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Procedia Social and Behavioral Sciences 9 (2010) 815–819

Procedia
Social and Behavioral Sciences

WCLTA 2010

The design of an expert system for the e-assessment and treatment plan of preschoolers' speech and language disorders

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Abstract

Communication skills play a vital Role in life's experiences. Especially when a child enters the formal education setting, the ability to communicate is a significant component in order to learn and interact with peers and adults. The curriculum at school aims to enhance students' literacy and language skills. Educators work hard to offer opportunities within a fruitful environment for the development of children's spoken and written language abilities. The child's learning process can be affected in the case of a communication disorder. Early diagnosis of a speech and language disorder is very crucial for the success of treatment and the child development. The evaluation and diagnosis of such disorders requires experienced clinicians, who may not be always available for a diagnostic evaluation or sometimes might not be experienced enough.

The purpose of the study was to investigate the design of a computer-based system with the knowledge to assess preschoolers' speech and language disorders. The development of the system was planned so as to assist preschool teachers for the diagnostic process. The methodology tool is based on expert systems. The development of the model was based on knowledge from the literature in combination with empirical data used as a knowledge source to facilitate accurate knowledge acquisition. The system also provides tips and recommended instructions for intervention and may partially make up for the expert-personnel shortage in the school setting.

Keywords: Expert system; speech and language disorders; assessment; preschoolers; Greek.

1. Introduction

The role of a child's oral communication skills is vital as it is connected with the child's development and it can be considered as the tool to participate in all the social activities of daily life in the family, the friendly and the school environment. The manipulation of speech and language constitutes a basic factor for the various situations of interaction and further more for the development of the complex relation between language and thought. Particularly, in the school environment oral communication skills are important in order to use speech and language in different conditions of communication. In this manner a motivation for productive thought will be given and the learning process will be strengthened (Michalopoulou, 2009, p. 23).

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1877-0428 © 2010 Published by Elsevier Ltd.
doi:10.1016/j.sbspro.2010.12.240

In the nodal point that children enter formal educational setting, early childhood education, the communication with the educator and with the other children is crucial to their further development. The school curriculum aims to enhance students' literacy and language skills. Therefore, the improvements and enrichment of oral language constitute curriculum's objectives and at the same time conform tools for the students' development in the school environment. For this purpose and in the frame of educational process the evaluation of the children's oral language is a necessary process, so as to identify any difficulties a child might face.

There are many instances where the development of children's communication skills is not advancing in a straight forward manner, having sometimes implications on the child's learning skills. Bond (1993) states that around 20% of children display a speech and language disorder. Speech and or language disorders and delays can have significant negative effect on a child's social, emotional, or academic development, accumulating risks for social problems, anxiety, depression, and attention problems (Bond, 1993; Sices et.al., 2007; Steiner & Braun, 2009; Carscadden, J., et.al., 2010). In the study by Bishop and Leonard (2000, p.228) it is notified that around 50% of children with speech and language difficulties have a range of emotional and behavioral problems as a consequence of their speech and language impairment. Nelson et.al. (2006) report that preschool children with speech and language delay may be at increased risk for learning disabilities once they reach school age, with possibility to face difficulty in reading skills and written language and therefore lead to overall academic underachievement. Likewise, Sices et.al. (2007) report that preschoolers with language disorders have been found to have weaker development of print concept knowledge than normal. Moreover, Nelson et.al (2006) notice that language delayed children have also shown more behavior problems and impaired psychosocial adjustment.

The assessment of speech and language disorders is a specialized process that requires mainly the clinical knowledge of an expert (speech language pathologist- SLP) in order to give a valid scientific diagnosis. In many cases, the collaboration of a scientific team is required, i.e. SPL, psychologist, pediatrician, special educator, etc. in order to accomplish an overall evaluation. In developed countries such as USA, Canada, Australia, Great Britain the school units employ specialized personnel (speech pathologist) that deal with children's communication issues (Naremore et. al., 2001 Roseberry-McKibbin and Hedge, 2000 Paul, 2001 Owens, 2002).

In Greece in the school setting, there is an absolute minimal number of speech and language therapists employed. On the other hand, the educators in Greek schools are not trained to assess a child's speech and language abilities. Preschool teachers are able to identify some symptoms or differences concerning speech and language matters of their students but they are not able to classify them as a disability/disorder. An expert's opinion is necessary to perform a valid diagnosis and set treatment plans. In diagnostic procedures, experience of the educator/clinician is a very important factor for a valid diagnosis.

Furthermore, early diagnosis of a speech and language disorder is very crucial for later success of treatment and child development. Nelson et.al. (2006) state that according to Schuster (2000): *"Identification of children at risk for developmental delay or related problems may lead to intervention services and family assistance at a young age when chances for improvement are best"*.

So, the role of the preschool teacher is to encourage and expand students' speech and language abilities. Hence, according to epidemiological studies in Greece (Vogindroukas et.al., 2004), amongst his/her students there is a strong possibility to find a number of children with some speech and language difficulty. These children's learning, confidence and ability to form groups and develop friendships might be affected, due to their communication disability. Somehow, the role of preschool teacher is to identify children with speech, language and interaction difficulties. In order to help a child with such difficulties the preschool teacher needs to learn more on the particular difficulties and find out the role of other professions that can support the child. Possible strategies can be used to help children in the classroom. A child's speech, language difficulty may be encouraged in a variety of ways, making use of strategies as well as more specific activities.

Consequently, teachers and language professionals must accept the reality that the language domain has expanded exponentially with the infusion of electronic technologies into our students' worlds (Landis, 2002). Teachers and related professionals (i.e. SLPs) can help children to deal with the realities of this complex language

environment. New technologies are full of possibilities to be explored, from assessing spoken language abilities and forming diagnosis to the intervention and management of any disorders.

The purpose of this study is to introduce a design of a computer-based system that embeds the expert's knowledge for the assessment of preschoolers' speech and language abilities. The design of such a system may serve as assistance for diagnostic process to a non expert such as preschool teachers.

2. The design of the expert system

A Knowledge Base system (Vlahavas, et.al., 2006, p.424) can be used in two ways. Firstly, it can be used by a non expert to provide solutions to simple problems and to make valid decisions on behalf of the expert. Thus, in this case a preschool teacher can use such a system to evaluate the speech and language of the child and according to the results of this analysis s/he can plan speech and language activities. In other cases the teacher is well trained to ask for an expert's advice when needed. Secondly, it can be used by an expert as an advisory knowledge system that is called to take a decision and offer consultation as an assistant. This way, experts can improve their effectiveness.

2.1 Ways of knowledge acquisition

The process of knowledge acquisition is considered to be one of the most difficult and time-consuming stages in the development of an expert system. For the expert knowledge extraction scientific handbooks and papers were used as well as collaboration with experts to establish the definition of factors of uncertainty in the diagnostic process.

Nelson et.al (2006) state, that there is no uniformly accepted screening technique for use in the primary care setting. Children's speech and language assessment may identify delays and disorders and it can be carried out in a variety of manners. Instruments such as (i) Child Developmental Milestones for speech and language, (ii) Parent questionnaires, (iii) Children's Communication Checklists (iv) Standardised Screening tests or (v) Other Informal tests can be used. Milestones for speech and language development and Children's Communication Checklists are generally accepted for use in young children (Nelson, 1998; Ketelaar et.al., 2009). Concerns for speech delay arise if there are no verbalizations by the age of 1, if speech is not clear, or if speech or language differs from that of others' of the same age. Moreover, parent concerns' on their children's language progress becomes the first step in the detection of a disorder. Questionnaires addressed to parents are often used to detect delays.

The successful use of speech means for the clinician, that the child is able to normally articulate, produce understandable speech and perceive speech. According to Shipley & McAfee (1998, p.133), normal articulation (the production of speech sounds) is a series of complex actions, requiring exact placement, sequencing, timing, direction and force of the articulators and occurring simultaneously with precise airstream alteration, initiation or halting of phonation and velopharyngeal action. Thus, articulation assessment is a complicated process and requires skills and expert knowledge.

Clinicians, when assessing speech, examine the verbal production of language (Nelson et al., 2006). Especially, articulation and phonology (the set of rules for sound production) are speech processes that must be examined (Nelson et al., 2006). Clinicians use also, typical assessment procedures which include a history of the child's development that provides background information, hearing and oral-facial examination, standardized or non standardized articulation and phonological tests or other observation methods and also representative speech samples, which are fundamentally significant to accurately diagnose speech and sound disorders (Owens et.al., 2000, p.136; Shipley & McAfee, 1998, p.136-140). According to Shipley & McAfee (1998, p.136-140) samples can be used to assess stimulability of misarticulated phonemes, error types, number of errors, prosody, speech rate, identifying dysarthria or apraxia.

SLPs often use normative data for phonemes to determine whether or not a child is developed within normal expectations (Owens, 2000, p.141; Shipley & McAfee, 1998, p.150). Although there are limitations, norms (a norm is the average age at which a behavior of a "hypothetical child" occurs) are practical for simple use in order to find out how well a child's sounds are developing (Shipley & McAfee, 1998, p.150).

In accordance to Nikolopoulos (2008, p.14-15), the successful use of language involves the interaction of three systems of language, which Bloom and Lahey (1978) described to show how the key language skills interrelate.

Figure 1 (Bloom and Lahey's, 1978) illustrates the model and the connection between the systems. In detail, they refer to the form of language, the content of language and the use of language stressing that each skill needs to be evaluated in order to result on the communication processes. In detail they distinguished in the following way:

- Form of language: refers to the ability to present a grammatically correct sentence
- Content of language: refers to the ability to choose the right words to present a message, involving concepts on vocabulary and meaning of words
- Use of language: refers to the ability to use of language in various communications, such as for greeting, argues, descriptions, expression of filings, summarizations, taking turns in conversation, understanding metaphors and jokes and so on.

Although Bloom and Lahey's model does not consider areas such as memory, listening and attention and does not distinguish understanding from expression it can be used for language assessment. The clinician when assessing language issues (a) tries to identify whether impairments in terms of form, content and use are present (b) if so, according to child's age s/he makes associations to disorders such as mental retardation, learning disability, specific language impairment, autism and pervasive developmental disorder, brain injury, early expressive language delay, neglect and abuse, and fetal alcohol syndrome and drug addiction (Owens, 2000, p.204).

To establish our new evaluation procedure cooperation with a team of three experienced clinicians was used in order to secure an accurate knowledge acquisition of the system.

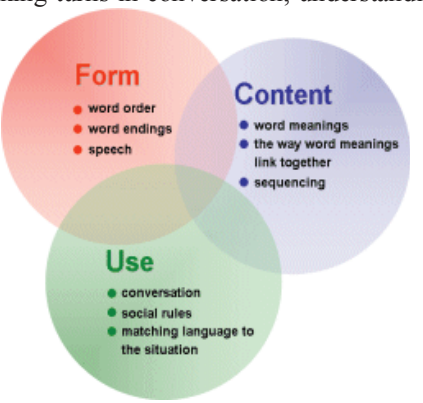

Figure 1: Diagrammatical representation of the language subsystems according to Bloom and Lahey's (1978, p.22)

2.2 Knowledge representation

After establishing speech and language assessment procedures that a clinician has to follow manually, it is important to design how this knowledge can be presented in software systems.

Demirci (2010) states, "generally a fuzzy system is a static mapping between its inputs and outputs. For a fuzzy system the mapping of the inputs to the outputs is characterized by a set of condition–action rules or, in modus pones (if–then) form, 'if premise then consequent'. Generally, the inputs of the fuzzy system are associated with the premise, and the outputs are associated with the consequences. These if–then rules can be represented in many forms. Multi-input multi-output (MIMO) and multi-input single output (MISO) are some of the standard forms".

The proposed system is a MIMO system. Precisely, it is a complex system that can be considered as a composition of other simple subsystems. These subsystems are composed parts of MIMO subsystems. Figure 2, describes the design of the speech and language expert system and how the various subsystems function, in accordance to MIMO systems (Pange & Makris, 2000, p.110). This system gathers first the data of the user (child's speech and language symptoms). Then the expert system with a range of subsystems i.e. articulation subsystem, phonological subsystem, fluency subsystem, etc. applies sets of "if-then" rules to the data in order to produce articulation results, phonological results, fluency results and so on. When all subsystems complete evaluation the results

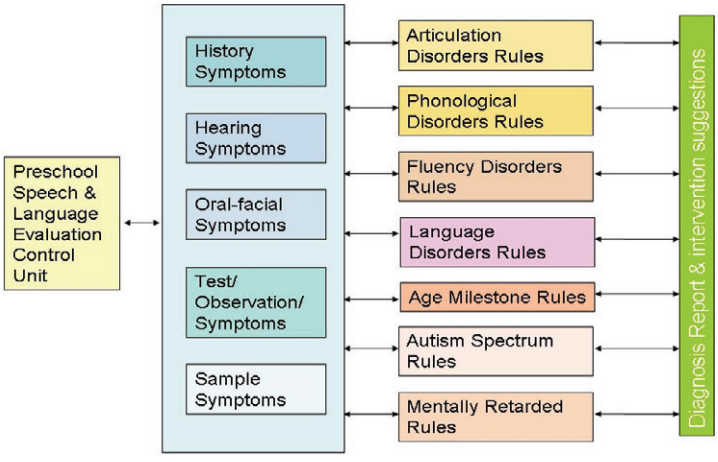

Figure 2: *The Design of an Expert system for assessing preschool speech and language disorders*

are shown in the last face of the system in the diagnostic report which also includes possible guidelines for intervention.

3. Conclusion

The proposed design discussed in this study, describes an expert system assessing speech and language abilities of preschoolers. It has been set up in such a way that the system may be an optional answer to the shortage of evaluation tools using the means of technologies and an assistant to a non expert like preschool teachers.

The designed application is a proof of the advances of new technologies in educational setting. It enhances the presentation of possible solutions in terms of managing the diverse parameters of such a difficult problem in diagnosis. Additionally, it has the potential to diagnose speech and language disorders at an early stage and therefore may offer the chance of a successful intervention at a crucial point that can lead to an ordinary child's development.

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