# PRESENT DAY TRENDS OF INNOVATIONS

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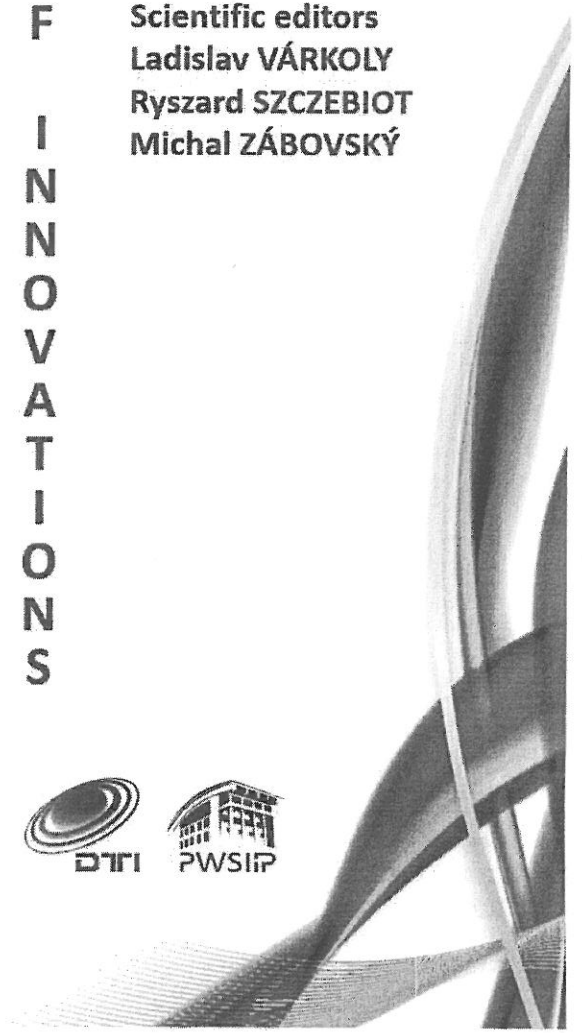

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Issued by Printing House of Lomza State University of Applied Sciences, Łomża



ISBN 978-83-60571-35-4
EAN 9788360571354

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# SUPPORTING EDUCATION OF CHILDREN WITH DISABILITIES THROUGH APPLICATION OF MODERN TECHNOLOGY

**Jolanta ZIELIŃSKA**

**ABSTRACT**
The paper demonstrates the use of computers as a cognitive tool in improving the educational opportunities available to handicapped children. We present the basic assumptions of the information storage and processing theory, treating it as a theoretical basis for modeling cognitive processes. We describe how modern technologies can be used in various areas of rehabilitation and educating children with disabilities, based on examples of: online solutions, computer systems for assisted learning and Laryngograph Processor and Nosality equipment. We present how the computer can be used to augment the educational space of a handicapped child and to unlock non-verbal knowledge.

**Key words:** modern IT, education, children with disabilities, cognitive processes

## INTRODUCTION

Professor Zygmunt Bauman, a notable sociologist, philosopher, essayist and co-formulator of the concept of *post-modernism* was asked in a TV interview held in 2010: "What sets the modern times apart in the history of the human race?" The answer he gave was that, up until now, sociological and technological progress had largely been separate and occurred in parallel, whereas nowadays, for the first time in history, they have begun to overlap. Humanism can make no further strides without the aid of engineering – and *vice versa*. We are fortunate to bear witness and – simultaneously – lend our own hands to this fundamental process. Professionals involved in diagnosing and supporting handicapped children must act as observers and conscious creators, as they shape the present and future of those they aim to assist. They shouldn't hesitate to apply modern technologies in support of their patients as well as in preventing disabilities.

## INTRODUCTION TO COGNITIVE SCIENCE

According to dictionaries, cognitive science deals with the functioning of the human mind and attempts to model the relevant phenomena. Cognition also forms the theoretical foundation for a research domain called cognitive science – a multidisciplinary field which draws upon such related sciences as cognitive psychology, neurology, philosophy of the mind, artificial intelligence and linguistics.

The central tenets of cognitive science include knowledge representation, languages, learning, mental processes, perception, consciousness, decision making and intelligence (i.e. cognitive intelligence).

The aims of cognitive science can be expressed as follows:

- explaining mental processes,
- simulating mental processes with the use of computers,
- developing various intelligent tools.

Basing on these assumptions, it seems highly beneficial to employ computers as a cognitive tool in the course of education and mental development of handicapped children. The computer, when used to model cognitive processes, may constitute an important element of the child's educational space, enabling the child to succeed in memorizing and applying useful skills. This ability is inexorably tied to the cognitive mechanisms of intelligence which underpin all learning processes. When discussing effective learning, we should focus on two distinct aspects. The first is the duration of



study. According to Bloom's concept of imperative didactics, every child can be taught to master a given skill, although the time required to do so varies from child to child. The second aspect is the ability of applying rational concepts, which forms the cognitive expression of one's intelligence. This ability relies on elementary cognitive determinants, such as attention span and memory capacity, but it also depends on more advanced phenomena, including the child's learning strategies [Nęcka 2003, p. 25]. It is in relation to this notion that computers play a crucial role in the educational process and in improving the cognitive opportunities of handicapped children. In order to achieve success in this field, two conditions need to be met. First, we require a suitable and properly programmed computer. Secondly, a competent special education teacher, capable of using such a tool, must be present.

## THE THEORY OF INFORMATION STORAGE AND PROCESSING AS A THEORETICAL BASIS FOR MODELING COGNITIVE PROCESSES

The theory of information storage and processing, which forms the theoretical foundation for the concepts presented in this paper, bases on the outcome of research in experimental cognitive psychology and computer science [Vasta, Haith, Miller 2001, p. 115]. This research treats humans as users of a symbolic language, with a capacity to process this language. It focuses on tracing the flow of information in response to a given task. Cognition can be divided into a number of basic processes and events, which occur in a set order. These processes include: recognition, coding, searching, sorting, categorizing, developing links and coordinating various pieces of information. Information processing, when applied to the problem of cognitive development, can be traced back to Piaget's theories which treat the child as an active participant in understanding the surrounding environment, predicating its own actions on two distinct processes, which shape cognitive structures. The first of these processes is assimilation, i.e. extending existing structures to cover new information. The second is accommodation, i.e. modifying existing structures in response to the emergence of new information or to changes in its form, all the while preserving the internal balance of cognition [Vasta, Haith, Miller 2001, p. 119].

The models of cognitive development established in the course of research on information processing are – in comparison to Piaget's models – more indicative of specific areas of development, easier to verify, more precise and more complete (and thus significantly less general). They base on two metaphors: multistorage and computer. The multistorage metaphor refers to the sequential memory model, which assumes that the short-term (operational) memory is a stage for a number of psychological processes occurring between data input (i.e. stimulus) and output (i.e. reaction) [Vasta, Haith, Miller 2001, p. 120].

For example, if the stimulus is a hitherto unknown word, it first enters the aural register, in which it is held only for a short period of time (approximately 1 second). Subsequently, it is forwarded to short-term memory for active and conscious processing. The duration of this step is typically on the order of several seconds (up to 30), but it can be extended with the use of suitable learning strategies. The next step involves transferring the word to long-term memory, to be stored there indefinitely. Thus, the long-term memory is the primary vocabulary storage mechanism for each individual. In children with hearing impairments, the presented process is derailed at the very beginning – i.e. during the sensory input stage. This necessitates replacing the malfunctioning aural receptor with a substitute – for instance, its visual equivalent. Subsequently, appropriate strategies need to be employed to ensure that the word is properly committed to the child's memory and preserved in the long-term vocabulary store [Vasta, Haith, Miller 2001, p. 121].

Applying predetermined strategies when dealing with handicapped children may prove difficult and requires help in the form of stepwise algorithms or repeatable action

schemes. The task must be clearly defined and structured; its repeated execution should lead to behavioral automation and create cognitive synergies between related events. Tracing the consistencies and inconsistencies involved in this process enables us to categorize and define cognitive changes in children [Zielińska 2004, p. 77].
To summarize, we can say that proponents of the information processing theory aim to capture and describe a coherent flow of information through the human cognitive system, in order to fully and accurately describe the processes which separate external stimuli from external responses. Thus, an important aspect of refining the cognitive field is the development of cognitive process schemes, with particular attention devoted to increasing the role of conscious control (both actionable and evaluative) in their execution. This leads us to the issue of gathering, organizing and presenting the available information [Meadows 1997, p. 45].

## THE COMPUTER AS A COGNITIVE TOOL IN THE HANDICAPPED CHILD'S EDUCATIONAL SPACE

The educational uses of computers are manifold. Computers help create rich and diverse study environments, introduce novel modes of communication and effect a fundamental shift from passive assimilation of knowledge to actively seeking useful information. When applied to a child's educational space, the use of computers falls into two mutually complementing categories: they can be treated as modern tools of work or as modern study aids (in the wider context of multimedia systems). The former case enables children (particularly handicapped ones) to execute tasks in a faster and more efficient manner, while the latter deals with augmenting and focusing the processes of gathering and processing actionable knowledge. Thus, computers facilitate generative and constructive cognition, enabling the child to acquire procedural and contextual skills [Siemieniecki 2002, p. 56]. This function is directly related to the use of computers as study aids and cognitive tools – an application field which is still lacking in modern educational practice, despite the improving availability of computers at schools.
Both the human congnitive system and computer architectures are capable of processing stimuli and generating responses in a systemic and intelligent manner. This ability requires access to preexisting information and well-defined rulesets. Here, the application of computers may be discussed on several distinct levels. The most general level is analogous to the human cognitive process in general. Both humans and computers store symbolic representations of knowledge and apply specific rules, some of which may be subject to modifications over time. These representations and rules are used to solve problems in a rapid and efficient manner, but at the same time impose some constraints on the types of problems which may be solved (a comparative study of these constraints, while an interesting subject in itself, is outside of the scope of this paper). The next level covers the application of computer-related vocabulary to describing concepts and events. The final, most specific level, involves computerized simulations of human behavior. This method is used to explain the cognitive processes which shape the way in which humans perform specific tasks. For example, when considering linguistic skills, complex human behavior may be simulated via appropriately complex computer programs. Such programs attempt to determine the rules which govern natural languages, as well as the principles through which small children are able to master the use of a language in a given period of time. They can also establish mathematical and formal descriptions of linguistic processes, thus proving that such processes are feasible in practice. These models have played an important part in theoretical studies, but have not yet gained widespread scientific acceptance, due to the fact that they are necessarily simplified and sometimes contrary to empirical observations [Vasta, Haith, Miller 2001, p. 68].
Both the concept of intelligence and the functioning of intellectual processes may be divided into four aspects, equivalent to four levels of information processing. The first



aspect relates to the efficiency of the nervous system (i.e. the speed and reliability of transmitting impulses). The second covers the speed of processing actual information. The third involves processing strategies, i.e. selecting appropriate elements of the cognitive process and creating mental constructs which correspond to a given task. The final aspect includes the ability to evaluate and control one's actions [Nęcka 2003, p. 95].
The process of learning calls for the execution of a specific task, presented to the person who wishes to learn. Being a latent process, learning cannot be directly observed; it is, however, possible to evaluate the manner in which the given task is executed by the individual. Thus, information can be committed to memory in spite of its apparent absence in the conscious field. Such information may later become expressed under suitable experimental conditions (or given suitable internal processing mechanisms). This process is sometimes termed "counterforgetting". It is not a rarity, much like the process of information erasure and the corresponding reduction in the operating memory capacity (itself a result of storing information acquired during earlier learning attempts). Information may be expressed through the use of computers which help model cognitive processes associated both with the acquisition of knowledge and its subsequent practical use. The most important aspect of this mechanism is diagnosing the manner in which a given type of disability affects the cognitive processes of a person (in comparison with a healthy individual). This knowledge enables us to develop compensative measures, with the use of suitably programmed computers, properly trained educational experts and proper algorithms of action. In this environment, the programmer plays only a supportive and technical role, while all creative aspects remain under the control of the teacher, caregiver and validator (who – naturally – needs to be prepared to assume this responsibility).

## MODERN TECHNOLOGIES AS APPLIED TO DIAGNOSIS AND REHABILITATION

The population of handicapped individuals, while highly nouniform, presents its own social and educational challenges. Thus, one of the principal issues faced by professionals who aim to assist such people is to select effective methods of support, ensuring rapid and appreciable results. Clearly, this is a field where modern IT solutions may render invaluable assistance, both in terms of devising support programs and implementing them in practice. Our first goal is therefore to present the applicability of computational technologies to diagnosing and assisting handicapped children. It should be noted that most tools presented in this paper can be accessed with the use of a standard personal computer.

## EXPLOITING THE POTENTIAL OF THE INTERNET IN SCREENING FOR SPEECH EYESIGHT AND HEARING IMPAIRMENTS

Diagnosing aural impairments with the use of computing technologies has several goals: the impairment needs to be detected as early as possible, its type and extent assessed and the degree to which it may affect development properly estimated. Speech comprehension relies on a number of distinct processes: physical perception of sound, phonemic awareness, aural memory, the ability to quickly focus on specific elements of speech, semantic knowledge, linguistic skill and the ability to interpret the words being spoken [Zielińska 2005, p. 10] Multimedia software applicable in this area combines practical knowledge with experience from various domains, including audiology, speech therapy, phonemic therapy, acoustic engineering and computer science.

A computer audiometer emulates a physical audiometric device coupled to a custom database. It can register and archive the results of audiometric tests. Such results are only precise if the tests employ properly calibrated audiometric headphones. Computerized audiometric tests are addressed primarily to children and adolescents – hence the preference for closed tests. There is a wide array of computerized audiometers available

on the market, capable of performing various types of tests, including tonal, Bekes, vocal, ABLB, TT Decay and SISI measurements. Once attached to a computer's parallel port, the audiometer can be controlled automatically with the use of application software. One module implements a full range of typical clinical tests, while another facilitates interaction with children and resembles a computer game. Test results are stored in a database [Czyżewski, Kostek, Skarżyński 2002, p. 287].

Another IT solution worth presenting is the Multimedia Aural Impairment Catalogue (Pl. "Multimedialny Katalog Uszkodzeń Słuchu"), which simulates various types of hearing defects. It includes a database containing graphical and textual representations of hearing defects, along with sound-based examples. The primary goal of this system is to enable people who do not suffer from hearing defects to understand the challenges faced by patients with such impairments (with particular focus on speech recognition). The authors have prepared a set of aural perception simulations for patients exhibiting various hearing impairments, using digital sound processing methods. The catalogue includes a set of descriptions, a glossary of popular hearing aids and a database listing common healing pathologies. Descriptions cover the anatomy of the ear, aural perception testing methods and types of hearing defects [Czyżewski, Kostek, Skarżyński 2002, p. 389].

## COMPUTER-AIDED DIAGNOSIS OF SPEECH DEFECTS – PRACTICAL SOLUTIONS

Another area in which computer technologies may prove helpful is diagnosing speech defects. Among the available online tools we find the Computer Speech Adjustor (Pl. "Komputerowy Korektor Mowy"; KKM), which helps correct various types of defects with the use of a personal computer with a sound card, microphone and earphones. Currently the system is capable of operating in five modes and is primarily aimed at stuttering patients. KKM is a novel attempt at developing a full-featured online speech defect correction system [Czyżewski, Kostek, Skarżewski 2002, p. 241].

Another similar solution is the Speech Recognition Training System (Pl. "System Treningu Rozumienia Mowy") – a multimedia application which aims to show that the personal computer may – to a significant extent – replace direct contact with a speech therapist and enable patients to practice their speech recognition skills (which is usually a long and time-consuming process). The system provides two hardware configuration modes: one for computers which contain a sound card attached directly to a prosthetic hearing aid, and another which entails the use of earbuds, an electronic calibrator and an amplifier. In the latter mode prosthetic aids are not required as the output signal is fed directly into the amplifier and then transmitted through earbuds. The system can play back speech, mix signal with ambient noise and interpret speech through analysis of lip movements, with the aid of a virtual lector [Czyżewski, Kostek, Skarżyński 2002, p. 375].

The central part of the screen contains a window which displays the faces of speakers and enables patients to study the movement of their lips. It is also possible to intermix speech with various types of noise and ambient sounds (e.g. wind, street noise, music, echoes, reverberation etc.) For children the program offers a picture quiz, a selection of sample words and sentences and a game which aims to develop speech recognition skills. For adults there is another set of sample words and sentences, a number-based test and a selection of audiovisual aids: news reports, video files and multimedia games.

We should also mention the online Multimedia Catalogue of Speech Defects (Pl. "Multimedialny Katalog Zaburzeń Wymowy"). It contains descriptions of various speech defects illustrated by sample recordings. It is also capable of storing additional recordings in its database, which is fully manageable and extendable [Czyżewski, Kostek, Skarżyński 2002, p. 398].



## MODERN TECHNOLOGIES IN EDUCATIONG CHILDREN WITH DISABILITIES

Computers are frequently employed as a didactic aid in special education as they can help diagnose and ameliorate the problems experienced by handicapped children.

## LARYNGOGRAPH PROCESSOR AND NOSALITY

The basic task facing a child deaf hearing system is to learn the ability of oral language communication in order to communicate better with the hearing environment. Early revalidation activities, ensuring the child's contact with oral speech in its critical period, namely in the first years of its life, seem to be the most fundamental. If hearing problems appear before 6-8 years of the child's life, then language abilities which are not properly strengthened, will decline. At present, activities aiming at the development of a language system which enables a non-hearing child to communicate with the hearing population are largely aided by quickly developing computer technology. Its use in diagnosis and rehabilitation of the voice of a child who has problems with achieving proper phonic speech substance covers both computer software and specialized equipment [Zielińska 2004, p. 69]. This development is being stimulated by significant didactic-educational results that have been obtained. The computer is used comprehensively in this field, enabling the withdrawal of development disorders, the development of intellectual abilities, the assistance of individualistic development and the acquaintance with a new learning and rehabilitation tool. The experimental research presented in this paper concerning the evaluation and the development of oral ability in deaf children have been conducted with the use of two computer attachments: Laryngograph Processor PCLX and Nosality, connected to a PC computer. This kind of computer research is the first and unique. It fully considers the specific character of the Polish language, including very difficult dental phones, digraphs and prosodic features of speech, mainly the flow of the melodic waveform, which largely influences the understanding of speech in Slavonic languages. Hence, the research results can be applied to not only diagnosis and rehabilitation of children with oral problems, for whom the verbal language is often not a natural language i.e. those children who cannot hear, but also for those, who have cleft palates or other defects. They can also help teach Polish to foreign students.

Computer-assisted modeling of cognitive processes

As computers can model cognitive processes (especially in the scope of creative thinking), they represent an important educational tool, helping handicapped children exploit the knowledge they possess. This ability is intimately tied to the cognitive mechanisms involved in effective learning [Zielińska 2004, p. 20].

In the case of handicapped individuals, the basic drawback of computer-aided learning – namely the mechanical, algorithmic nature of learning functions – can be treated as an advantage. The issue is, however, more complex than it would seem. Handicapped children (particularly those with significant disabilities) usually exhibit low creative skills and a certain degree of "rigidity", which is caused by impaired aural perception or vocalization difficulties. Imposing a mechanical learning regimen may exacerbate this problem, which, coupled with inappropriate learning programs, may hamper progress rather than encourage it. Employing computers for educational purposes solves is undoubtedly helpful, but care should be taken to prepare a suitable learning program – each step of the algorithm should be based on well-founded theoretical assumptions, injecting an element of creativity into the educational process. Problem-based education, focusing on heuristic thinking, should also be applied when dealing with didactic difficulties – i.e. theoretical or practical issues which should be overcome by the student's own curiosity and action. In such cases, the computer can be employed to shape the student's cognitive abilities [Siemieniecki 2002, p. 89].

## THE COMPUTER AS A TOOL FOR UNLOCKING NON-VERBAL KNOWLEDGE

The issues involved in exploiting computers to assist handicapped individuals who have problems expressing their knowledge should also be considered in the scope of non-conscious information processing. This issue is tied to conscious storage of information (or lack thereof) and possession of hidden knowledge. In handicapped individuals the assessment of learning results, including conscious knowledge acquisition as well as gathering knowledge without being aware of this fact (i.e. developing intuitive problem-solving skills) often proves highly complicated. Psychological studies equate the limits of knowledge awareness with the ability to verbalize one's knowledge. Speech impairments necessarily limit the degree to which patients can put their knowledge into words – hence the problem of ascertaining the limits of perception in people with special educational needs. Conscious learning is often assumed to be subliminal and it frequently becomes difficult to distinguish conscious and non-conscious aspects of knowledge assimilation.

The problem of non-conscious assimilation of knowledge is a novel issue – and a highly complex one at that. Studying it requires a suitable methodology, confirmed by empirical research – and, in fact, several such studies are presently being conducted [Underwood 2004, p. 43].

The characteristics of computer systems for assisted learning

Computer systems for assisted learning share several common characteristics. A program targeted at handicapped students should not present an excessive quantity of textual information – particularly at an early stage of learning. Text should be displayed with the use of national characters, be concise and easy to comprehend. Longer passages should be augmented with pictorial representations. It is important to employ sound effects and animations (e.g. color changes or flashing alerts) to attract the student's attention to important information; however one should be careful not to direct attention away from the content of the material being presented. The system should also adjust its pace to the student's learning capabilities – this applies to any video content, which should be easy to replay. At the same time, the program must encourage active involvement and be sufficiently engrossing to hold the student's attention for an extended period of time.

Relating to special needs of handicapped individuals, computer programs for assisted learning should:

- fundamentally enhance communication capabilities. A well-designed program should enable the student to understand each exercise, provide dynamic examples and eliminate spurious details (which would be very difficult to achieve without the aid of computers),
- adjust the difficulty of the exercises to the mental capabilities of the student, and not just to his/her language skills (in students with speech impairments the former are usually far more robust than the latter),
- provide an auxiliary source of objective knowledge,
- personalize the learning experience in terms of speed and content,
- encourage the student to invest effort into the learning process by showing that a handicapped individual may assimilate knowledge as rapidly as someone who does not experience similar problems,
- facilitate control and objective grading of the learning process.

The advantage of multimedia software for assisted learning compared to traditional learning aids (such as printouts, illustrations and books) is undeniable and stems from its more attractive forms of presentation, the ability to combine education with entertainment and the fact that certain aspects of the language which play an important role in communicating – such as verbs, adjectives and prepositions – may be illustrated in a way which is easy to understand, for example through animations [Zielińska 2005, p. 147].



Effective multimedia systems for assisted learning are interdisciplinary in character – developing them requires linguistic and programming skills, as well as suitable hardware. An example is provided by the application called "Find the caption" [Pl. "Szukamy podpisu"]. The user is shown an illustration and has to match it to one of several available captions. The captions themselves can be either simple or complex, and can exhibit varying degrees of similarity (both lexically and grammatically). Another system which provides a learning aid in the areas of spelling, grammar, math and traffic laws is called "Multimedia fun and games with Click" [Pl. "Multimedialne gry i zabawy z Klikiem"]. At the core of the series of programs called "Click teaches..." [Pl. „Klik uczy..."] is the concept of learning through play. The programs feature attractive graphics, animations, picture puzzles and exercises, all based on a systematic analytical/synthetic methodology, with the ability to customize the learning process (including the learning curve) and focus on putting theoretical knowledge to practical use [Zielińska 2005, p. 147].

## CONCLUSION

As computers can model cognitive processes (especially in the scope of creative thinking), they represent an important educational tool, helping handicapped children exploit the knowledge they possess. This ability is intimately tied to the cognitive mechanisms involved in effective learning. In the case of handicapped individuals, the basic drawback of computer-aided learning – namely the mechanical, algorithmic nature of learning functions – can be treated as an advantage. Employing computers for educational purposes solves is undoubtedly helpful, but care should be taken to prepare a suitable learning program. We hope that ongoing research in the area of human cognition and further advances in computer science will be combined together to provide complex solutions supporting education of children with disabilities.

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