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The Development of Academic and Technological Computerization of Education at the Institute of Cybernetics of Ukraine in the Late 20th — Early 21st Century

The introduction of the field of computer science at Ukrainian universities is characterized by a complex of interrelated organizational, administrative, scientific, technical and educative processes. They were directed to create conditions which would meet informational requests of all participants of its study as well as the educative and research process. The process envisaged the implementation of computer science into university curriculums with the following integral constituents: computerization of the education process, university and scientific research management, university education quality assessment and others. Investigation of the progress of academic and technological computerization and of the training process at particular scientific schools, the Institute of Cybernetics of the Academy of Science of Ukrainian Soviet Republic and later V. M. Glushkov Institute of Cybernetics of the National Academy of Science of Ukraine (hereinafter IC of Ukraine), was an important aspect in the history of the introduction of computer science in higher education of Ukraine. The results of the investigation concretized the contribution of certain scholars, characterized the style of management of the school President, presented the achievements of the school to the world of science and highlighted the problem of the development of computer science and its implementation into the higher education of Ukraine. They also helped to disclose basic reasons for establishing main principles of computer science and software support for university development. Previous research in the history of computer science was mostly dedicated to the periods of its foundation and formation as well as to the development of its technical devices; found in the works of Khomenko L.[1] (deve-

[1] Khomenko L. H. Ystoryya otechestvennoy kybernetyky y ynformatyky. Monohrafyya. / L. H. Khomenko – Kiev 1998. – 455 p. (in Russian).

lopment of native cybernetics by the Ukrainian scholars), Sergiyenko I.[2] (foundation of computer science), Malynovskyy B.[3] (history of computing technology), Onopriyenko V. and Onopriyenko M.[4] (development of scientific schools in computer science). Many other works on the history of computerization education were devoted mainly to the evolution of educational systems concerning the implementation of information technologies into learning processes at universities in Ukraine and the world. However, the history of academic and technological computerization education in Ukrainian higher education is not presented as systematic or with the detailed information of what had been previously created and implemented by groups of scientists from IC of Ukraine from the 1960s to now.

Thus, the objective of this article is to investigate the historical development of academic and technological computerization education processes at universities of Ukraine during 1960–2010 periods and to study what was previously created and implemented by the scholars of IC of Ukraine during its existence. To realize this objective the following subtopics were analyzed: *a) studying the basis of information sources; b) investigation of the evolution of academic and technological computerization in the creation of automatic systems for the learning process by scholars at the IC of Ukraine; c) periodization of the scholars' activity in the creation of automated educational systems.*

The approaches to define theoretical and methodological basics of using a computer in the learning process formed under the influence of programmable instruction. Originally a computer was considered as a more advanced technical device compared to elementary educating technical appliances. The advantages of using a computer were mainly perceived as broadening possibilities for individual approaches in the learning process. Only later was it realized how much computing could contribute to learning methods, forms and content. Initially, the elaboration of education systems was carried out at big scientific and educational centers. In the United States for instance, such centers were Dartmouth College, the University of Illinois and Stanford University as well as the "International Business Machines" (IBM) Corporation. In Great Britain the main projects of computerization of education were carried out at Glasgow University, the University of Leeds and at Edinburgh College. In the USSR pioneering educating systems were worked out at Riga Polytechnic Institute, Belarus University, the Educating Center of the USSR Academy of Science in Moscow and at scientific centers in Kyiv (automatized educational systems based on software packages of applied programs SPOK — IC of Ukraine). These systems were mainly focused on teaching programming; as a result their software components were used for the purpose of learning. Today, almost all educating systems produced in the 1960s, apart from PLATO (Programmed Logic for Automated Teaching Operation), have lost their practical significance. They did not differ in their didactic possibilities from those systems which were used by most elementary technical learning devices and thus anticipated tough determination of pupils' activity excluding dialogue maintenance. But only the first projects stimulated much interest to computer-oriented learning and promoted the creation of educating systems.

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[2] Serhiyenko I. V. Stanovlennya i rozvytok doslidzhen' z informatyky / I. V. Serhiyenko – Kyiv 1998. – 204 p. (in Ukrainian).

[3] Malynovskyy B. N. Ystoryya vychyslytel'noy tekhnyky v lytsakh / B. N. Malynovskyy – Kiev 1995. – 384 p. (in Russian).

[4] Onopriyenko V. I. Informatyka v Ukrayini: istoriya, naukovi shkoly, suchasni problemy / V. I. Onopriyenko, V. P. Solovyov, M. V. Onopriyenko // Nauka ta naukoznavstvo. – 2004. – # 4. – P. 148–150 (in Ukrainian).

For over 20 years (from the mid 1960s to the mid 1980s), IC of Ukraine under V. M. Glushkov's supervision carried out specific work in creating specialized software and automated educating courses. The authors of the following works[5] heavily researched the creation and development of dialogue maintenance devices in automated systems of different assignments including automated educating systems. In 1971 the team of contributors under V. M. Glushkov's supervision defined the fact that in the process of creating automated educating systems a systemic approach to the theory, development and operation of electronic digital computational machines (EDCM) had to be employed. This approach anticipated complex research of the problems concerning interrelation between the components of the system in the issue "a man — a computational machine"[6]. The theory of solving tasks by man in the EDCM dialogue mode as well as quantitative analysis and formalization of effective interrelation between man and computational machines were factors defined as initial issues of the above-mentioned research.

The main scientific results entitled *The Theory of Solving Tasks by a Man in the Dialogue-Mode with EDCM* were presented by IC of Ukraine scholars under V. M. Glushkov's supervision in the following works[7]. It was revealed that the task-based approach to the *man — ECM* correlation was based on defining the types of solved tasks, on detaching abstract means of the tasks solution and on task-based analysis of different kinds of *man — ECM* correlations. The authors defined the goals of a task-based approach as a creation of different artificial systems capable to solve tasks and conduct a dialogue with specification of a user's educational content that comes into contact with ECM. The main stages of the task-based approach development may be seen through 4 periods. The first stage (preparatory — 1960–70s) was characterized by a series of lectures, organized at IC of Ukraine, concerning the problems of programmed learning and educating machines. The second stage (formation of conditions for the task-based approach to development) was marked by the determination of the importance of the problem of ECM-users in learning processes and the analysis of main trends in education and organization. The third stage (publishing some results concerning the task-based approach usage in *man — ECM* correlation research — 1971–1975s) was distinguished by the exploration of the essence and purpose of the task-based approach, possible variants of its implementation, formalization of the notion of a *task*, creation of different

[5] Ball H. A. Teoretycheskyy analyz obuchayushchykh prohramm: Soobshchenye 1 / H. A. Ball, A. M. Dovhyallo, E. Y. Mashbyts // Novye yssledovanyya v pedahohycheskykh naukakh. – 1965. – # 4. – P. 10–14 (in Russian); Hlushkov V. M. Dyaloh, Upravlyaemyy vychyslytel'noy mashynoy / V. M. Hlushkov, V. Y. Branovytskyy, A. M. Dovhyallo, Z. L. Rabynovych, A. A. Stohnyy / Pod obshchey red. V. M. Hlushkova. – Kiev 1971. – 296 p. (in Russian); Hlushkov V. M. Chelovek y vychyslytel'naya tekhnyka / V. M. Hlushkov, A. M. Dovhyallo, Z. L. Rabynovych, A. A. Stohnyy. – Kiev 1971. – 290 p. (in Russian); Hreben' Y. Y. Avtomatycheskye ustroystva dlya obuchenyya (obuchayushchye mashyny) / Y. Y.Hreben', A. M. Dovhyallo. – Kiev 1965. – 196 p. (in Russian); Dovhyallo A. M. Dyaloh cheloveka y EVM / A. M. Dovhyallo, A. A. Stohnyy. – Moskva 1975. – 66 p. (in Russian); Dovhyallo A. M. Dyaloh pol'zovatelya y EVM: osnovy proektyrovanyya y realyzatsyy / A. M. Dovhyallo / – Kiev 1981. – 232 p. (in Russian); Dovhyallo A. M. Dyalohovye systemy. Sovremennoe sostoyanye y perspektyvy razvytyya / A. M.Dovhyallo, V. Y. Branovytskyy, K. P.Vershynyn y dr. – Kiev 1987. – 248 p. (in Russian).

[6] Hlushkov V. M. Dyaloh, Upravlyaemyy vychyslytel'noy mashynoy... .

[7] Ball H. A. Teoretycheskyy analyz obuchayushchykh prohramm.... ; Hlushkov V. M. Dyaloh, Upravlyaemyy vychyslytel'noy mashynoy ...; Dovhyallo A. M. Dyaloh cheloveka y EVM ...; Dovhyallo A.M. Dyaloh pol'zovatelya y EVM: osnovy proektyrovanyya y realyzatsyy ...; Dovhyallo A.M. Dyalohovye systemy. Sovremennoe sostoyanye y perspektyvy razvytyya ... .

mathematical task-models, the study of correlations between such notions as *operation*, *action*, and *activity* as well as through specifying the methodology of its usage while organizing the dialogue between a man and EDCM[8]. The fourth and final stage (verification of the effectiveness of the task-based approach usage — 1975–1980s) was characterized by theoretical and practical research of engineering EDCM ways, the main peculiarity of which was a certain level of automation of all aspects of a man and ECM correlation up to the user's learning with the help of EDCM[9].

The main scientific results of *Quantitative Research and Formalization of the Factors of Effective Correlation between Man and ECM* were presented by the above-mentioned team of scholars under V.M.Glushkov's supervision[10]. In the context of the problem definition[11] the authors pointed out that the time, cost and quality of task solutions with the help of EDCM must be presented in the form of certain functions of values which characterize the suggested factors of effective interaction. Besides, it was necessary to equip ECM with special software devices for dialogue arrangements and to teach users. The dialogue was defined as an information process of message exchange between the two systems directed to the effective mutual solution of one task. By 1972, the results of the development of teacher educating systems on the basis of Dnipro-2 ECM were presented. The progress of the solution-educating Fortran systems elaboration based on Dnipro-21 ECM was analyzed and the results of the educating system of programming language KOBOL based on Dnipro-21 ECM were also provided here[12]. The solution to these problems (and others like it[13]) made it possible to identify the components of the *man — ECM* system and to specify the functions of these components taking into account the degree of automation of information being processed. Key results of the solutions were the elaboration of the general methodology of automated educating systems (AES) within the framework of task-based approaches[14], the for-

[8] Ball H. A. Semynar po teoryy zadach y sposobov ykh reshenyya / H. A. Ball, A. M. Dovhyallo, V. M. Rozyn // Voprosy psykholohyy. – 1972. – # 6. – P. 153–154 (in Russian); Ball H. A. Adaptyvna navchayucha mashyna shyrokoho pryznachennya / H. A. Ball, A. M. Dovhyallo, H. I. Tkachenko. – Radyans'ka shkola. – 1972. – # 5. – P. 73–92 (in Ukrainian); Hlushkov V. M. Chelovek y vychyslytel'naya tekhnyka ... ; Matematycheskye y ynformatsyonnye modely upravlenyya naukoy. – Kiev 1972. – P. 75–83. (in Russian).

[9] Branovytskyy V. Y. Voprosy yssledovanyya dyalohovykh system, oryentyrovannykh na massovoho pol'zovatelya [Tekst]: Avt. dys... kand. tekh. nauk / Branovytskyy V. Y. – Kiev 1975. – 26 p. (in Russian); Kudryavtseva S. P. Voprosy yssledovanyya avtomatyzatsyy reshenyya zadach v systeme «chelovek – ETsVM» (na prymere zadach obrabotky dannykh) [Tekst]: Avt. dys... kand. tekh. nauk / Kudryavtseva S. P. – Kiev 1977. – 19 p. (in Russian).

[10] Branovytskyy V. Y. Voprosy yssledovanyya dyalohovykh system, oryentyrovannykh na massovoho pol'zovatelya ...; Dovhyallo A.M. Dyaloh cheloveka y EVM ... ; Dovhyallo A. M. Dyalohovye systemy. Sovremennoe sostoyanye y perspektyvy razvytyya.... ; Kudryavtseva S. P. Voprosy yssledovanyya avtomatyzatsyy reshenyya zadach v systeme «chelovek – ETsVM» (na prymere zadach obrabotky dannykh) ... ; Prymenenye ETsVM dlya avtomatyzatsyy ob.-uchenyya y upravlenyya uchebnymy zavedenyyamy // Sbornyk dokladov III respublykanskoho semynara «Podhotovka pol'zovateley tsyfrovykh vychyslytel'nykh mashyn». – Kiev 1972. – 154 p. (in Russian).

[11] Hlushkov V. M. Dyaloh, Upravlyaemyy vychyslytel'noy mashynoy... .

[12] Prymenenye ETsVM dlya avtomatyzatsyy obuchenyya y upravlenyya uchebnymy zavedenyyamy ... .

[13] Branovytskyy V. Y. Voprosy yssledovanyya dyalohovykh system, oryentyrovannykh na massovoho pol'zovatelya ...; Kudryavtseva S. P. Voprosy yssledovanyya avtomatyzatsyy reshenyya zadach v systeme «chelovek – ETsVM» (na prymere zadach obrabotky dannykh) ... .

[14] Dovhyallo A. M. Dyaloh pol'zovatelya y EVM: osnovy proektyrovanyya y realyzatsyy ... .

mation of the methodology of designing mobile instrumental application programs (as well as designing language description oriented to mini- and micro- ECM architecture); the description of special Prologue-ES application program packages as a means of axiomatic knowledge machine presentation and the description of natural-language dialogue systems in which the emphasis is shifted from comprehension to the interface role of linguistic processors as a specific application program package[15].

Thus, the development of early dialogue systems transitioned through several stages. The first (mid 1960s – early 1970s) — when dialogue systems were based on operational type languages, the second (mid 1970s – early 1980s) — when dialogue systems were based on descriptive type languages (rigid languages with a set format), the third (1980s) — dialogue systems were based on linguistic processors capable of analyzing incoming massages (syntactic, morphological, and semantic algorithms).

In order to solve economic, scientific and educating tasks the following periods can be singled out. The first period (1960s) marked the first usage of ECM as well as the organization of dialogues with machine codes. Furthermore, the scheme of solving tasks in ECM included the following structural components: "a person who sets the task — a mathematician — a programmer — ECM." Here, the question concerning an improvement of the effectiveness of the man and machine correlation was not raised. The second period (1970s) embraced the elaboration of programming languages and the first translator as well as the implementation of information package processing in the ECM. An operator in the abovementioned scheme between a programmer and a machine appeared as well as multiprogramming and multiprocessing ECMs, memory guard hardware devices were worked out while a great number of different programming languages (including translators, devices for program settings and effective condition devices of multiprogramming) were created. The third period (first half of the 1980s) was characterized by the fact that specialists of different fields became program users (as a result, the scheme of solving tasks with the help of ECM got simplified to the structure of "a person who sets the task — ECM"). Here, systems of group usage on the basis of big multiprogramming ECM were realized while mini- and micro-ECMs with an incoming language oriented to certain tasks solution were created (including tasks connected with ANS elaboration where ECM served as a subject and as a means of learning). The final period (second half of the 1980s — present) is marked by the mass implementation of personal ECMs (PECMs) and ECM networks, by setting and the solution of the general computer literacy task (involving mass user's mastering general principles of algorithmic thinking). The publication of a 2-volume dictionary-reference book *Computer Technology of Learning* was the result of the abovementioned research.

Further research done by IC of Ukraine scholars at the beginning of 2000 presented the results of the creation of a man-machine dialogue system and the elaboration of automated educating courses and intellectual expert-educating systems (hereinafter — EES)[16]. As the basis for EES architecture, the following model of learning process was suggested: there is an objective of studying which is expressed in the terms of current pupil's characteristics. Until the objective is not accomplished, the actions are repeated through the following succession: on the

[15] Idem. Dyalohovye systemy. Sovremennoe sostoyanye y perspektyvy razvytyya … .
[16] Petrushyn V. A. Ekspertno-obuchayushchye systemy / O. V. Ybrahymov, V. A. Petrushyn. – Kiev 1989. – 21 p. (in Russian) and Kiev 1991. – 196 p. (in Russian).

basis of the current condition of a pupil and a method of teaching the next task is generated (the task is understood as any information demanding relevant pupil's actions). A pupil's answer is compared to a standard decision and the diagnostics of mistakes is conducted taking into account all dissimilarities. According to the results of such diagnostics, the pupil's characteristics are corrected. Grounding on the learning process model, authors developed the architecture of EES which may be viewed as a complex of three interrelated systems — the system of tasks solution in the researched field, the system of pupil's mistakes diagnostics and the system of education management. The computer system of solving tasks in the researched field is aimed at working out a standard solution. The computer system of pupil's mistakes diagnostics is assigned to reveal their wrong ideas about the research field on the basis of the comparison between their answers and the standard. The computer system of education management is the system of planning the learning process under such circumstances which are caused by given educational materials[17]. The author states that education management must have graded nature where each grade involves skills and knowledge diagnostics, a certain block of information as well as the diagnostics of the level of tasks solution formation. The information block contains some educational information which wasn't mastered by a pupil but is important for mastering the task solution principle while the tasks to be solved are offered in the order of increasing complexity. Task solution activity management must be provided in EES with the help of heuristic means chosen from the corresponding intelligent database[18].

In 2004, a team of scholars led by Honoured Worker of Sciences and Engineering V. I. Hrytsenko, the head of the center, published a work[19] which contained the results of the experimental work of the center concerning theoretical and practical experience of distant and computer learning. The results are as follows: a) didactic basics, possibilities of computer communication usage and the application of informational, educational resources and multimedia systems in computer educational systems are specified; b) the ways of solving the problem of theory and practice of computer learning organization are pointed out and analyzed, the usage of software devices and shells for computerized courses formation (including those of distant character), pedagogical technologies and control-and-testing systems organization are specified. From 2005 to 2010 the center research program included several new perspective projects[20] which encompassed many areas: highly intellectual technologies of educating dialogue, multi-language technologies and multilinguistic environments, architectonics of global scientific-educational contexts, highly dynamic models of uninterrupted education and electronic informational learning technologies, accelerated information-educational resources designing technologies and teacher-pupil-multipurpose electronic environment correlation technologies. Another important technological result of the center's activity was setting the task regarding the necessity of electronic learning systems development which was described as capable of giving a person the possibility to get professional education or knowledge in certain subjects through the selection of national or

[17] Petrushyn V. A. Ekspertno-obuchayushchye systemy ... – Kiev 1989. – 21 p. (in Russian).
[18] Idem. Ekspertno–obuchayushchye systemy ... – Kiev 1991. – 196 p. (in Russian).
[19] Hrytsenko V. Y. Dystantsyonnoe obuchenye: teoryya y praktyka / V. Y. Hrytsenko, S. P. Kudryavtseva, V. V. Kolos, E. V. Verenych / NAN Ukrayny, MON Ukrayny, Mezhdunarodnyy nauchno-uchebnyy tsentr ynformatsyonnykh tekhnolohyy y system. – Kiev 2004 (in Russian).
[20] Hrytsenko V. Y. Perspektyvy komp'yuternoho obuchenyya / V. Y. Hrytsenko // Upravlyayushchye systemy y mashyny. – 2009. – # 2. – P. 3–14 (in Russian).

international learning structures. To achieve this, it was necessary to arrange fundamental research including intellectual environment theories, educating dialogues and creative thinking which were of special importance[21].

As a result, the research of computerization of learning process at universities of Ukraine during the 1960–2010 period led to the following regularities of processes:

1. From the mid 1960s up to the mid 1980s (the period of automated learning supply formation) at IC of Ukraine under V. M. Glushkov's supervision, innovative works on special software creation and automated educating course elaboration were organized and conducted. In the works of the scholar's team[22] the main principles of formation and development of dialogue supply in automated educating systems were analyzed. It was defined that the systemic approach to the theory, elaboration and organization of EDCM operation become the essence which must embrace complex research of the man — ECM correlation problem[23]. The initial issues of the research were considered to be theories of solving tasks by a man through the dialogue with EDCM while the quantitative investigation of effective man — machine correlation factors were grounded. In the paper, the main stages of the task-based approach development of the man — ECM correlation research and the main stages of early dialogue systems for solving economic, scientific, and educating tasks were singled out.

2. Further research of theories and methods of Ukrainian scholars concerning the computerization of learning processes (O. V. Ibragimov, V. O. Petrushin[24] — from the mid 1990s to early 2000 — the period of formation of learning process intellectualization supply) allowed for the carrying out of domestic theoretical investigation of the computerization learning processes. The authors also grounded the statement that the essence of computer learning is an intellectual educating system which not only raises the learning process to pedagogical standards but levels the drawbacks in education management conditioned by human's low possibilities in information processing.

3. The main result of the further evolution of the computerization of learning processes by IC of Ukraine scholars (beginning of 2000 — the period of electronic systems of learning process supply creation) turned to set the task concerning the necessity of electronic systems of learning process developments[25]; the latter being capable of giving a person the possibility to get professional education through the selection of national or international learning structures.

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[21] Hrytsenko V. Y. Perspektyvy komp'yuternoho obuchenyya ... .

[22] Ball H. A. Teoretycheskyy analyz obuchayushchykh prohramm ... ; Hlushkov V. M. Dyaloh, Upravlyaemyy vychyslytel'noy mashynoy ...; Hlushkov V. M. Chelovek y vychyslytel'naya tekhnyka ...; Hreben' Y. Y. Avtomatycheskye ustroystva dlya obuchenyya (ob.-uchayushchye mashyny) ...; Dovhyallo A. M. Dyaloh cheloveka y EVM ...; Dovhyallo A. M. Dyaloh pol'zovatelya y EVM: osnovy proektyrovanyya y realyzatsyy ...; Dovhyallo A. M. Dyalohovye systemy. Sovremennoe sostoyanye y perspektyvy razvytyya ... .

[23] Hlushkov V. M. Dyaloh, Upravlyaemyy vychyslytel'noy mashynoy ... .

[24] Petrushyn V. A. Ekspertno-obuchayushchye systemy ... Kiev 1989. – 21 p. (in Russian).

[25] Hrytsenko V. Y. Dystantsyonnoe obuchenye: teoryya y praktyka ...; Hrytsenko V. Y. Perspektyvy komp'yuternoho obuchenyya / V. Y.Hrytsenko // Upravlyayushchye systemy y mashyny... .

Renat Rizhniak. The Development of Academic and Technological Computerization of Education at the Institute of Cybernetics of Ukraine in the Late 20th — Early 21st Century

This article intends to discuss the implementation of the field of computer science at universities of Ukraine from the late 20th — the early 21st century in the wider context of historical research of the development of the academic and technological provision of computerized educational systems produced by the scholars at the Institute of Cybernetics of Ukraine.