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Modeling Cognitive Processes in Disabled Children

The aim of the presented research is to answer several questions pertaining to the possibility of improving educational opportunities of handicapped children. We intend to focus on the following question: should the handicapped child's awareness of the surrounding world be necessarily limited (as indicated by studies carried out at special schools), or is it possible to extend it through better educational activities?

The presented study focuses on the field of cognition. According to dictionaries, this area of knowledge 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 intellectual 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 disabled 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]. 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.

2. 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]. 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].

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].

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].

Applying predetermined strategies when dealing with disabled 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].

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].

3. The computer as a cognitive tool in the disabled 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 disabled 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]. 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 cognitive 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].

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].

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).

4. Summary and conclusions

While the principal responsibility of a teacher (particularly one working with disabled children) is to create a rich information environment and stimulate the activities of the pupil, it is important to note that scientific modeling of cognitive processes may exert a beneficial influence on these activities. Such modeling deals with designing (or even enforcing – in the case of handicapped individuals) appropriate strategies of cognition. It requires a suitably equipped computer and an algorithm of action, based on the results of scientific research in the area of information processing and storage by the human cognitive system.

The ability to describe intellectual processes (which elude direct observation) may significantly improve the effectiveness of educational and validation-oriented activities. The subject is a complicated one, posing significant challenges both from the methodological and applicative points of view, although the impact of information processing theories on this field remains significant. Such theories have thus far enjoyed considerable success (which is the focus of this paper), although they are not devoid of drawbacks – namely, their relatively narrow and highly specific scope, their laboratory-like artificiality and lack of account for a wider social context. All of these disadvantages are difficult to resolve in the context of education – a notoriously complex setting, associated with many chance events and unquantifiable phenomena. A potential way to approach this problem is to strive for deeper theoretical understanding and a thorough, methodological approach. This, in turn, calls for the formation of interdisciplinary research teams, possessing in-depth knowledge of the problems and challenges faced by handicapped children, along with the will to assist them in their learning process. It is important for such experts to be able to collaborate with one another.

In order to assist a disabled person, we must first understand his or her needs. This is not always easy: abnormal development should not be confused with normal development occurring under abnormal circumstances (both when interpreting the results of scientific research and in daily educational practice). We hope that ongoing research in the area of human cognition and further advances in computer science will ameliorate the present situation and prevent educational experts from committing this error, thus enabling them to better understand and meet the needs of handicapped individuals in a real, measurable way.

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