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DESIGNING AND IMPLEMENTING APPLICATIONS FOR HEARING-IMPAIRED CHILDREN

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Abstract. Hearing-impaired children need extra help when learning new words and concepts. Because they cannot truly understand and perceive all the information they hear or read, a very effective method is to use images and sign language during the learning process. *aSIGNment* helps in providing an education for hearing-impaired children, starting from preschool, by using technology to bring a new way in meeting their needs during the learning process and in obtaining the supervision of a qualified educator.

1. Introduction

We all learn throughout our lives. Human beings have five senses as their main assets in experimenting the world around them, learning and communicating. A child is open-minded and eager to learn as much as possible. His understanding and integration into society are much better if he receives as much information as possible.

Hearing is crucial in speech and language development. It is extremely important to diagnose and treat hearing loss at an early age. A hearing-impaired child can normally develop speech and language if he benefits of a hearing aid device before the age of 6 months [1].

This is ideal, but not possible in many cases. Therefore, one of the first problems that arise is schooling. Hearing-impaired children need extra help when learning new words and concepts. Physical objects normally do not pose problems, but abstract concepts such as time, feelings and thoughts are harder to explain [3]. The solution proposed, *aSIGNment*, is a software that works towards providing education to every child with hearing impairment around the world (starting from preschool, ages 3-6), by optimizing education systems

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1998 *CR Categories and Descriptors.* K.3.1 [**Computing Milieux**]: Computer Uses in Education – *Computer-assisted instruction*; J.4 [**Computer Applications**]: SOCIAL AND BEHAVIORAL SCIENCES – *Psychology*; J.3 [**Computer Applications**]: LIFE AND MEDICAL SCIENCES – *Health.*

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already in place. Similar solutions (e.g. ABC Deaf Software, IDRT software) are mostly targeted on hearing development and are used to sustain teaching or as self-study. Compared to them, *aSIGNment* uses technology, especially Microsoft Silverlight and Microsoft .NET, to present the information in a way in which hearing-impaired children can understand in better — images and videos of sign language. Children will learn in a specialized organization or at home, but always under the supervision of a qualified educator.

2. Problem Definition

Communication is a necessary skill for us to function well throughout life. We tend to take it for granted that children will develop their language and communication skills naturally and in a predictable way. Being deaf can make that process more challenging, but with the right support, commitment and encouragement from both families and professionals, deaf children can learn to communicate as effectively as other children [8].

It is important to make a clear distinction between deafness and mental deficiencies [1]. Hearing-impaired children bear the burden of their handicap and may become shy, anxious, afraid of people around them, but this is definitely not enough to assume the existence of retardation.

Several relevant facts about deafness are presented below:

- In 2005, about 278 million people had moderate to profound hearing impairment. 80% of them live in low and middle-income countries [10].
- An estimated 12.5% of children and adolescents aged 6–19 years of the United States have permanent hearing damage [2].
- About 2 to 3 out of every 1000 children in the United States are born deaf or hard-of-hearing. Nine out of every 10 children who are born deaf are born to parents who can hear [9].
- Only 1 out of 5 people who could benefit from a hearing aid actually wears one [9].

A key aspect here is that most hearing impairment is not genetically inherited, but rather acquired as the effect of disease or trauma. This means that families of deaf children usually have no experience with the challenges that will follow.

In order to better understand the learning process of a hearing-impaired child and the methods that are used, we have had several discussions with Mrs. Cristina Dohotaru, speech psychotherapist for preschool children at Şcoala Specială pentru Surzi Cluj-Napoca. She explained that many families choose to enroll their hearing-impaired child at mainstream schools, mainly because they do not have enough knowledge about this problem, but also due to financial and geographical reasons — specialized institutions are not available

nearby. Even in special schools, most of the times the emphasis falls on improving children's hearing, despite the fact that they cannot truly understand and perceive all the information they hear or read. For many deaf children, sign language is the only way of efficient communication and learning. It is the critical first step to communication and to the later on development of literacy and spoken language skills [4]. Sign language also provides a way of interacting with other children, which will put the basis for social integration and a healthy self-image.

3. *aSIGNment* — Educational Software for Hearing-Impaired Children

Our solution intends to help hearing-impaired children (starting from preschool) to adapt more quickly to life, by learning them the means to make themselves understood by the others — the sign language. *aSIGNment* is an educational application which can be successfully used in any kindergarten for hearing-impaired children, but also by any other such child from home, as it can be seen in Figure 1 [3].

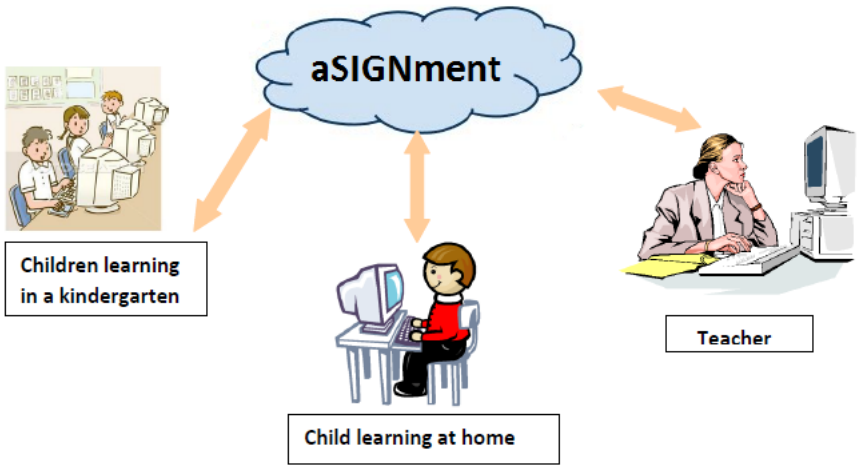

Figure 1. Usage of *aSIGNment*

aSIGNment promotes learning by playing, is accessible from any Internet connected computer, and offers real-time communication. Our approach has several important advantages:

- Permanent monitoring and development under the supervision of a qualified educator.

- Child evolution can be enhanced through specially designed lessons and activities: the teacher can create new lessons and games, can choose which activities to assign to a child based on his evaluation.
- A child who cannot enroll in a special kindergarten or school (due to financial or geographical reasons) has access to education corresponding to his special needs.
- The multiple mice experience in lessons and games offers real communication between children and between child and educator.

The project consists of two applications: one for the children (*aSIGNment Learning*) and one for the teacher (*aSIGNment Teaching*).

The lessons and games were designed starting from Mrs. Dohotaru's advices and explanations regarding the teaching methods used for young hearing-impaired children.

3.1. **Special Features and Technologies.** Since the emphasis falls on learning by playing, the information is presented through a simple, friendly and attractive interface, such that it is appealing to children. A demo in a kindergarten has produced positive feedback, from both children and Mrs. Dohotaru.

Using *aSIGNment Teaching*, the teacher can create new lessons or just modify an existing one, according to the needs of the children, by using a simple menu with all the needed options. There are several patterns of lessons, organized into topics (such as animals or vegetables), according to the various teaching methods that a teacher uses in class. Each pattern can contain text, images and videos of sign language. For example, a pattern requires the children to choose between several images in order to correctly associate a video with a word expressed in sign language with the image that represents that word.

The lessons the teacher creates are presented to the children in the form of educational games, a very effective method for them to learn at this age. In order to create lessons in a more interactive way, the teacher can upload his own photos and videos and then use them.

The children can participate to the lessons in the classroom or from their home computer. The teacher will still supervise their work, analyze their progress by viewing statistics and create corresponding lessons.

A special category of lessons and games contains multiple mice interaction. Children develop social skills and team spirit by working on the same lesson or game together with other children, each having his own mouse device.

Some of these functionalities are illustrated in Figures 2, 3 and 4.

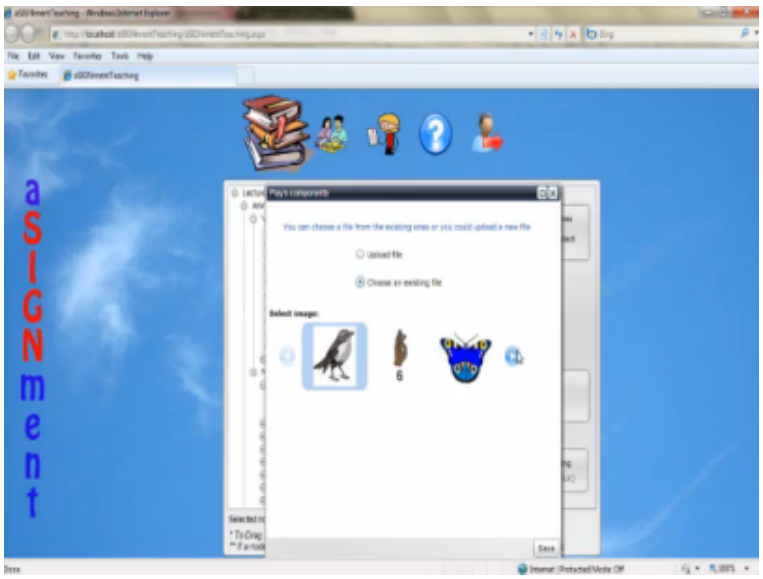

FIGURE 2. *aSIGNment Teaching* — Choosing content for lessons

FIGURE 3. *aSIGNment Teaching* — Viewing results and analyzing progress

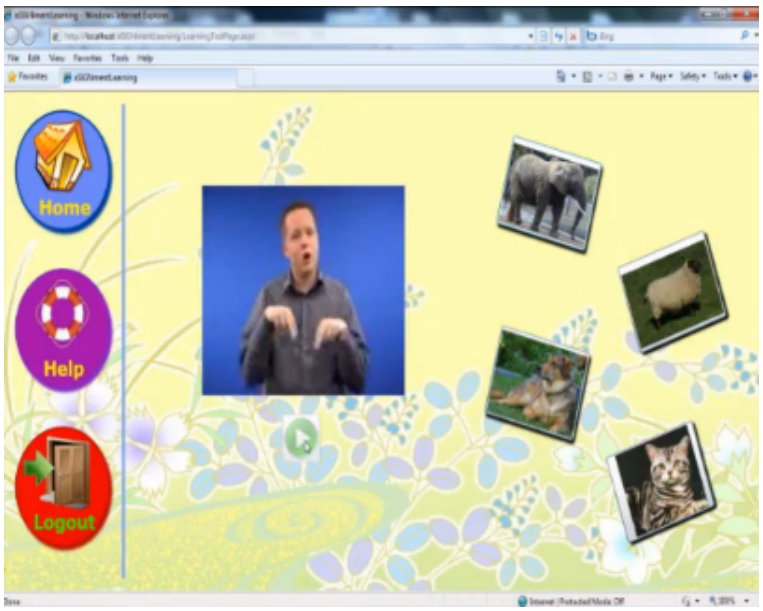

FIGURE 4. *aSIGNment Learning* — Lesson example

3.2. **Technical Aspects.** Both *aSIGNment* applications are based on a 3-Layer architecture, together with the database connection. Each layer communicates only with its neighbors: serves as a client for the layer below and as a services provider for the layer above. Each layer is briefly described below:

- **aSIGNmentLearning** and **aSIGNmentTeaching** are Presentation Layers. They contain the user oriented functionality responsible for managing user interaction with the system and components that provide a common bridge into the core business logic encapsulated in the Business Layer [7].
- **aSIGNmentWFCService** is the Business Layer, which implements the core functionality of the system and encapsulates the relevant business logic. It also exposes service interfaces that the Presentation Layers can use [7].
- **aSIGNmentRepository** is the Data Access Layer and provides access to data. This layer exposes generic interfaces that the components in the Business Layer can consume [7].

The architecture of the solution is shown in Figure 5.

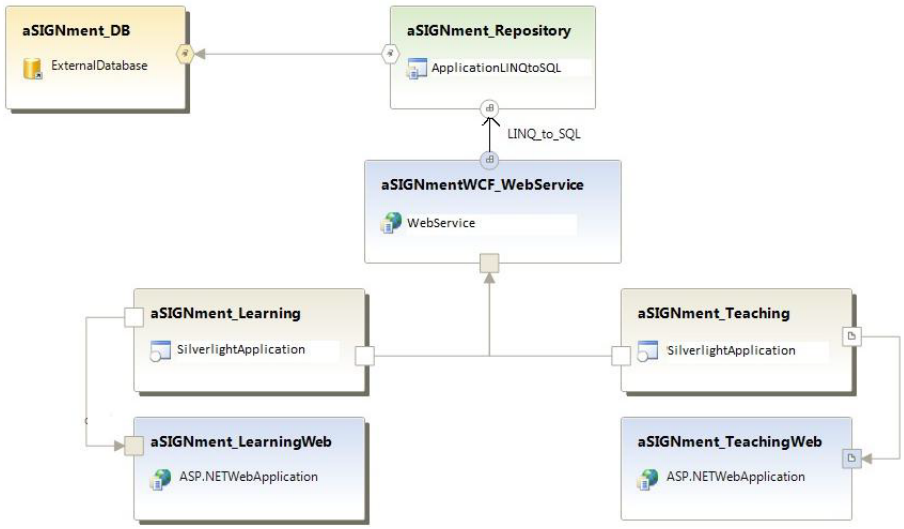

FIGURE 5. *aSIGNment* Architecture

aSIGNment was developed using Visual Studio 2010 and the main technologies used were .NET 4.0, Silverlight 4, Windows Communication Foundation (WCF) Web Service, Windows MultiPoint Mouse SDK 1.5, LINQ to SQL and SQL Server for the database connectivity.

aSIGNmentLearning and *aSIGNmentTeaching* are Silverlight projects that expose information to the end user. Silverlight helps in creating interactive applications, especially important when considering their main users (children are attracted by nice designs and easily learn by "playing"). Silverlight enables Web-based applications to deliver the business functionality users demand with a modern, efficient user interface. This layer communicates with the Business Layer through a Web service.

aSIGNmentWCFService communicates with the Data Access Layer directly through method calls. WCF itself is designed in accordance with service oriented architecture principles to support distributed computing where services are consumed by clients. In this case, the consumer is a Silverlight project (the Presentation Layer). The Presentation Layer uses a WCF service reference to allow the Silverlight project to communicate by asynchronous calls with the Data Access Layer, according to its operation contracts and data contracts. The data contracts expose the structure of the entities from the data layer part. This makes it simple for the Silverlight application's controls to be bound to the instances of the entities and their properties. The operation

contracts define the methods that the Silverlight application can invoke on the WCF service [6].

aSIGNmentRepository accesses the underlying data store, an SQL Server database. It uses LINQ to SQL to connect to the database, which brings several important advantages. LINQ to SQL provides a run-time infrastructure for managing relational data as objects without losing the ability to query. It does this by translating language-integrated queries into SQL for execution by the database and then translating the tabular results back into the defined objects. The application is then free to manipulate the objects while LINQ to SQL stays in the background tracking the changes automatically and taking care of data consistency [5]. There is no need to write code to define the entities in the application, LINQ to SQL uses specific attributes that map the database tables into the classes it generates. Further on, the WCF Web service reference makes them known to the rest of the application. In this way, the layers share a model, but not as actual code written by a programmer, but by some sort of common "language" that is taken care of by the technologies used.

4. Conclusions and Future Work

Our project, *aSIGNment*, intends to provide an education for hearing-impaired children, according to their needs, and it is still at its basic level of functionalities. It can further be improved, for example, by adding new lesson patterns or by allowing the teacher to create his own patterns.

An extension of *aSIGNment* is currently under development, in collaboration with an educational NGO, Media Kinder. This extension is an online general knowledge contest for hearing-impaired children. The questions are formulated by specialized teachers, according to the information they learn in school, and the children compete in teams of two or three. There is a separate set of questions for each grade, from the 2^{nd} to the 6^{th} grade.

Our final aim is to obtain a software product which is used by schools and institutions for deaf children, that will truly help with their education and integration.

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