in the fact that the most profoundly deaf members of the class will continually be at the greatest disadvantage.
Additionally existing language skills in ISL may go unacknowledged.

2. Deaf children who are fluent or native signers can be considered to have first language fluency (not something that can be assumed for all deaf children as 90% are born to hearing parents) and therefore can also be supposed to have all the templates for deep linguistic processing in place. This situation would appear to be optimal for the teaching of an additional language, as fluency in one language would already exist.

The former can be considered to represent an oral teaching methodology where English is largely taught through the spoken form and the latter can be considered to represent a bilingual teaching methodology where English is taught through the medium of ISL.

In previous papers I have often promoted the idea that all deaf children be given access to a sign language however minimal the hearing loss he or she is diagnosed with. This is because ISL is the only fully accessible language option for deaf children (Duffin 1999), notwithstanding hearing parents of deaf children's concerns around English speech skills, I still feel this is the best option for securing fluency in a first language (that is a signed language), fluency in reading and writing English and that it gives optimal opportunity for the development of speech skills.

Sign Writing

The task underlying the creation of a written form of a sign language is basically the same as for English; an abstraction from the performance to a set of symbols on paper will allow the communication to be *read.* However, two factors in the process of developing sign language writing are very different to developing spoken language writing:

1. Here we are not conveying a representation of sound to a visual form, we are conveying a representation of a visual-spatial language (which is perceived visually and produced kinesthetically) to a visual form. Unlike spoken language sign language performances can be captured visually either by photographs or on video.

2. Because or sign language perception of signed language uses a visual channel we can be can employ a visual symbols in creating an orthographic representation. For example we can show handshape using a symbolic representation that is not abstract but is directly related in shape and form to the handshape it represents. This is because of the isomorphic nature of sign languages (... signs are iconic: that is, there is a relation between the form of the sign and its meaning. Emmorey 2002. p.17).

One of the best-known sign writing systems is that developed by Sutton (1973, 1981, 1995 and cited in Matthews 2000). This system existed in a written form for 10 years before the software programme SignWriter was developed. SignWriter can be written from the productive or the receptive perspective of the writer. This system can be used in four different ways giving different levels of detail. In effect the system ranges from a simple note form to a fully detailed descriptive form.

In reaching this point in the discussion supporting the development of a meta-linguistic curriculum we have been required to take a number of disciplines of study each of which has its own supporting body of research and publications. These include: psychology, theoretical linguistics, language acquisition, second language acquisition and psycholinguistics. The development of this curriculum has necessitated the isolating of the salient points from each and combining them in a meaningful discussion to demonstrate the sounds theoretical basis upon which the curriculum is being built.

The meta-linguistic solution

The following points summarise the factors that need to be considered when developing programmes for the teaching of English to deaf children and adults:

- Psycholinguistic research demonstrates that the greatest difference between spoken and sign language occurs at the performance level.
- Signed and spoken languages have very different phonologies.
- Signed and spoken language grammars are adapted to the performance modality.
- The only modality of language that can be fully accessed by the deaf child or adult is a signed language.
- All deaf children experience difficulty in acquiring spoken English.
- Deaf people's understanding of their own language remains wholly dependent on the functioning grammar each individual.

- The functioning grammar of each individual varies enormously depending on early sign language acquisition experience.
- Neither mainstream nor specialist schools timetable teaching about the grammar of ISL.
- Deaf people's restriction of access to spoken English has an effect on accessing the orthographic form of English.
- Deaf people do not have equivalent numbers of English spoken words in their long-term memories to their hearing peers.

Model of the Curriculum

My research is a response an identified need for deaf students to be able to access academic text and takes a 'meta-linguistic' approach to reconciling the grammatical differences between English and ISL. I am developing a curriculum that 'bridges' the two languages by deconstructing the grammars of both under a Chomskian model of universal grammar. The curriculum in development at the Centre for Deaf Studies is presented over 10 weeks. The classes are two hours in duration with each session comprising a lecture containing the theoretical element and a practice session where students work as a group translating from English into ISL.

This paper does not touch on historic and current methods of assessment of deaf students English skills of which there is also a large body of research studies and publications. The topic of assessment in the context of this curriculum is only spoken of in terms of any individual's improvement on his or her past performance.

The curriculum acknowledges is the diversity of experience and skills within any one group of adult students in the introduction students are encouraged to set rules for the group in terms of discussing what happens in the class outside the classroom. It is generally agreed that what happens in the class is not discussed outside the classroom in order that members of the group can feel comfortable during the learning process. During discussion it always emerges that a simple and effective way of assessing whether the person understands when reading is to translate the English text into ISL.

The following model demonstrates that the curriculum proceeds from the premise that an approach of simply looking at word meanings and translating them will not provide an adequate understanding of the text. By the fifth teaching session students are aware of the

importance of context and inference and that grammatical forms and writing conventions must also be taken into consideration when translating the meaning of text.

Discussion

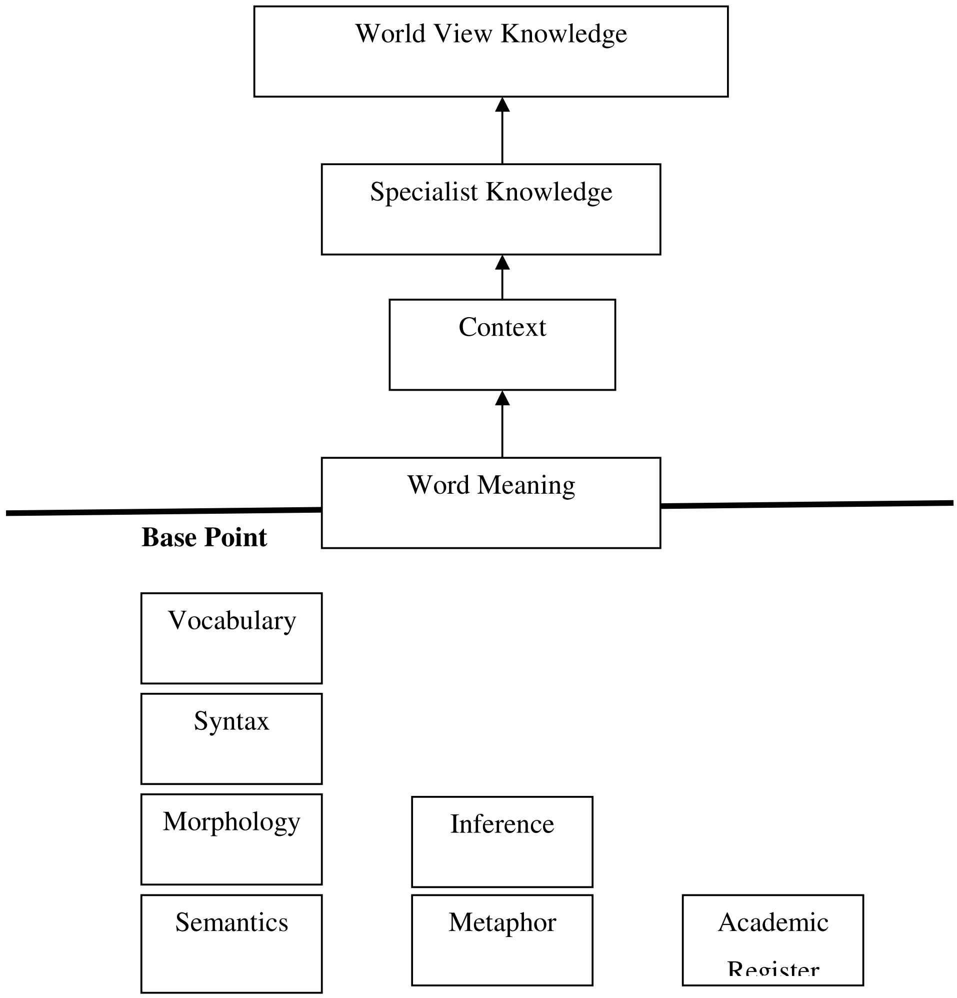
Over the duration of the course students may be taught one-to-one, may work together in pairs or may work together as a group. It is very important at the start of the course that an environment of safety and confidentiality is established. This is because students will be asked to demonstrate their abilities in understanding complex English sentences. Historically deaf students become proficient at concealing what they do not understand because they may have spent many years in education asking for information to be repeated or explained and, having tired of constantly being at a loss, have developed a number of ways of hiding lack of comprehension.

It is important, therefore, in delivering this course to create an environment of openness and honesty. This is done by acknowledging the difficulty of translating English meaningfully and by agreeing that the best way to see what comprehension is present is to translate the English into ISL. There is usually a discussion around why the use of Signed English (a signing system that mirrors the syntax of English) and finger spelling can also mask comprehension.

One of the goals of the first teaching session is to establish agreement amongst the students that there will be no criticism of any other student's skills, that what is said in the class remains confidential and the students will be honest and open about their own skill. It is because of the sensitivity each individual may have around his or her English skills that the course is not formally assessed. Instead there is discussion about the reasons for the diverse range of deaf people's skills and abilities in English to show that any form of comparative assessment would be without value. At the start of the course each student is videoed as he or she translates a short passage of English by signing it in ISL.

At the end of the course and also again at the end of the year the student is given a passage of similar difficulty to translate and he or she and the teacher will discuss the improvements that are visible. As has been said earlier many curricula for deaf students are based on the English as a second language model and their grammatical perspective focuses entirely on the grammar of English. The meta-linguistic curriculum builds on the functioning grammar of ISL of the native sign is whom it targets. By presenting grammar as a linguistic concept, which describes components of communication in terms of roles (or grammar jobs), the

curriculum is able to describe and demonstrate the way the roles within communication manifest themselves in the performance of ISL and in the written form of English.



Model of Meta-Linguistic Curriculum: Duffin forthcoming

Although this particular curriculum has been developed for University students at the Centre the Deaf Studies in Trinity College Dublin, its underlying methodology should hold true for future development of curricula for different age groups and for different levels of ability.

The curriculum has two main aspirations for the deaf person. The first to provide a substitute for the stage of reading development that all people must go through and which is even more difficult for deaf people to achieve successfully than it is for hearing people. This is the complex process of relating known sounds to an alphabet of abstract symbols and to substitute instead a system for understanding some of the principles of linguistic behaviour at a deeper level of processing. The curriculum should therefore be equally effective for

profoundly and *partially* deaf students alike as it removes the disadvantage experienced by the students with the lowest levels of hearing with curricula using spoken language methodologies.

The second aspiration is concerned with self-advocacy: it is the intention to place the deaf person in control of his or her English reading development by equipping him or her with:

- A body of knowledge on which further knowledge can be built over a period of time
- A series of strategies that can be employed when decoding text
- The growing self-confidence to make a lifelong commitment to this difficult, time-consuming and lengthy process

When employing a meta-linguistic curriculum we are necessarily bound to discuss and understand complex conceptual and abstract ideas. Although the Centre for Deaf Studies is an ideal environment for such discussions, primary and secondary of schools are not. Therefore versions of the curriculum for application in a variety of settings would need to slowly and gradually build such awareness and understanding within the context of education in general. This would seem to be one of the biggest arguments for deaf children being offered a different type of education to the current system.

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Catalan: The Renaissance of Europe's "Stateless" Language: A Paradigm for the Irish Language Revival?

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Abstract

This paper looks at the history of the struggle to keep Catalan – the "stateless" language - alive. Throughout the period of Franco, Catalan suffered almost devastating oppression. It came close to extinction and was kept alive by language enthusiasts determined to preserve an integral part of the Catalan culture. As a result, Catalan today not only survives but flourishes, reaping the benefit of benevolent and progressive government programs. Have we, in Ireland, a lesson to learn from the success of Catalan?

The Language of Llull

Straddling the border of France and Spain, snuggled in to the foothills of the Pyrenees, lies the Principality of Andorra. Its population of 64,000 people inhabit an area of no more than 468 square kilometres of rugged land. During the winter months it is a Mecca to European skiing enthusiasts. For the rest of the year its tax haven status draws visitors in search of cheap alcohol, perfumes, cigarettes and electronic goods. Were it situated in the mid-West of America this population would feature as an insignificant dot on a standard O/S map.

Yet Andorra is a unique entity. Its population is the only group of people in the world to have Catalan as their official language. While Andorra is the only place where Catalan is the sole official language, Catalan is spoken by approximately 10.5 million people in areas covering Spain, France and a small city on the Italian island of Sardinia. The combined total area of Catalan speaking territory is 68,000 square kilometres.

That Catalan-speaking area is bigger than Holland, Belgium Denmark or Switzerland. As a language it is more widely spoken than Danish, Finnish and Norwegian, and is equivalent in number to speakers of Swedish and Portuguese. Although only Andorra has it as a unique official language, Catalan - along with Castilian (Spanish) - has official status in three Spanish autonomous regions: Catalonia, Balearic Islands and the Community of Valencia. Today some 27.5% of Spanish citizens live in territories where Catalan is the official language (albeit jointly with Castilian).

Catalan is not a dialect of Castilian – a common misunderstanding by people who first encounter it. Nor is Castilian a dialect of Catalan. Indeed, both could be said to be dialects of low Latin having been forged from that source many centuries past. The first Catalan words were found in documents dating as far back as the 9th century. The first known literary texts written in Catalan date from the 12th century. The language is thought to have evolved about two centuries previously. The oldest extant book - titled Les Homilies d'Organyá - can today be found in the National Library of Catalonia.

In the 13th century Catalan had its first literary giant: Ramon Llull (1235-1316). Llull, writer and philosopher, was the first writer to use Catalan - the language of the people. At the time it was the norm for scholars to write in Latin. In his 80 years Llull produced some 256 texts, using Catalan for a large majority of them.

But it was during the 19th century that Catalan became the medium of a literary revival which raised its status from the language of dusty antiquity and the vernacular of the peasant to the accepted and respected language of the middle and upper classes and officialdom. The period became known as the Catalan Renaixença (Renaissance). During this time several outstanding writers emerged including Jacint Verdaguer, Àngel Guimerá, Narcís and Joan Mangill.

At the start of the 20th century there was a drive to have Catalan accepted as the language of government. The architects of this campaign believed rightly that the language's long-term survival could best be achieved by embedding it as the language of government and commerce. Such a strategy assured the language of funding. It also provided a central driving force and blessed it with the imprimatur of officialdom. It was a tactic that was to bear fruit. Interestingly, Israel adopted a similar strategy in its drive to restore Hebrew to the pantheon of living languages and, too, succeeded.

In the early 20th century the foundations of Catalan's long-term well-being were systematically put in place. In 1907 the Institut d'Estudis Catalans (www.iec.es) – The Institute of Catalan Studies - was founded to assist in the standardization of the language. The Institut set about preparing a report on how the spelling and grammar of Catalan might be standardized. The effort culminated in a report, published in 1913, titled "Normes Ortogràfiques" (Spelling Rules). In 1917, the Diccionari Ortogràfic (Spelling Dictionary) was published. The following year the Gramàtica Catalana (Catalan Grammar) was completed. Soon after, a full scale effort was launched to create the first, comprehensive Catalan

dictionary. The work culminated in the publishing of the definitive Catalan dictionary in 1932.

So, only five years after the defining dictionary of English was completed – the Oxford English Dictionary – Catalan had its definitive dictionary and all the standardized rules and regulations of a modern, living language. For a brief, glorious spell during the 1930's Catalan enjoyed the status of official language of Catalonia. It was actively promoted and taught throughout the education system. At the outbreak of the Civil War in Spain Catalan had the cornerstones of its language in place – widespread acceptability and use, a literary tradition and standardization. It was the fact that Catalan was so robust in health at this historical juncture that allowed it to survive through the next four decades of turmoil and suppression.

The Language's Nadir

Catalan's lowest ebb came during the reign of Franco who ruled Spain as a right-wing dictator from 1939 until his death in 1975. During that reign Franco pursued a relentless campaign of repressing all things Catalan, especially the language. He saw the existence of other languages within the greater Spain as a threat to his centralized control. Publishing houses, book shops and libraries were emptied of Catalan literature. Priceless collections of Catalan works were burned in the streets. A campaign of "Castilianisation" was enforced with street names and village names changed from the Catalan to a Castilian equivalent or approximation. Catalan was wiped from the airways of TV and radio and banned from use in the education system. The publishing of books, newspapers and magazines in Catalan was banned. The language of government, commerce and law was Castilian. Any legal documents written in Catalan were not considered to have any legal status.

In short, Catalan was subjected to a literary garrotting. The slogan of the Franco era was "Si eres español, habla español" ("If you are Spanish, speak Spanish"). Yet, remarkably, the language did not die but survived as an underground language, spoken in the homes of Catalan speakers. Catalan philologists continued to update the vocabulary – the life-blood of every living language. Exiled and non-exiled writers continued to produce literary works. In essence, an underground literary resistance was practised throughout the reign of Franco. It kept the language alive and healthy. As a result, when Franco died, Catalan was ready to be restored to its former glory.

The Modern Era

With the death of Franco in 1975, and the gradual reassertion of democracy across Spain, tolerance for cultural diversity grew. This tolerance was manifested in the 1978 Constitution of Spain which give official recognition to minority languages and paved the way for languages like Catalan to be restored to joint official status with Castilian. Article 3 declares: *"The other Spanish languages shall be official in their respective autonomous communities in accordance with their statutes"* and, furthermore, *"The wealth of the different languages variations of Spain is a cultural heritage which shall be the object of special respect and protection"*. Between 1979 and 1982 Catalan was restored as an official language across the different autonomous areas of Spain where it had survived Franco's suppression.

Under these statutes, the autonomous parliaments of Catalonia, the Balearic Islands and the Community of Valencia passed laws favouring the Catalan language. During the 1980's the use of Catalan was introduced in to the education system, government and media. The Catalan Statute of Autonomy of 1979 established that while both Catalan and Castilian were joint official languages, only Catalan was "native" to the region. It was a subtle assertion of Catalan's primacy in the minds of the Catalonian people. The Linguistic Normalization Act of 1983 provided for Catalan to be used in all official contexts and actively encouraged the use of Catalan in all business or commercial transactions. In 1997 the Catalan Language Act made it obligatory for all radio and TV stations in Catalonia to broadcast at least 50% of their programmes in Catalan. In the schools Catalan became the language of education with non-Catalan speakers undergoing "immersion" programs to bring them up to the accepted standard. The government of Catalonia – The Generalitat - saw the use of Catalan in daily, commercial life as the way to ensure that it survived and grew as a living language amongst the wider population.

During the 1980s and early 1990s there was a growth in mass media outlets for the Catalan language in the autonomous regions of Spain. Television and radio channels flourished and the presence of Catalan in the written media increased to the point where today there are approximately – according the official site of the Catalan government - 10 daily Catalan language newspapers, a hundred magazines and over 200 local Catalan papers (www.gencat.net). According to the same sources in the Catalan-speaking regions of Andorra, Catalonia and the Balearic Islands 95% of the citizens understand it. In the Community of Valencia that number is an estimated 80%.

The Catalan publishing industry – which is subsidized - is also flourishing. In 1999, for example, 7,492 titles were published in Catalan with a total print run of 20 million copies. These same publishing houses publish around 6,000 new titles every year. At the beginning of 2000, the number of titles available in Catalan, according to the ISBN, was in excess of 75,000. According to the Institució de Les Lletres Catalanes (www.cultura.gencat/ilc) there are more than 1,200 living Catalan authors. Today, there are more books published in Catalan than there is in either Hebrew or Norwegian.

Catalan in an Expanded Europe

In 2004 the European Union will grow with the addition of 11 new states. Of these new "Accession States" only one has a greater population than the aggregate area where Catalan is spoken; Poland with its 38 million people. Nevertheless, Catalan is still categorised as a minority European language. Catalan advocates argue that this is an anomaly arguing that while Catalan is not the language of a monolingual people (apart from Andorra); it has the characteristics of a majority language.

Minority languages are defined as those which have no monolingual population, the speaking populations are part of a bigger state where there is a majority language, and the language is not completely assimilated in to some aspect of social life. However, advocates of Catalan argue that there are good reasons to argue that Catalan is not a minority language:

1. Catalan has a legal status and governmental recognition;
2. Catalan has a demographic force of numbers. It is the 7th most spoken language in the European Union as that entity is presently constituted;
3. Catalan speakers represent more than one third – 33.5% - of EU minority language speakers. The nearest next minority language is Galician at 13%.
4. Catalan has a robustness and historical pedigree that has allowed it to survive and grow;
5. Catalan has a vibrant and growing literary pedigree;
6. It has a recognised linguistic authority and all the linguistic resources of a majority language.
7. Catalan has all the attributes of a majority language: it is codified, standardized and controlled, has an organic philology and is accepted by both citizens and academics in their daily lives.
8. Unlike English, Catalan has an agreed spelling across all of its dialects!

(Source: http://cultura.gencat.es/llengcat/publicacions/)

Compared with other minority languages Catalan jumps out as a class of its own. This fact received some recognition when Catalan, following a proposal from the Intergroup for Minority Languages, was granted limited recognition within the European Parliament. Unlike many of the other minority languages it appears to be progressing rather than regressing. Admittedly, in urban centres such as Barcelona the predominance of Catalan is challenged by the constant influx of non-Catalan speaking people. These new residents, mostly from other parts of Spain, tend to dilute the preponderance of Catalan speakers.

The impact of non-Catalan speakers settling in the Barcelona area is probably the biggest challenge to the growth of the language in that area. In a survey commissioned by the Spanish national paper *El Pais* earlier this year one out of every two adults living in Barcelona said that they considered Spanish and not Catalan to be their main language. However, the same survey noted a six fold growth since 1985 in the number of people who classified themselves as bi-lingual (*El Pais*, April 26, 2003).

Yet even in Barcelona Catalan still retains a strong presence and new migrants find they need to learn to understand the language even if they do not reach fluency. The fact that Catalan is used so widely in business, appears in road signs and is prevalent in the media behoves them to at least develop a degree of bi-lingualism. What one commentator dubbed "passive bi-lingualism" has resulted in the strange situation where it is quiet common to hear conversations in Barcelona shops with one party speaking the native Catalan and the other person speaking in Castilian. Even in Andorra locals easily switch between their native Catalan and speaking Spanish when required.

The children of these migrants are educated solely through Catalan and so develop a fluency for the language. This has resulted in the children having Catalan as their first language while their parents have Spanish. Both the parents and the children consequently find a need for bi-lingualism. Figures from the recent *El Pais* survey show that the younger population of Catalonia – 18-25 year olds – consider Catalan their native language and use it in every aspect of their daily lives. It is a factor that seems to augur well for the survival of the language.

In early June the Conselleria d'Ensenyament de la Generalitat de Catalunya (the Education Department of the Catalan Government) announced it would promote the social use of Catalan language in the schools with out-of-school activities. It plans to start up these language activities in the course 2003-2004. In addition, under the slogan 'En català, tu hi

guanyes'(in Catalan you win), the Direcció General de Política Lingüística (Generalitat's Linguistic Policy department) also announced a programme addressed to business leaders and workers emphasising the importance of learning Catalan and using it in all kinds of social gatherings.

Harry Potter and the Philosopher's Language

Some cynics might be tempted to argue that the language of Llull reached some form of mundane acceptance when, in 2001, the makers of the Harry Potter films agreed to dub their films in to Catalan. Speakers of Catalan had threatened to boycott the first Potter film – and all Time Warner films - because it was not available in Catalan. The boycott was avoided after an agreement was reached between Time Warner AOL and the government of Catalonia that all future Potter films would be dubbed. As an interim solution Time Warner circulated copies of the original film with Catalan subtitles.

The government of Catalonia - the Generalitat - continues to pursue a rigorous campaign promoting the language in all aspects of life. They have identified the web as a vital area for the promotion of the language. In 2002 they launched an ambitious e-government project. The objective of the campaign is to open up access to all departments of the government through the internet. One resulting symbolic move was to change the web site of the regional government from the .es suffix of Spanish web sites to the more international suffix .net. Also as part of the campaign they invited Yahoo to develop a Catalan version of its search engine directory. This resulted in a launch of the Catalan version of Yahoo in 2002. According to the Italian newspaper "La Repubblica" Catalan has 440,000 web pages and is the 19th language in terms of volume on the web.

But perhaps the biggest disappointment to speakers of Catalan is the slowness of Microsoft to make a full version of its Microsoft Office product available in their language. Nevertheless, several Microsoft products and operating systems are available in Catalan for example, Widows 98, Windows XP Professional, MS Messenger and Word 6.0. Meanwhile, the government of Catalonia continues to encourage Microsoft and other software providers to localize more of their products in to the Catalan language. (For a full list of all available software and operating systems available in Catalan see the Generalitat´s web site at: http://cultura.gencat.net/llengcat/informat/index.htm#progr).

The Future

Through the slings and arrows of outrageous fortune Catalan has survived. And its survival does seem assured. Its longevity and resistance would seem to bear witness to that. In addition, it has the backing of a government which is striving daily to ensure that it not only survives but prospers as a living, vibrant language. Certainly its existence has been weakened in areas where immigration from outside the region is highest. That is probably the greatest source of concern for the Generalitat. Ironically, the biggest threat to the language is the attractiveness to immigrants of an area like Barcelona, with its strong economy, beautiful location and temperate climate. The challenge for the Generalitat is to ease the absorption of these new residents in to the area and to make the use of Catalan attractive to them. Campaigns such as the recently announced 'En català, tu hi guanyes'(in Catalan you win) are aimed at precisely this.

The Generalitat must also encourage more communications providers, the mass media, film makers and software providers to supply their products in Catalan. If they can build this momentum the erosive effect of non-Catalan communications will be greatly weakened. Finally, the aficionados of Catalan should feel encouraged: the fact that Catalan has these challenges to overcome and not the more daunting, life-threatening challenges facing the other minority languages of the European Union is in itself a wonderful achievement and a testament to the Catalan speakers of Europe. It should also give encouragement – and act as a blue-print? - to Irish language enthusiasts as they strive to continue the revitalisation of An Gaeilge.

Note: A version of this paper was first published in *Multiligual Computing and Technology, in* November 2003

Appendices

Regions where Catalan is spoken in Spain

- The old principality of Catalonia, which, since 1977, has had its own autonomous government, the Generalitat de Catalunya. This corresponds to the Spanish provinces of Barcelona, Girona, Lleida and Tarragona.
- The old kingdom of Valencia (consisting of the Spanish provinces of València, Castelló and Alacant)
- A strip of eastern Aragó.
- The Balearic islands (Mallorca, Menorca, and Eïvissa)
- Within the Spanish territories mentioned above, Catalan has joint official status with Spanish.

Regions where Catalan is spoken outside of Spain

- The Co-Principality of Andorra, where Catalan is the only official language. However, Spanish and French are also spoken and widely understood.
- The French province of Rosselló, the Department des Pyrénées Orientales (also known as Catalunya Nord)
- The city of Alguer (Alghero) in Sardinia, Italy

Source: http://www.bham.ac.uk/CatalanStudies/language.htm

The population of Catalan-speaking areas compared to the 10 New Accession States

Polish	38.7m
Catalan	**10.8m**
Hungarian	10.5m
Czech	10.3m
Slovak	5.4m
Lithuanian	3.7m
Latvian	2,4m
Slovene	2.0m
Estonian	1.4m
Cyprus	0.76m
Maltese	0.4m

Data Source: IDESCAT INE PANORAMA OF THE EU 2000

Examples of Spanish and Catalan Words

ENGLISH	CATALAN	SPANISH
chair	cadira	silla
table	taula	mesa
window	finestra	ventana
(drinking) glass	got	vaso
ground	terra	piso
ceiling	sostre	techo
boy	noi	muchacho
woman	dona	mujer
uncle	oncle	tío
cousin	cosí	primo
nephew	nebot	sobrino
clean	net	limpio
dirty	brut	sucio

Source: http://www.geocities.com/aeccsa/faqs.html

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http://www.itb.ie