SOVIET TECHNIQUES AND DEVICES FOR AUTOMATING INSTRUCTION

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ABSTRACT

SOVIET TECHNIQUES AND DEVICES FOR AUTOMATING INSTRUCTION

By

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Purposes

This investigation was an exploratory study within the broad field of Soviet educational technology. Specifically, it concerns the development and use of programmirovannoe obuchenie, (Soviet programmed instruction), a Russian concept encompassing both techniques and devices for automating instruction. The purpose for the study was to extend and amplify insofar as possible American and Soviet knowledge about the automation of instruction in the Soviet Union during the sixties.

Background

In the past, neither Soviet nor foreign scholars have extensively investigated the impact of modern technology on Soviet educational theories and practices. This lack of scholarship is understandable because the more concrete technological manifestations, the electronic teaching machines, have been developed rather recently in the early 1960's. Fortunately, the Soviet development of teaching machines attracted the attention of two American researchers, R.E. Levien and M.E. Maron of the RAND Corporation. In their 1964 report, prepared for high ranking US Government officials, Levien and Maron focused mainly on printed Russian reports about electronic teaching machines

and suggested further studies of them by American scholars.

Procedures

The bulk of the information in this study, however, was obtained from on-the-spot observations and materials collected in the Soviet Union. These data were gathered from the following primary sources: (1) personal observations of classrooms where the new technology was being applied; (2) interviews with students and teachers who were using it; (3) consultations with various administrators who were directing the development of Soviet programmed instruction; (4) studies under engineers who were designing Soviet hardware and software at the Moscow Energetics Institute; (5) and references including filmstrips, photographs, and Russian printed materials collected in the Soviet Union.

Findings

It was discovered in the investigation that key Soviet leaders looked upon programmirovannoe obuchenie as a cybernetic means for updating and modernizing Soviet education. In fact, the data clearly show how the Soviets wasted little time in designing and testing the technology's techniques and devices. Briefly, the Soviets successfully achieved in the sixties the first stages of automated instruction by using digital computers in their classrooms, and with their more systematic efforts to disseminate the innovation moved towards the next phase at the end of the decade; but the final outcome depends considerably on the reactions of Soviet teachers in the seventies.

Implications

Nothing in what was discovered in the investigation implied that a social or even an educational millennium has been ushered into the Soviet Union by its embrace of modern technology. As a matter of fact, it was repeatedly pointed out in the study that a legacy of obsolescence for the Soviets and their institutions has followed in the wake of automation. What does suggest itself in the investigation is that the Soviet Union is facing a cybernetic crisis in key sectors of its economy and much of the problem stems from an educational system which is failing to meet the needs of citizens who must cope with a variety of changes resulting from the rapid advances of science and technology.

SOVIET TECHNIQUES AND DEVICES FOR AUTOMATING INSTRUCTION

By

Bryce Franklin Zender, Jr.

A THESIS

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To my wife, Mary Ann,
and our daughter, Kira

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The preparations for the present study really began seven years ago in San Francisco where this investigator began seriously his study of the Russian language. I am deeply indebted to all my teachers of Russian for their encouragement and guidance. In particular, I wish to acknowledge the assistance and support of Mary Ulianitskaya who taught me to speak my first Russian words and encouraged me to continue my study of the language.

I also owe a debt of gratitude to a host of Americans and Soviets who made the necessary arrangements for my study in the Soviet Union. More specifically, I wish to thank Willis Brooks and Robert Byrnes from the Inter-University Committee on Travel Grants and their counterparts from the Ministry of Higher and Specialized Secondary Education of the U.S.S.R. for implementing so ably those provisions of the American and Soviet Cultural and Educational Exchange which allowed me to investigate firsthand Soviet educational technology. I am also grateful to John Paul of the Department of Health, Education, and Welfare for his aid in administering my Fulbright-Hays Fellowship.

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CHAPTER I

ANOTHER REVOLUTION

> In December, 1920 . . . there was only one sixty watt electric light burning in the Kremlin![1]

Introduction

By the end of 1920, the promise of Communism seemed like a far-off dream and the reality of Russia resembled a hell on earth. Millions of Russians had been killed in combat. But even more of them had died slowly from disease and starvation. The German, Red, and White armies had savagely destroyed entire villages and cities. Industrial and agricultural production had declined to such a low level that it was almost impossible for people to obtain the basic products needed to sustain life. As a result, the signs of dissatisfaction and discontent with the new regime were evident everywhere in the ravaged nation.

Aware of the explosive situation and the need to unite the country behind a popular cause, Lenin urged the Eighth Congress of Soviets to adopt a radical program which would rally the people. This plan called for the electrification of Russia. To support his position, Lenin argued that kilowatts of electricity could be transformed into "mechanical

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1. Sheyberg, Ya. A. and I.A. Shalobasov, *Moskovskii energeticheskii institut* (Moscow Energetics Institute), Moscow, 1967, p. 9. This light was burning in the Council of People's Commissars.

slaves" which then could replace human labor. Furthermore, he boldly advanced the following formula for achieving the Communist millennium: "Soviet power + electrification = Communism!"[2] As might be expected, the delegates approved the proposed blueprint for electrification and literally promised the restless populace a bright future.[3] Between their plan and its fulfillment, however, years of hardship and suffering awaited the Russian people. Nevertheless, Lenin and his followers in the Winter of 1920 had precipitated by design another revolution that unleashed the tremendous forces of automation in the Soviet Union.

The first stages in the Soviet technological transformation were marked by the construction of an automated network of power stations that linked together a diverse country and encompassed one sixth of the earth's land mass. By the end of the 1950's, the automatic production of electricity - once viewed as a new and revolutionary goal - had become commonplace, and automation had reached other vital phases of Soviet economic life. Unlike the political revolution of the Bolsheviks that tended to lose its drive with the passage of time, the impetus of the Soviet technological revolution resulting from automation has gained momentum in the last ten years (1960 - 1969).

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2. Ibid., p. 9.

3. Ibid., p. 9.

This acceleration was particularly evident in the Soviet industrial and military complexes where computers, instead of men, were used to regulate automatically the flow of information in key processes. Even certain functions of government, such as planning and regulating the economy, were partially performed by electronic devices. Moreover, Soviet machines were moving, processing, and storing data almost instantaneously in space, on the moon, and far beyond it on Mars. Such achievements in the sixties as factories without workers, low-level governmental decisions made by high speed computers, and communications satellites in the skies represented giant strides towards an automated Soviet economy. These activities also inaugurated a new stage in the Soviet technological revolution and underscored the growing Soviet capabilities to automate.

In addition to the more obvious aspects of Soviet automation that aroused interest in the West, there was another phase which was unnoticed by most Western observers and scholars. This phase involved new techniques and electronic devices which controlled automatically the flow of information in Soviet instruction. In the long run, these efforts to bring together men and machines in Soviet classrooms could be very decisive in determining how the Soviet Union responds to the challenge of technological change in the 1970's and 1980's. If one considers a few of the salient characteristics of Soviet society, its educational system, and the technology designed to change it, then one can understand more fully why automation in the Soviet classroom is so important.

Traits of the Schools

One of the most distinctive features of the Soviet educational system is its size. There are approximately 233,000,000 Soviet citizens and 72,000,000 of them are studying full or part-time in some type of educational institution.[4] These students are receiving instruction in schools located in various parts of a nation with 8,600,870 square miles of territory. On the bases of both student enrollment and scope of operations, this educational organization is one of the largest in the world. Logically, it follows that the automation of Soviet instruction ranks as one of the most ambitious educational tasks ever undertaken by any society.

This technological innovation also involves the very processes of education in which generations of Soviets have received their ideological orientation. For over fifty years, traditional instruction has served the Communist Party by transmitting its ideology. This process has greatly influenced how the Soviets related to each other and how they viewed the rest of the world. Changing to automated instruction

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4. These are 1966 statistics given by Admiral A.I. Berg in a speech to a group of Soviet educators. His estimate was quoted because it probably includes those students who were enrolled in military schools. Sostoyanie i perspektivy razvitiya programmirovannoe obuchenie (Conditions and Perspectives of the Development of Programmed Instruction). Moscow, 1966, p. 24.

involves the risk that the new mechanized approach will not mold the "new Soviet man" as effectively as traditional instruction.

Another significant trait of the Soviet schools is that they exert considerable influence in the struggle to industrialize the emerging nations. With more than half of mankind living in underdeveloped economies and needing technical skills, the Soviet educational system poses for these "have not" countries a somewhat appealing model for training skilled manpower. Yet, more importantly, many members of the scientific, technical, and political cadres from African, Latin American, and Asian nations are trained in Soviet classrooms. Consequently, this system's impact on people is not confined to those who reside within the boundaries of the Soviet Union, but reaches out to others who live in the third world. At the very least, automated Soviet instruction has already had an impact on those Latin Americans, Africans, and Asians who used it while studying in the Soviet Union. However, if the Soviets could develop this approach so that it would provide their specialists with technical skills quickly and inexpensively, then the Soviet model for training skilled manpower would become even more attractive for emerging nations.

Furthermore, the automation of Soviet instruction impinges upon another more important aspect of Soviet education - the training of scientific and technical manpower. The efforts of these professionals determine directly the rate of development of Soviet science and technology which are two basic sources of Soviet political and economic power. The dramatic transformation of the Soviet Union from a defeated country to a superpower indicates how successful the Soviet schools were in educating scientists and technicians during the past fifty years.

Automating the instruction of such specialists could affect the power potential of the Soviet Union. If this technological approach fails and hinders the professional growth of skilled manpower, the development of Soviet science and technology could be seriously impaired in the future. On the other hand, if automation speeds up and improves the training of scientists and technicians, it could accelerate Soviet scientific and technological development. For these reasons, the introduction of machines into Soviet classrooms has created some very important consequences which range from a serious loss of power potential to a major gain of it.

Trends in Society

In order to understand why the Soviets began to automate instruction in the sixties, it is also necessary to consider how the Soviet research establishment and its output of knowledge have mushroomed during the past two decades. With a few historical comparisons, the Soviet scholar, R.S. Shaduri, has put these trends into a clear perspective. He observes that of all the scientists and technicians trained for the past three centuries in both Tsarist Russia and the Soviet Union, the majority of them were living in the 1960's and were involved in some phases of Soviet research and development.[5] Furthermore, Shaduri notes that the output of knowledge, produced by Tsarist and Soviet scholars from the early 1700's to 1945, has been doubled by Soviet researchers working from 1946 to 1965.[6]

The massive expansion of professional manpower and spectacular growth of knowledge have been two driving forces that have caused an acceleration of technological innovations which in turn have multiplied the scientific knowledge of the Soviets. For example, it took them less than ten years to go from an atom bomb to a hydrogen bomb, and less than four years to go from Sputnik to a man in space. While creating these inventions, Soviet technicians and scientists were gaining tremendous amounts of new knowledge in their disciplines.

But the upward spiral of information and innovation also had such an impact on Soviet society that many of its traditional patterns became obsolete and were swept aside by technological advances. Some of the more dramatic and revolutionary changes were in methods of waging war, communication, transportation, and production. By the early sixties, these achievements had created some unprecedented stresses and strains on the Soviet educational system.

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5. R.S. Shaduri, _Perspektivy rosta nauchnykh znaii i nekotorye problemy obucheniya_ (Perspectives about the Growth of Scientific Knowledge and Some Problems of Instruction), Tbilis, 1966, pp. 5 & 6.

6. _Ibid._, p. 7.

There was a new generation of students who needed to master the deluge of data and inventions that would probably become outmoded in a decade or so. While Soviet educators were trying to meet the needs of a new technological age, their efforts attracted the attention of scientists, technicians, and military leaders. These Soviets were particularly concerned with the methods of teachers who were directly involved in education Soviet specialists. Such Soviets as Admiral A.I. Berg and Academician V.M. Glushkov pointed out that there was an overload of information in the educational system and that the traditional ways of coping with this critical situation seemed to be ineffectual. In other words, there was a growing chasm between what was known and what was taught in scientific and technical subjects. Moreover, the traditional methods of teachers did not permit them to bridge this gap. Realizing that such inadequacies could impede the development of Soviet manpower and thus its economy, a group of Soviets began to create a type of educational technology that would aid the classroom teacher by regulating automatically the flow of information in instruction. Thus like spring that comes when it is most needed in the Soviet Union, the struggle to automate instruction was a response to preceding conditions that needed to be changed before they became intolerable.

Characteristics of the Technology

It is important to distinguish here between how "technology" is usually defined by laymen and how it is delineated by technicians and scientists. In many magazine and newspaper articles, there is a tendency to equate this concept with machines. Such a superficial conception has created many false problems and issues about whether these mechanical objects will be the destruction or salvation of mankind. Today, few scholars limit the meaning of "technology" to machines. It is generally viewed by these professionals as the use of scientific or organized knowledge to achieve a practical end. For example, Daniel Bell, a leading American authority on "technology", sums up this concept "as a systematic, disciplined approach to objectives using a calculus of precision, and measurement and a concept of system."[7]

The type of educational technology that the Soviets are relying on to speed up the flow of information in their classrooms fits within Bell's conceptual framework. The disciplined approach stems out of knowledge from such areas as computer technology, cybernetics,[8] psychology, and pedagogy; and the precise calculations are made by electronic devices. In addition to these characteristics, the Soviet

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7. Daniel Bell, "The Year 2000 - The Trajectory of an Idea," Daedalus (Volume 96, Number 3, 1967, p. 643.

8. Cybernetics is the "study of information and control in animals and machines, includes all facets of natural and biological information and control systems." This definition was developed by R.E. Levien and M.E. Maron, in An Evaluation of Soviet Development and Use of Teaching Machines, (Santa Monica, California: The RAND Corporation, April, 1964), p. 38.

technology for automating instruction has some other more specific traits in its design. This approach is designed to (1) organize rationally the processes of instruction, (2) create continuous feedback between the student and the teacher, (3) accelerate the rate of learning of students in critical subject matter areas, (4) and automate certain functions of classroom teachers by using technical devices ranging from small teaching machines to digital computers.

All of these traits are encompassed by the Russian term, programmirovannoe obuchenie. It is the Soviet designation for their technological approach to automation in the classroom. Since the meaning for the Russian phrase is derived from a Soviet cultural context, programmirovannoe obuchenie is translated into English as Soviet programmed instruction in the chapters that follow.

Thus, broadly described, this technology is aimed at revitalizing Soviet instruction by emphasizing the application of machines and knowledge in the classroom. Implicit in such a use of Soviet programmed instruction are changes which have far-reaching implications for Soviet education in the next decade. If the role of the teacher as the principal purveyor of information in the classroom could be performed by labor-saving machines, they would free the teacher to do other types of tasks. Furthermore, if Soviet educators could organize instruction according to optimum means for achieving clearly ennunciated goals, then these teachers would need to modify their practices so that they would be consistent with this rationalistic approach. In turn, the use of machines and the modification of methods would require major changes in the training of teachers and the physical design of the learning environment. Making such changes involves certain risks because schools designed for electronic computers and teachers trained to use these devices would be a radical departure from what dominated the learning and teaching situations of the sixties.

American Interest

It is hardly surprising that the development and use of Soviet programmed instruction have attracted the attention of the Rand Corporation whose main purpose is to explore questions pertaining to the national security of the United States. Two members of this research organization studied Russian reports about teaching machines and submitted their findings to high ranking government officials. In this 1964 study, R.E. Levien and M.E. Maron point out that the Soviets were using electronic devices as teaching machines and they were significant innovations in Soviet education.[9] Furthermore, Levien and Maron state that these inventions and their related research merited the serious study of American scholars.[10] Unfortunately, Levien and Maron's report was not disseminated widely among those American educators, scientists, and technicians who were involved with automation in the American schools and who might have profited from studying similar activities in the Soviet schools. As

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9. Levien and Maron, op. cit., p. 7.

10. Ibid., p. 7.

a result, there were no follow-up studies made by American scholars in 1965 and there was a lack of information in the American research establishment about a major technological trend in the Soviet Union. Like the Soviet plan to launch Sputnik that was revealed in advance in Russian publications and was generally unnoticed by American scholars, the Soviet reports about automation in the classroom were neglected in the United States.

More Data Since the Rand Report

Meanwhile, the American gap in information increased in the sixties because the Soviet experiments with programmed instruction continued after the Rand Report in 1964. These activities were reported in various Russian publications. The reports contained descriptions of applications and endorsements of programmed instruction by many leading educators, scientists, party leaders, and military officials.

For example, T. Samokhvalova described in a Soviet journal for higher education that 1,500 Soviets participating in a 1966 conference about programmed instruction endorsed its use in the Soviet schools.[11] Heading the list of participants in the meeting were such well-known and respected public figures as: V.P. Yelutin, the Minister for Higher and Secondary Specialized Education in the USSR; A.I. Berg,

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11. The official name for this meeting was the "First All-Union Conference about Programmed Instruction and the Application of Technical Means to the Educational Processes." Hereafter, it will be designated simply as the All-Union Conference. T. Samokhvalova, "First All-Union Conference about the Achievements of Science and Engineering in the Aid of Pedagogy," Vestnik Visshey Shkoli, No. 7 (July, 1966), p. 41.

a member of the Soviet Academy of Science and an admiral in the Soviet Navy; V.M. Glushkov, an expert in cybernetics; T.I. Rostunov, a general in the Soviet Artillery; and M.G. Chilikin, a winner of the Russian award: "Honored scientist and technician." In their speeches, all of them endorsed Soviet programmed instruction and urged its further development. According to Samokhvalova, these prestigious Soviets and the other 1,500 participants were particularly impressed with this educational technology because Soviet experiments had provided the following results:

> The research in pedagogy, psychology, cybernetics, mathematical logic, statistics, theory of probability, and computer technology has demonstrated that programmed instruction in combination with other methods of instruction has increased significantly the control of the processes of instruction and (also) increased significantly their activeness and effectiveness.[12]

Such reports as Samokhavalova's summarization and the many accounts of individual applications, published in professional journals in 1966, suggested that the Soviets had increased their activities since the publication of the Rand Report in 1964. For better or worse, it seemed by the end of 1966 that the movement to automate Soviet instruction had gained some momentum and a powerful group of Soviets were propelling it forward. Yet, in 1966, the recommendations of Levien and Maron were still unfulfilled and most Russian reports about their programmed instruction were not translated into English.

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12. *Ibid.*, p. 41.

Part of an Unfortunate Trend

In the past, Americans have usually failed to keep abreast of what Soviet scientists and technicians have disclosed in their professional publications. Walter Buckingham, the Director of the School of Industrial Management at the Georgia Institute of Technology and consultant for the U.S. Congress, has studied the situation and concluded: "There is no greater scientific bottleneck today than that of translating Russian scientific periodicals."[13] This bottleneck has caused American researchers to lose much valuable time solving problems which their Soviet counterparts have already resolved, and this duplication of effort has been costly for American taxpayers whose taxes support it. For example, "American scientists worked five expensive years on an electrical engineering problem that had already been solved, and the results published by the Russians."[14]

When the author began this study in 1967, it seemed possible that there could be similar instances where American researchers were trying to unravel problems in the automation of instruction that Soviet engineers and educators had already untangled. These possibilities of Americans needlessly duplicating Soviet research seemed probable for

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13. Walter Buckingham, Automation Its Impact on Business and People, New York: The New American Library, 1961, p. 33.

14. Ibid., p. 33.

several reasons. First, both the Americans and Soviets had to overcome certain common obstacles in designing the hardware and software for their respective classrooms.[15] Second, the solutions for many of these problems required considerable research in cybernetics and educational psychology, two areas in which the Soviets had excelled in the past. Third, Levien and Maron had concluded from their study focusing on teaching machines that American scholars should seriously investigate Soviet programmed instruction.

In short, American and Soviet educators encountered one common problem in the sixties. Both discovered that they cannot stand still while their societies advance technologically. This fact was reflected in how automation began to impinge upon both the Soviet and American processes of instruction. Since the trend has emerged in both technologically advanced countries almost simultaneously, they could possibly benefit from each other's experiences. All of this leads to the simple conclusion that if Americans want to benefit from the Soviet experience, they must first study it.

Aims and Methods

When the following study was initially planned in 1967, its main objective was to bridge at least partially the American gap in information about the Soviet development and use of programmed instruction during 1961-1967. Instead of first hand observations of the technology, it seemed that the best methodological approach would be (1) to review Soviet

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15. Hardware designates the technical devices and software symbolizes the materials used in them.

newspapers, professional journals, and government publications which could be obtained in the United States, (2) and then to arrange into meaningful patterns the data available in these printed materials. A series of events in 1967, however, created some new sources of information and required the investigator to change his methods.

Provisions for the author to study in the Soviet Union were made under the Cultural Exchange Agreement between the American and Soviet governments. From the Fall of 1967 to the Spring of 1968, the author was an exchange student at Moscow State University and the Moscow Energetics Institute. These opportunities provided research sources which were not available in the United States. Hence the bulk of the information in this study was obtained from firsthand on-the-spot observations and materials collected in the Soviet Union.

These data were gathered from the following primary sources: (1) personal observations of classrooms where the new technology was being applied; (2) interviews with students and teachers who were using it; (3) consultations with various administrators who were directing the development of Soviet programmed instruction; (4) studies under engineers who were designing Soviet hardware and software at the Moscow Energetics Institute; (5) and references including filmstrips, photographs, and Russian printed materials collected in the Soviet Union. This study is of importance, if for no other reason than it presents for Americans basic Soviet data, hitherto unavailable in the English-speaking world.

In presenting this information, the emphasis has been on (1) outlining the basic conceptual framework, (2) establishing a chronological sequence of major events, (3) describing the applied knowledge, (4) explaining the designs and uses of electronic devices, (5) illustrating how the hardware and software were employed in classrooms, (6) and offering suggestions for future research. While offering a wide range of basic data from which American engineers, psychologists, and other specialists can generate hypotheses for further specialized studies, this general exposition should provide American educators with information answering the following vital questions:

(1) Who emerged as leaders in the Soviet programmed instruction movement and what other leadership functions, if any, did these Soviets perform in their society?

(2) Why were high ranking military officers and leading scholars from such diverse disciplines as psychology, cybernetics, and engineering attracted to this educational movement?

(3) Who were the theoreticians for Soviet programmed instruction and what were their basic conceptions?

(4) What were some of the major events and decisions that shaped the historical development of this technology, and were these turning points related to other significant aspects of contemporary Soviet history?

(5) What were the important Soviet aims and achievements in the research and development of programmed instruction?

(6) Who designed the Soviet teaching machines, what were the designers striving to achieve with their electronic devices, and what were the characteristics of these machines?

(7) Where did the Soviets apply their hardware and software, and what results did they report about these applications?

(8) What phases of the Soviet experience with automation in the classroom merit the serious study of American educators and what steps can be taken by both American and Soviet educators so that they can share information and reduce costly duplication of efforts in automating instruction?

As the preceding questions should indicate, this study was not intended to be a highly theoretical foray into poorly chartered terrain or a limited probe of a specialized sector. The main purpose was to conduct an overall inquiry of how the Soviets developed and used programmed instruction from 1961 to 1968. The results of this study are revealed in the following manner:

Chapter II consists of an examination of the various Soviet conceptions of the technology and a brief historical sketch of its development.

The description and analysis in Chapter III are focused on how key principles and techniques from Soviet psychology, pedagogy, computer technology, and cybernetics were applied in programmed instruction.

Chapter IV is about the electronic devices ranging from small teaching machines to the digital computers employed in Soviet classrooms. This description includes photographs of students using the machines and diagrams of these classrooms.

Actual case studies of how the Soviets applied electronic devices and programmed materials are discussed in Chapter V.

The last chapter contains the conclusions of the author. These are essentially recommendations concerning those phases of Soviet programmed instruction's development and use which could merit further investigation by American scholars and educators.

In the appendixes, there is a directory of the institutions and individuals who were involved in the research and development of the technology during the sixties.

Perhaps some readers will be shocked by the following image of the emerging technological reality in the Soviet schools and others will be pleasantly surprised by this picture. Regardless of their reactions, the facts remain that the Soviet colossus has started a technological revolution in education and the initial tremors of the technological upheaval have disturbed an educational system which encompasses one sixth of the world. Hopefully, the following pages will provide an initial explanation and will stimulate serious study of the Soviet efforts to automate their classrooms.

CHAPTER II

A SOVIET VISION AND HISTORICAL STRUGGLE FOR IT

> Speakers of different languages see the Cosmos differently, evaluate it differently, sometimes not by much, sometimes widely. Thinking is relative to the language learned.[1]

The Soviet Fountainhead

The search for the driving forces behind the movement to automate Soviet instruction led directly to men with ideas, not machines. These were merely the tools with which the Soviets were restructuring their educational environment. But the wellsprings for Soviet programmed instruction were the theorists who devised the overall theoretical framework from which plans for educational change and the means for achieving them were evolved. This raises a series of questions about the theoretical foundations of the technology: What were the basic Soviet conceptions of it? Who stated them? Did their ideas vary or did they follow an orthodox pattern, established by some ideologist of Marxism-Leninism?

Instead of answering such questions with general statements, it may be more useful to cite specific examples of major conceptions, explain who developed them, and note their similarities and differences. These illustrations are presented as follows: (1) a very broad educational or engineering conception, (2) a psychological point of view, (3) an interdisciplinary outlook, (4) and a cybernetic framework.

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1. By Stuart Chase in his Foreword to Benjamin Lee Whorf's book, Language, Thought, and Reality. Cambridge, Massachusetts, 1966. p. x.

A Dualistic Viewpoint

Like many teachers who were involved with Soviet programmed instruction during the sixties, A.G. Molibog was by training a skilled technician who was teaching a highly specialized subject in a higher educational establishment. While he was preparing engineers at the Minsk Engineering Radio-Technical School so that they could serve in the Soviet anti-ballistic missile system, Molibog played an important role in automating instruction in engineering disciplines at this institution. From 1963 to 1967, he collected data about these efforts in Minsk and similar ones in other Soviet locations. In 1967, the Soviet authorities published his material in a book, entitled Programmed Instruction - Problems of the Scientific Organization of Pedagogical Work. As his background and title for his text should suggest, Molibog tends to view the technology from the standpoint of an engineer and a classroom teacher. This dualism becomes even more apparent when his views are examined and his underlying assumptions are exposed.

In constructing a general framework, Molibog begins by making three key suppositions. Perhaps his most important assertion is that Soviet programmed instruction will not destroy the existing system of Soviet instruction, but will move it to a new and higher level of development.[2]

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2. A.G. Molibog, Programmirovannoe obuchenie (Voprosy nauchnoi organitzatsii pedagogichechogo truda) (Programmed Instruction - Problems of the Scientific Organization of Pedagogical Work), Moscow, 1967, p. 16.

He adds, however, that reaching this stage will require the mechanization of instruction.[3] Finally, he assures the reader that electronic devices will not replace teachers in classrooms, but only aid them by regulating automatically the flow of information in the processes of instruction.[4] Thus Molibog, like most engineers, believes that machines can improve the flow of data; and he presumes, like most classroom teachers, that they cannot be displaced by electronic devices.

After making these suppositions, Molibog proceeds to outline the more specific parts in his theoretical structure. These are as follows:

> Programmed instruction is a (series) of complex tasks which consist of the following: (1) the ordering of the structure and content of all instructional material - the optimization of the instructional plan; (2) the development of a program for the very process of learning these materials - the optimization of the student's activities in studying and mastering these materials; (3) the creation of an effective system for measuring the student's achievement and for evaluation of the whole instructional process.[5]

This viewpoint of Molibog rests upon the assumption that instruction involves mainly the transmission and reception of knowledge within a given field. With this type of supposition, which is apparently made by many theorists and practitioners in the Soviet programmed instruction movement, the role of a teacher is a dual one. He transmits the required

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3. Ibid., p. 16.

4. Ibid., p. 16.

5. Ibid., p. 16.

information to the learner and then evaluates the acquisition of this knowledge. The student's role is to acquire the material and to demonstrate his competency by performing various tasks in some type of examination. Afterwards, the learner will hopefully apply the facts, concepts, and methods outside the classroom. Since Molibog and many other Soviet educators begin with the preceding assumption about instruction and perceive the roles of student and teacher in such a limited way, it is conceivable for them to program all instruction.

A Psychological Point of View

Unlike most of the theorists who tended to view Soviet programmed instruction in terms of their specialized disciplines and classroom experiences, P. Ya. Gal'perin, A.A. Reshetova, and N.P. Talyzina were leading Soviet educational psychologists who attempted to develop a broad psychological base for this technology in the sixties. Gal'perin played a particularly important role in their theoretical developments because he was in charge of the Laboratory for Programmed Instruction at Moscow State University. During the last decade, he and other psychologists conducted their experiments with this technology in such subject matter areas as mathematics, language, physics, and industrial training.[6] Reshetova and Talyzina also collaborated with Gal'perin in

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6. P. Ya. Gal'perin, A.A. Reshetova, and N.P. Talzina, Psikholog-pedagogicheskie problemy programmirovannogo obuchenie na sovremennom etape (Psychological-Pedagogical Problems of Programmed Instruction at the Contemporary Stage), Moscow, 1966, pp. 3-39.

these projects at the Laboratory. As a result, all three were selected to outline at the All-Union Conference the psychological and pedagogical problems arising from the use of teaching machines and programs. The following description and analysis stemmed from a printed report of their presentation.

In their psychological frame of reference, Gal'perin, Reshetova, and Talyzina conceive of Soviet programmed instruction as essentially "an approach to instruction (starting) from the standpoint of a theory of control."[7] According to these Soviets, such a theory would explain what happens psychologically when a student is learning and this explanation would guide the teacher in devising procedures which would give him feedback about the student's progress.[8] In other words, their programmed instruction would consist of (1) feedback about what is occurring when a student reads a book, solves a problem in a laboratory, or manipulates a tool in an industrial education class, (2) and regulation by the teacher who modifies conditions according to this information. In summary, Gal'perin, Reshetova, and Talyzina agree with Molibog that Soviet programmed instruction is an approach to instruction. But in sharp contrast to Molibog who stresses mechanization, they focus on explaining the behavior of the learner and using feedback to regulate his learning activities.

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7. *Ibid.*, p. 4.

8. *Ibid.*, p. 4,5, & 6.

A closer examination of their psychological framework reveals that it rests on two theoretical planks. One is that learning entails a hierarchical development of mental activities and conceptions.[9] This means that one learns, for example, to generalize about something by gradual stages. The other supposition is that it is possible to design a system in which a teacher could receive feedback about how a student is learning, for example, to make a generalization.[10] In comparison with Molibog's general aim to improve the flow of information in the classroom, these Soviet psychologists are striving to attain a similar goal. They are attempting, however, to obtain and apply data concerning the mental activities of students during the learning process, while Molibog is interested in various ways of transmitting and receiving subject matter. At this point, it should be added that Gal'perin, Reshetova, and Talyzina have attempted to devise a system in which they could receive feedback about the mental activities of learners and that these psychologists have claimed some positive results in their experiments.[11]

An Interdisciplinary Outlook

In the sixties a group of Ukrainian educators, psychologists, and cyberneticians prepared a joint report outlining the theoretical problems of Soviet programmed instruction and suggestions for resolving them. V.M. Glushkov, G.S. Kostyuk,

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9. *Ibid.*, pp. 5 & 6.
10. *Ibid.*, p. 5.
11. *Ibid.*, pp. 20-39.

G.A. Ball, A.M. Dovgyallo, E.I. Mashbitz, and Ye. L. Yushchenko participated in the collective effort. It is necessary here to note that V.M. Glushkov, who was mentioned earlier, is recognized as one of the Soviet Union's most brilliant scientists. Although he is still in his thirties, Glushkov is Director of the Institute of Cybernetics at Kiev and Vice President of the Ukrainian Academy of Sciences. His other achievements range from introducing computers into the planning processes of the Soviet economy to conducting basic research in the design of cybernetic devices for weapons systems. It should not be too surprising that he is also a leader in the Soviet programmed instruction movement. For these reasons, a theoretical framework, elaborated by Glushkov and his Ukrainian colleagues, merits special attention.

Their conception stems from how they interpret certain trends in Soviet society, list priorities for the educational system, and relate programmed instruction to these goals and tendencies. In interpreting economic growth, Glushkov and the other Ukrainian scholars attribute it mainly to modern science which is thrusting the nation forward and demanding the scientific organization of work at every level and especially in education.[12] This "scientific organization" in an educational context entails the rationalization of (1) planning to meet future manpower needs in all branches of the

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12. V.M. Glushkov and others, Nauchnye problemy programmirovannogo obucheniya i putikh razrabotki (Scientific Problems of Programmed Instruction and the Course of their Development), Kiev, 1966, p. 3.

economy, (2) administration in all educational institutions, (3) and regulation of the learning processes of students so that the needed cognitive aspects are developed and the necessary psychic traits are formed in the learners.[13] In achieving these goals, Glushkov and the other academicians point out that programmed instruction can play a very important role in meeting future manpower needs and controlling the learning processes. Specifically, these Ukrainian scholars believe that the technology can aid educators in developing subject matter for future specialities and updating established curriculums which will become obsolete every five or ten years.[14]

Unlike Molibog who tended to see programmed instruction as the scientific way to organize pedagogical work, Glushkov and his Ukrainian collaborators view this technology as only one method to be used in planning and regulating Soviet education. Their collective viewpoint is as follows:

> Programmed instruction is one form of student and teacher interaction. The special characteristic of programmed instruction is that in it several functions of the teacher are fulfilled by the teaching program.[15]

The automation of certain teaching functions is a distinctive characteristic which is noted by both Glushkov and Molibog. While the latter stresses the use of machines,

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13. Ibid., p. 3.

14. Ibid., p. 3.

15. Ibid., p. 5.

the former attributes automation to the software or teaching programs. Also in contrast to Molibog, Glushkov and his Ukrainians cohorts do not view programmed instruction as the panacea in teaching and learning. In short, these theorists define this technology as one type of teacher and student interaction in which a program performs certain teaching operations.

In some respects, these Ukrainians view this technology like Gal'perin and the other psychologists because both viewpoints are derived from a broader context than the classroom and they reflect the efforts of theoreticians and not those of practitioners in the schools. For example, Glushkov and his colleagues see the relationship between programmed instruction and the rationalization of key aspects of Soviet education. On the other hand, it is quite unlikely that classroom teachers observe this type of relationship and it is more likely that they are concerned chiefly with how programmed instruction relates to their subject matter and their students. What is more important, however, is that other leaders in the movement, such as Admiral Berg, tend to share the perspective of Glushkov and the other Ukrainians.

A Cybernetic Framework

While most Soviet educators in the sixties were still confronting the unresolved dilemmas of the past mechanical age, the staff at the Kiev Higher Engineering Radio-Technical School were solving key educational problems of the new electronic age. By the end of 1964, these Soviets had already demonstrated in a specially designed complex, called Radon, that the digital computer could perform certain functions of the teacher. From 1964 to the end of the decade, thousands of specialists were trained in the Radon Complex to serve in the Soviet anti-ballistic missile system. As a result of these achievements, the Kiev Higher Engineering Radio-Technical School became a frequently studied and copied model for other Soviet schools.

In 1967, the Superintendent of this military school, General T.I. Rostunov, published a book that was based on his experiences with computer-based and non-computerized programmed instruction, and his studies of similar efforts in other locations. Since Rostunov's theoretical views in the book were derived from his firsthand observations as the administrator of the Radon Complex, which embodied a Soviet technological vision for its schools, it may be useful at this point to examine his theories.

Rostunov defines the technology by describing what happens when it is prepared and then used in classrooms:

> Programmed instruction is conducted in accordance with a specially prepared teaching program stipulating the breaking down of subject matter into doses (portions). In the process of instruction, a systematic volume of information is transmitted between the teaching program and the student.[16]

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16. T.I. Rostunov, Programmirovannoe obuchenie i obuchayushchie mashiny (Programmed Instruction and Teaching Machines), Kiev, 1967, p. 28.

Thus Rostunov's basic conception includes two techniques: one for organizing subject matter and the other for transmitting it.

His notion rests on an assumption that instruction is mainly the transmission and the reception of knowledge. This limited supposition is almost like Molibog's reduction of instruction to an information process. The major difference is that instead of stressing hardware Rostunov attributes control to the software or the teaching program. Although Rostunov's theoretical frame of reference may be based on an imprecise image of instruction, his framework allows for a more precise regulation of the flow of information. The doses in the program, for example, can be determined by calculations which take into account the type of program, capacities of the teaching machines, traits of the transmitted subject matter, and the responses of the student.

Another important characteristic of Rostunov's conception is that it designates a highly structured learning situation. This trait is also clearly reflected in almost all of the Soviet theoretical and practical models.[17] In these prototypes, the processes of instruction are broken down into a series of step by step procedures which Rostunov describes as follows:

(1) the presentation of instructional data containing some type of question, task, or problem for the student.

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17. There were some variations from this pattern. A few Soviets were attempting to develop heuristic programs in the late sixties. These would permit a less structured situation. See Chapter III for more details.

(2) a response by the student to the preceding message,

(3) and a reply to the student indicating whether he has responded correctly or incorrectly and suggesting the next step.[18]

Perhaps Rostunov's views about the essential characteristics and design of programmed instruction can best be summarized by describing briefly and diagramming approximately how computers and programs were employed to regulate the flow of information between student and teacher in the Radon Complex. According to Rostunov, the teacher or technician entered the data from the teaching program into the computer (Phase I), then an instructional task was presented by the computer to each student at his terminal (Phase II), next each student responded by typing a reply on the input device at his terminal (Phase III), and finally the teacher received feedback by viewing the replies on a master electronic panel or by reading a printout from an output device attached to the computer, (Phase IV).[19]

Graphically, all four cycles in the application are described as follows:

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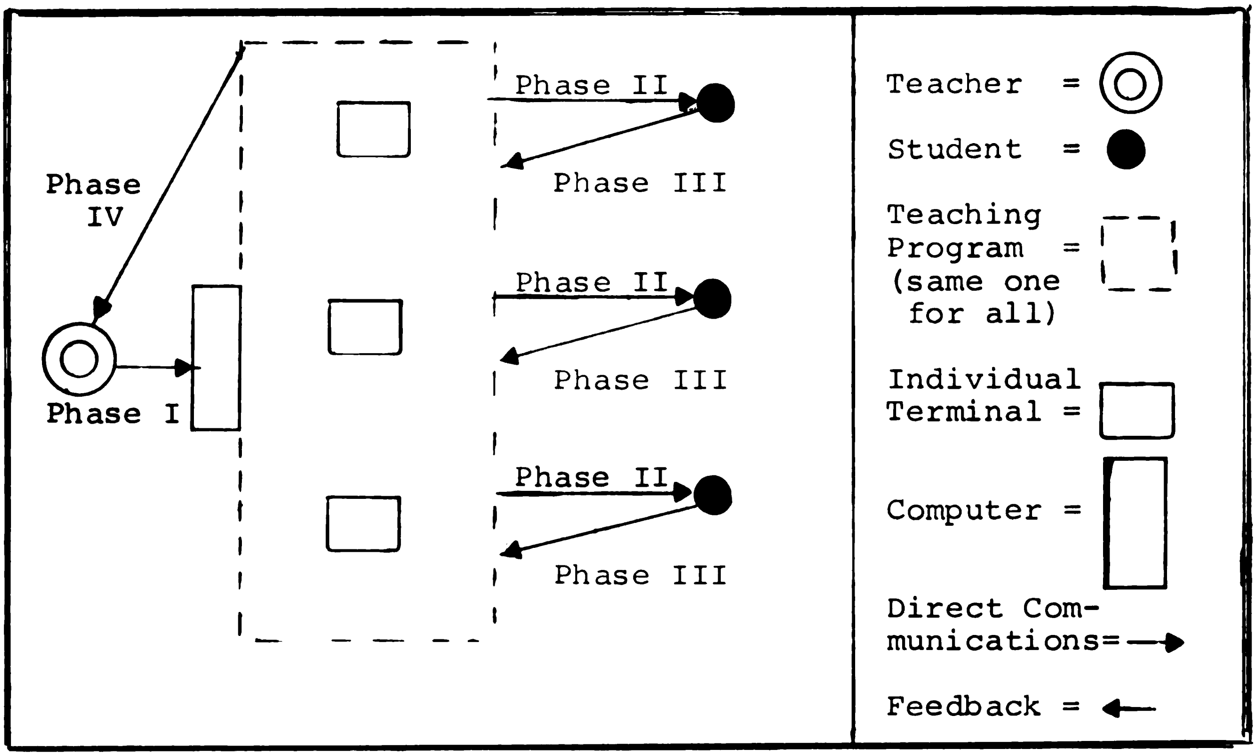
18. Ibid., p. 28.

19. Ibid., p. 8.

Figure 1: Flow of Information in Radon Complex[20]



In summary, Rostunov, beginning with the premise that instruction is essentially the transmission and reception of information, conceives of programmed instruction as two approaches for improving these processes. One technique breaks down subject matter into small portions and the other attempts to regulate how this knowledge is transmitted between the teacher and the student. Furthermore, his conception entails a highly structured learning situation which the teacher controls with the aid of a teaching program stored in a machine or printed in a book. Even though the theories of Rostunov are not as complex as the theoretical frameworks of other theorists, his point of view was very

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20. Ibid., p. 8, adapted from Rostunov's original diagram.

influential in the sixties because he was in charge of the Radon Complex and it demonstrated dramatically the utility of his viewpoint.

General Comments on Models

In the sixties, the visions for this technology were expressed by its theorists "differently, sometimes not by much, sometimes widely."[21] Their theories seemed relative to the language of their own specialities. Molibog, Rostunov, Gal'perin, Glushkov, and others, for example, tended to describe their conceptions of programmed instruction in terms from their respective professional vocabularies.

The participation of engineers, cyberneticians, and many other noneducators in the elaboration of Soviet programmed instruction's theories should not be misread as signs of weakness in Soviet pedagogical thought. This dynamic interaction, for example, between the educator and cybernetician during the sixties set in motion some unique forces for educational change in the Soviet Union. To give an example, never before did Soviet teachers think of "instruction" in terms of automation with computers controlling the flow of information in their classrooms. Likewise, some of these teachers collaborated with engineers, technicians, and cyberneticians for the first time; and their collective efforts produced such innovations as the Radon Complex where the effectiveness of integrating men and electronic devices

21. Chase, *op. cit.*, p. x.

in a learning system was demonstrated very concretely. Thus the interaction of professionals with different viewpoints served as an important catalyst in bringing about the emergence of another dimension in the Soviet educational reality.

Yet amid these divergences, there are some common threads. The theoreticians for Soviet programmed instruction tended to view it as one type of instruction with the teacher, assisted possibly by various kinds of hardware or software. These Soviets made no claims in the sixties that machines would replace teachers. However, Glushkov, Gal'perin, Rostunov, Molibog, and many others like them were replacing old didactic terms and viewpoints by introducing into the terminology of Soviet pedagogy such new concepts as the flow of information, theory of control, automatic regulation, and feedback.

Although the approaches of those involved with Soviet programmed instruction reflected these more recent developments in science and technology, their basic assumption about the nature of instruction was almost identical with the one which many educators have been making for years. Both the innovators and the traditionalists assumed that instruction was essentially an information process with two phases: the transmission and the reception of knowledge. In contrast with this agreement, Molibog, Rostunov, Glushkov, Gal'perin and the others advanced a new perspective about the equipment needed to send and receive subject matter. This dream of computers and programs in classrooms possibly clashed with the established ideas of more conservative teachers who seemed preoccupied with chalk, blackboards, books, pencils, papers and other memorabilia of past technological ages. In other words, Molibog, Rostunov, Gal'perin, and others created an initial design for technological progress in the Soviet schools that contained both conventional and radical thoughts about instruction.

Their plan for modernization raises such questions as: How did professional educators, party leaders, and scientists react to the options for educational change offered by the advocates of Soviet programmed instruction? How did the members of the movement attempt to advance their aim to modernize instruction? What did these Soviets achieve during the sixties? Finding initial answers for such questions requires one to examine the historical context of Soviet programmed instruction's development and use.

Soviet Attempts to Translate Ideas into Actions

The following sketch is limited mainly to the major events and trends in the history of this technology starting in 1961 and ending in 1968. The aim here, therefore, is not to present a detailed account, but merely to trace briefly the broad technological landscape and to indicate its landmarks.

Historical Beginnings

As with most technological innovations, it is difficult to determine the exact location and date of Soviet programmed instruction's inception. In the Rand Report, Levien and Maron trace the origins of this educational technology to the simultaneous development of two electronic devices: "Sometime in 1961, . . . two separate groups in Moscow began to construct teaching machines."[22] L.N. Landa led one group who constructed the Repetitor (a device for testing Russian language students) and Yu. N. Kushelev directed the others who built the Ekzamentor (a machine for testing engineering students).[23]

In a source unavailable outside the Soviet Union, however, A.G. Molibog points out that primitive teaching machines were invented and utilized by the Soviets in the early 1920's. He supports his claim by describing numerous cases in which these devices were employed to train students and workers in a few industries and technical schools.[24] This evidence indicates that the full potential of such mechanical innovations remained untapped for over three decades, and suggests that this Soviet lag in exploitation was somewhat analogous to a series of events in the United States. Like their Soviet counterparts in the twenties, American educators failed to exploit fully a teaching machine invented by Sidney Pressey, and they allowed his ideas to lay dormant for over thirty years.

What is more important than the disagreement about the date when teaching machines were first used in the Soviet

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22. Levien and Maron, op. cit., p. 7.

23. Ibid., p. 7.

24. Molibog, op. cit., pp. 11-12.

Union is that Molibog and the Rand researchers agree that a serious interest in programmed instruction was manifested by the Soviets in 1961. Their concern was maintained and even intensified during the rest of the decade. This resulted from a sequence of events of which the following ranks as perhaps the most important.

An Important Merger and Influential Leader

One year after Landa and Kushelev developed teaching machines, Soviets programmed instruction was officially linked with a broader technological movement which was leading the entire Soviet system into the age of instant information and regulation. This transformation had already begun in the late fifties, when the Soviets initiated serious studies in cybernetics and programs for applying this research. By 1964, the Soviet government had established a network of cybernetic institutes, laboratories, and planning councils; and cybernetics had intruded into almost all Soviet academic disciplines "from computer technology and economics to psychology and philosophy."[25] Yet even more significant, is the fact that Soviet leaders in the sixties viewed important political, social, economic, and educational problems from a cybernetic standpoint. In order to establish cybernetic policies and coordinate efforts in their implementation, the Soviet government organized a Scientific Council for Cybernetics. This organization was and still is

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25. Levien and Maron, op. cit., p. 38.

directed by Admiral A. I. Berg who is also a full member of the Soviet Academy of Science, former Deputy Minister of Defense, expert on radio-electronics, and "hero of socialistic work."[26]

In contrast to the powerful cybernetic movement with its influential leader, the advocates of Soviet programmed instruction lacked organization and leadership in 1961. This ended abruptly on July 7, 1962, when the Scientific Council for Cybernetics publically endorsed this educational technology and assumed administrative responsibility for its development and use.[27] The endorsement gave legitimacy to the efforts of Landa, Kushelev, and other pioneers like them. What is even more important is that Admiral Berg became the leader of their movement. In short, the master designer for the emerging technological reality in the Soviet Union was now the official spokesman for programmed instruction and when Berg spoke, other high ranking government and party officials usually listened.

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26. This title is awarded to the recipients of one of the highest medals given by the Soviet government. The author met Admiral Berg at the Moscow Energetics Institute and heard him deliver a speech at this school. Berg is probably in his early sixties and he is a very impressive speaker because he can overwhelm an audience with his knowledge and challenge it with his imaginative thinking. In addition, Berg has travelled widely and studied outside of the Soviet Union. According to John Ford, the American specialist on Soviet cybernetics, Berg has studied and worked on special research projects in the United States during World War II. Thus it would be a mistake to dismiss him as a conventional Soviet military thinker.

An Important "First" Exhibition

By 1964, the construction of hardware had reached such a level of sophistication that the Soviets decided to display their machines. Their pride in these achievements and the importance attached to them by the Soviets were reflected in the site selected for the exhibition. It was located in one of the most impressive places in the Soviet Union. The exhibit for teaching machines was arranged in the massive Pavilion for Public Education which is only a small part of the Exhibition for Economic Achievement in the USSR. Although the Exhibition's seventy-three permanent pavilions, sprawling over fifty acres in Moscow, provide enough space for many products to be displayed, only the best ones produced in the Soviet Union are shown in the pavilions.[28]

Nevertheless, the author discovered that the Soviet officials were not completely satisfied with the display because it attracted the attention of only those hundreds of Soviet visitors who daily passed through the Pavilion of National Education.[29] In order to gain more publicity and to display the hardware to more people, the Soviets decided in 1966 to show the exhibit in every major Soviet city and

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28. Exhibition of Economic Achievement of the USSR (A specially published book with no date of publication, publisher, or author given and pages were not numbered).

29. This investigator visited the Exhibition for Economic Achievement in 1968 and interviewed members of the staff. They presented him with some of the original brochures for the exhibition of teaching machines and provided information about the traveling tour.

thus take the hardware to the masses. In 1968, this extraordinary show with an all-star cast of hundreds of machines was still performing on the road in the Soviet Union.

A Breakthrough in Kiev

While the Soviets were exhibiting teaching machines in Moscow, a series of events in Kiev demonstrated that this hardware was obsolete. In 1964, the officials at the Kiev Higher Engineering Radio-Technical School opened the Radon Complex and Soviet students learned for the first time by using computer-based programmed instruction. In this electronic classroom, the digital computer, Dnepr, taught 100 military specialists simultaneously, while they studied at their individual terminals.

With such an arrangement of men and machines in the Radon Complex, the Soviet dream of utilizing sophisticated electronic devices in classrooms became an educational reality.[30] By demonstrating that the digital computer could be used in instruction, the Soviets raised some very serious questions: (1) Should they attempt to expand immediately this electronic reality to other Soviet schools? (2) Or should this dissemination be delayed until the officials at Kiev had refined their equipment? (3) Should the development of small teaching machines, which were apparently obsolete, be halted? In other words, the Soviets

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30. In 1968, the author was informed by his Soviet advisor at the Moscow Energetics Institute, P.D. Lebedev, that the Radon Complex was being rennovated and that new equipment was being installed.

had to decide what they should do next. The answer for such a question required careful consideration of existing data, formulation of short and long range goals, and detailed planning in order to implement them. From 1964 to 1966, the Soviets grappled with these tasks in a series of meetings and conferences held in the various Republics.

A Plan for the Future

In the Spring of 1966, the results of the preliminary meetings were summarized and discussed in Moscow at the First All-Union Conference about Programmed Instruction and the Application of Technical Means to the Educational Processes. Approximately 1,500 Soviet educators, scholars, politicians, and military leaders participated in this Conference at the Moscow Energetics Institute. From May 31 to June 4, the participants discussed their theories, described their applications of programmed instruction, and listened to speeches given by such influential leaders as A.I. Berg, V.M. Glushkov, and V.P. Yelutin. Of these activities, three seem particularly significant and merit a brief description.

First, the Soviet accounts of their applications revealed that the innovators concentrated on applying programmed instruction in the following subject matter areas: higher mathematics, descriptive geometry, chemistry, physics, theoretical mechanics, resistance of materials, electro-techniques, hydraulics, foreign languages, Russian, general technical and science courses.[31] Moreover, their reports suggested another priority which the Soviets had in applying the educational technology. They stressed its use at the higher grade levels. In short, their efforts were focused on the preceding subject matter areas in the following schools: 250 higher educational institutions, 300 semi-professional schools, 200 vocational-technical schools, and 700 general secondary schools.[32]

Second, as might be expected, Admiral Berg and Academician Glushkov endorsed the technology in their presentations. But the most important endorsement was given by the Minister for Higher and Secondary Specialized Education in the USSR. In his speech, V.P. Yelutin stated the official Soviet position:

> Experiments demonstrated that the device and methods of programmed instruction can render definite assistance to the teachers in professional institutions and for beginning courses in higher educational institutions.[33]

After pointing out to the participants that the technology should be used at the higher grade levels, Yelutin urged that educators use programs and machines on a much broader scale in the training of Soviet specialists and that the development of programmed instruction be accelerated.[34]

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31. T. Samokhvalova, _op_. _cit_., p. 26.

32. _Ibid_., p. 42. See the Appendixes for a more detailed listing of the Soviet applications and the personnel involved with them.

33. _Ibid_., p. 27.

34. _Ibid_., pp. 27 & 28.

Finally, if there is validity in what the historians teach about the world of yesterday shaping the world of today and tomorrow, then the Soviet plans resulting from the All-Union Conference should be considered. Their basic goals for research and development are listed as follows:

(1) Study of perception, processing and assimilation of information in the processes of instruction;

(2) Elaboration of theories and methods for programmed instruction;

(3) Development of programmed materials for other major disciplines _at all levels of instruction_;

(4) Creation of cybernetic devices and the adaptation of electronic computers for individualizing instruction and research in programmed instruction;

(5) Development of a television communication systems which would connect the large cities with their surrounding areas so that students can learn without interrupting their work in industry;

(6) Development of cybernetic devices which respond to voice commands;

(7) Testing and evaluating the effectiveness of programmed instruction in basic educational institutions.[35]

It should be mentioned that the Soviets also were concerned with more immediate aims such as: (1) the input and output capacities of the machines, (2) their reliability, (3) and the quality of their programs. In summary, the comments of the participants suggested that they were particularly concerned about the limitations of their

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35. _Ibid._, p. 43.

teaching machines, high costs in maintaining them, and a shortage of quality programs.

An Imaginative Location for a School

A history of the Soviet technology would not be complete without a description of a special Soviet school for teachers and its unique "board of education." The Moscow School for Programmed Instruction is sponsored and directed by a branch of the Scientific Council for Cybernetics - the Council for Problems in Programmed Instruction. The members of the Council and their sponsorship give the school a rather lustrous image.[36]

Another unusual feature about this educational institution is that it is located in the Moscow Polytechnical Museum, a Soviet tourist attraction somewhat like the Smithsonian Institute in the United States.

In a lengthy interview, the Director, I.I. Tikhonov, stated that in the school over 2,000 Soviet "students" have already been taught how to write programs and to apply them

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36. One of the most active members on the Council for Problems in Programmed Instruction is Professor I. Ya. Konfederatov. He has written many articles about the technology and also a book about teacher training and the need to improve it in higher education. What is particularly relevant about his career is that he has been selected on numerous occasions to represent the Soviet Union in international conferences concerning the problems of modern science and technology. As an example, when the author was studying under Konfederatov at the Moscow Energetics Institute, he was preparing to debate with Arthur Clarke, the English scholar, at an international conference in Paris. Thus Konfederatov is keenly aware of contemporary developments in the twentieth century and his insights are reflected in his outlook about programmed instruction. He is paradoxically about sixty years old.

in their classrooms. He added that most of the classes are held in the late afternoon and early evening because most of the "students" are teachers in the Moscow schools. Finally, he explained that these Soviets must pay a fee to enroll in the course which includes lectures, laboratory sessions, consultations with staff members, and some field experiences.[37]

The Soviet Nerve Center

The control center for the Soviet technology and other technological innovations for the Soviet schools is the Information Center for Programmed Instruction. It is located in Moscow and directed by M.V. Zalyetayev. In an interview, he described the functions of the Center as those of planning and being a central "clearing house" for both information and ideas. To illustrate what he meant by planning, Zalyetayev described how he and his staff coordinated the preparations for the First All-Union Conference. In addition, he explained that his basic problem was to develop systematic ways of disseminating information about programmed instruction and other innovations in the various

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37. The author visited the school in 1967 and interviewed I.I. Tikhonov. He was very helpful in describing the school and he also permitted the author to attend lectures and laboratory sessions where the teachers were preparing programs and using teaching machines.

Soviet educational institutions.[38]

In an age of rapid technological change, it should be rather evident that M.V. Zalyetayev plays an important role in the Soviet educational system and that his task is not a very easy one to fulfill. In some respects, M.V. Zalyetayev and his work reminds one of the legendary Sisyphus condemned to roll a heavy stone up a steep hill.

A Complete Circle: From Obscurity to International Recognition

By 1967, the Soviets were convinced that their hardware for the technology had reached a level of sophistication in both design and performance warranting display in their pavilion at the World's Fair in Montreal. Three devices: KISI-5, Ogonek-2, and Ekzamenator were selected and displayed at "Expo 1967." Thus the mechanical circle, starting with the obscurity of the devices in the 1920's and ending with the recognition of teaching machines in the 1960's, was completed ironically not in the Soviet Union but in Montreal, Canada.

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38. From an interview with M.V. Zalyetayev in 1968. It is interesting to note that the Center also represents an innovation in Soviet educational administration in that this control unit was created specially in response to modern technology and its impact on education. When the author visited the Center and interviewed Zalyetayev, the Soviet impressed the author with his broad perspective about modern technology and the problems involved in disseminating innovations.

Configurations in the Patterns

This historical overview has attempted to produce a rough map showing the approximate boundaries of the technology as well as important landmarks in its development. On the basis of these symbolic representations, one could make the following observations about the Soviet technological terrain:

(1) The lines of demarcation for "Soviet programmed instruction" were not smooth and even, but jagged and projected into other conceptual areas. Consequently, the Soviet conception of this technology included such diverse phenomena as: (a) the automation of certain teaching functions by programs and electronic devices; (b) the know-how used to design and develop the hardware, software, and the very processes in which they were applied; (c) a myriad of applications in classrooms; (d) and a series of historical events highlighted by dramatic turning points where the path of Soviet programmed instruction intersected with the cybernetic movement and other technological advances in the Soviet Union.

(2) In almost every phase of the educational technology starting with the leadership of Admiral Berg and ending with its application in the Kiev Higher Engineering Radio-Technical School, there was considerable evidence of strong support by the Soviet military establishment. It would be, however, an oversimplification to think of this technology as the product of "the conventional military mind."

(3) The participants in the movement to advance Soviet programmed instruction were not only classroom teachers and administrators, but included a wide range of professionals who apparently have considerable influence in military, scientific, and Party circles. From the rank and file, there emerged a group who attempted to elaborate the theoretical foundations for the technology. This elite included such Soviets as A.G. Molibog, a teacher and engineer; P. Ya. Gal'perin, a leading educational psychologist at the University of Moscow; V.M. Glushkov, a brilliant cybernetician and innovator; T.I. Rostunov, a general and head of the first Soviet computer-based instructional complex. These Soviets generally tended to conceive of teaching and learning from a cybernetic vantage point which stressed information and the automatic control of it. On the whole, their theories reflected rather sophisticated thinking. Apparently, ideology did not limit these Soviet theorists.

(4) The Soviet research and development for weapons systems and learning systems were conducted simultaneously in many instances during the sixties. For example, V.M. Glushkov and others in Kiev were involved with projects which would improve electronic devices designed for use in both the military and educational complexes. Thus it would be an unwarranted position to underestimate either the Soviet desire or capability to develop sophisticated teaching machines for their classrooms.

CHAPTER III

NEW FRONTIERS IN SOVIET RESEARCH AND DEVELOPMENT

> Technology means the systematic application of scientific or other organized knowledge to practical tasks.[1]

A Dangerous Distortion

The viewpoint, that modern technology is only hardware, fits comfortably within the pattern of conventional wisdom, but dangerously oversimplifies today's technological reality. Missing in the oversimplification is any mention of the scientific and technical know-how employed in designing the overall technological processes and the very machines regulating them. The significance of this knowledge is perhaps best brought into focus by Arthur C. Clarke, the British writer and scholar. As he tersely states it, ". . . brains are always more important than hardware."[2]

When Soviet programmed instruction is viewed from such a perspective as Clarke's, it leads to a few basic questions which should not be left unanswered: Who constituted the Soviet brain trust for this educational technology? What have they achieved in the sixties? Towards what goals will they probably move in the next decade?

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1. John Kenneth Galbraith, The New Industrial State, Boston: Houghton Mifflin Company, 1967, p. 12.

2. Arthur C. Clarke, The Promise of Space, New York, Evanston & London: Harper & Row, Publishers, Inc., 1968, p. 37.

Some Clues in the Soviet Mystery

In attempting to answer the preceding questions, it necessary to describe briefly what Levien and Maron have already discovered about the underlying Soviet technical and scientific know-how.[3] In this phase of their investigation, the two Rand researchers obtained their basic information from four papers written by V.M. Glushkov, L.N. Landa, Yu. Kushelev, and A.M. Doroskhevich in 1962 and 1963.[4] The data from these Russian documents indicated that the research and development of Soviet programmed instruction were closely related to advances in Soviet psychology, computer technology, pedagogy, and cybernetics.[5] Furthermore, Levien and Maron explained how theoretical developments in the four preceding areas could improve the Soviet prospects for creating a teaching device which would interact with students like a human teacher.[6] In short, Levien and Maron discovered the starting point for Soviet programmed instruction's research and development; described how both could be influenced by breakthroughs in related areas; and predicted important trends in Soviet research for teaching machines.

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3. Levien and Maron, op. cit., pp. 31-44.

4. Ibid., p. 31. Landa's paper was published in 1962 and the other in 1963.

5. Ibid., pp. 31-44.

6. Ibid., p. 32.

New Information about Soviet Activities

In contrast to the Rand Report about teaching machines, the focus in this chapter is on how the Soviets employed knowledge from computer technology, cybernetics, psychology, and pedagogy in the research and development of their programmed instruction and what they actually achieved in both phases. Also unlike Levien and Maron whose investigation of the technology's basic foundation was limited to only four initial papers, this investigator collected data from more recent Russian sources: (1) approximately fifty papers presented at the All-Union Conference in 1966, (2) recently published books about Soviet programmed instruction, psychology, cybernetics, pedagogy, and computer technology; (3) firsthand inspections of the Soviet hardware and software, (4) and discussions with their designers.[7]

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7. It should be noted that the Soviets define psychology as "one of the areas of science in which both types (natural science and socio-historical science) of scientific knowledge about man are united," pedagogy as "the science of education and moral upbringing," computer technology as "the systematic study of computers and their practical application," and cybernetics as "the science of control in living and non-living systems." Those readers, who wish to explore the definitions further, will find the following books very useful, particularly the cited chapters from which the preceding definitions were taken: History of Soviet Psychology (p. 348, Chapter VIII) by A.P. Petrovskii, New Research in the Pedagogical Science (p.3, Chapter I) by B.G. Anan'ev and others, Multi-Machine Complexes of Computational Devices (p.5, Chapters 1,2,3 & 4) by Yu. Golubev-Novozhilov, Cybernetics in the Service of Communism (p.314, Chapter 11) ed. by A.I. Berg.

This information is grouped under four headings and is presented as follows: (1) psychological, (2) pedagogical, (3) electronic (computer), (4) and cybernetic phases of programmed instruction's research and development. In turn, each of the four sections has an introduction with explanations of key Soviet terms and methods so that those readers who are not specialists in either Soviet pedagogy, psychology, computer technology, or cybernetics can better understand the specialized data from these areas. Thus, it should be kept in mind that even though the following four dimensions overlap in actuality, their arrangement in this study resulted from a consideration for readers who are probably examining for the first time such specialized data and do not have access to the original and still untranslated Russian sources.

The Disciples of Marx and Pavlov

> . . . the one branch in which they (the Soviets) have excelled has been in educational psychology, and it has been suggested by a leading American psychologist (Professor Gardner Murphy who visited the Soviet Union a few years ago) that we could learn from the Soviet investigations in the psychology of education.[8]

Introduction

As indicated earlier, three Soviet psychologists: P. Ya. Gal'perin, A.A. Reshetova, and N.P. Talyzina were very active in the Soviet programmed instruction movement during the past decade. In their experiments, they were particularly concerned with combining new Soviet psychological knowledge

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8. Maron and Levien, op. cit., p. 42.

with two important legacies from the past. This combination seemed like old vodka in a new bottle because Gal'perin, Reshetova, and Talyzina were integrating the physiological theories of Pavlov and the philosophical ideas of Marx into a new cybernetic conception of learning However, before entering into a discussion of their integrated viewpoint, it is necessary to explain briefly how the thoughts of both Pavlov and Marx have generally influenced the development of Soviet psychology and particularly shaped Gal'perin, Reshetova, and Talyzina's approach to programmed instruction.

Like American psychologists whose theoretical frame of reference rests upon certain basic assumptions about the nature of reality, the Soviets also have such a starting point in their approach to psychological issues and problems. But unlike their professional counterparts in the United States, Soviet psychologists derive their basic assumptions from the writings of Marx as interpreted by various Soviets in terms of existing problems and goals.[9] These Soviet premises have been derived primarily from the Marxian explanation of how the forces of production shape the ideas of man and his consciousness. Marx's viewpoint is summarized in the following quotation:

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9. It could be argued that relatively few American psychologists have been influenced by the writings of Marx. Erich Fromm's conception of alienation, for example, reflects many of the basic premises and ideas elaborated by Marx. Erich Fromm, Marx's Concept of Man, New York: Frederick Ungar Publishing Co., 11th printing, 1969.

> The production of ideas, of conceptions, of consciousness, is at first directly interwoven with the material activity and the material intercourse of men, the language of real life . . . . Men are the producers of their conceptions, ideas, etc. - real active men, as they are conditioned by the definitive development of their productive forces.[10]

In their elaboration of this materialistic outlook Soviet psychologists have focused on explaining the development of the "psyche" or the "mind" as it is usually called by American psychologists. By 1940, S.L. Rubinstein had advanced an explanation which became a theoretical foundation in contemporary Soviet psychology.[11] His conception of the psyche is as follows:

> . . . in Soviet psychology the understanding of the psyche is that it is a reflection of real life, but neither a passive nor a mirrored reflection, but it is a reflection of the process in which man actively influences natural and social phenomenon . . . the psyche and activity are one.[12]

Thus one should remember that Soviet psychologists do not dichotomize "mind" and "matter" in explaining psychic images and physical activities, but rely on a dialectical explanation in which both are united in dynamic interaction. Furthermore, it is apparent that the followers of Marx do

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10. K. Marx and F. Engels, ed. with an introduction by R. Pascal, German Ideology, (New York: International Publishers, Inc., 1939), p. 14.

11. From Foundations of General Psychology by S.L. Rubinstein, summarized by A.V. Petrovskii in Istoriya Sovetskol psikhologii, (History of Soviet Psychology), Moscow: 1967, p. 321.

12. Ibid., p. 321.

not view the psyche as resulting from any supernatural forces or even subconscious ones. In short, Soviet psychologists - including Gal'perin, Talyzina, and Reshetova - view the psyche as a physical phenomenon which can be studied empirically and explained precisely in scientific terms.[13]

In addition to resting upon an ideological base, the Soviet theoretical frame of reference for studying the psyche is undergirded by empirical data, amassed in the detailed research of Ivan P. Pavlov. To understand Pavlov's role in shaping modern Soviet psychological thought, one must first disregard some of the myths about him and then consider the historical facts of his life. At this point, therefore, it is necessary to trace briefly a few important aspects of Pavlov's research which have greatly influenced the views of Talyzina, Gal'perin, Reshetova, and other contemporary Soviet psychologists, but have been almost completely overlooked by most Western observers.

Ivan P. Pavlov (1849-1936) studied medicine in Russia and physiology in Germany.[14] After his intensive preparations, he became a professor of physiology at the Military Medical Academy and later the Director of the Academy of

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13. Even today in the Soviet Union, psychologists recognize Freud and his disciples as speculative thinkers whose thoughts remain empirically unconfirmed.

14. I.P. Pavlov, Izbrannye trudy (Selected Works), M. Usievich, editor, Moscow, 1954, pp. 6-25.

15. Ibid., pp. 6-25.

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Science's Physiological Laboratories.[15] As a result of his medical training and innovative techniques in physiological investigations, Pavlov was able to probe internally, explain initially the higher nervous activities, and pass on both his knowledge and concern for these subjects to Soviet psychologists.[16] Thus unlike most American psychologists who tend to study and then to explain learning with observations and descriptions of the learner's external behavior, Gal'perin, Reshetova, Talyzina, and the other disciples of Pavlov approach this process from a physiological standpoint which stresses the internal neural activities of the learner.

In 1904, Ivan P. Pavlov was awarded a Nobel Prize for his research in physiology, not psychology. This award was given to him for his pioneer study of the conditioned reflex in animals. But historical evidence indicates that Pavlov did not end his investigations with this study which apparently captured the attention of many American scholars. In fact, he refined and even modified his basic theories so that they could explain the higher nervous activity in man. These developments, which are frequently overlooked in the West but studied assiduously by Soviet psychologists, are reflected in the later writings of Pavlov. For example,

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16. Although Pavlov contributed much to the development of modern psychology, he considered himself a physiologist and Soviet scholars classify him as a physiologist. This viewpoint clashes with the popular American image of Pavlov as a psychologist. However, historical data support the Soviet viewpoint.

he explained one of the main subjects of his twenty-five years of scientific labor in the following moving manner:

> But what about man? Really are not all of his highest activities dependent on the normal structure and functions of the cerebral hemispheres? As soon as the complicated structure of his cerebral hemispheres is broken in any way or seriously disturbed, man becomes an invalid, he cannot freely and equally live among his family and ought to be isolated.[17]

His theories and investigations of the cerebral hemispheres and higher nervous activities led him to conclude that learning stems from a basic reflex. Pavlov called it the investigatory reflex and described it as the source of man's curiosity or orientation activities.[18] He added, however, that man has a second system of signals which is found only in his higher nervous activity and allows him to process data symbolically.[19] Pavlov's conclusion about the importance of language led him to reject the views of American behaviorists. For example, he criticized Edwin R. Guthrie for oversimplifying the learning process by explaining it as a form of conditioning:

> The psychologist (Guthrie) recognized conditioning as the principle of learning, and then assuming that the principle is fully developed and that it does not need further research, he attempts to conclude all from it and to bring all the separate traits of learning into the same process . . . . The physiologist (Pavlov) conducts himself in an entirely opposite manner.[20]

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17. Ibid., p. 365.

18. Ibid., p. 373.

19. Ibid., p. 412.

20. Ibid., p. 278.

This Pavlovian viewpoint is still shared by P. Ya. Gal'perin and other Soviet psychologists who frequently criticize American behaviorists for viewing learning as simply a stimulus-response reaction and the brain as a dark box with only mechanical activities inside it.[21]

Thus it should be kept in mind that Pavlov explained the psyche and its activities in terms of underlying neural activities and his modern disciples approach learning from a similar physiological standpoint. Furthermore, such students of Pavlov as Gal'perin, Reshetova, Talyzina, and other Soviet psychologists realize that the theory of the conditioned reflex does not explain higher forms of learning because between the external stimulus and response there is an extremely complex higher nervous activity. Moreover, these Soviets accept Pavlov's theory of a second system of signals and acknowledge the importance of the symbolic processes in controlling the behavior of man.

Moving from Something Old to Something New

Working within the framework of closely meshed Marxian and Pavlovian principles, P. Ya. Gal'perin, N.A. Reshetova, and N.F. Talyzina first devised an overall rationale for

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21. _____, Teoriya poetapnogo formirovanniya umstvennykh deistvii i upravlenie protessom ucheniya doklady nauchnoi konferentsii. (Theory of the Stages in the Formation of Mental Activity and the Control of the Learning Process - Reports of the Scientific Conference), Moscow: 1967, pp. 25 & 26.

programmed instruction, next organized its processes along the lines of a cybernetic system, then designed specific instructional procedures, and finally tested them in the classroom. It is necessary here to examine the essentials in all four phases of these Soviet activities.

In their theoretical elaborations, the three Soviet psychologists began by describing the basic aim for programmed instruction. Their main goal was to change the learner's psyche which according to their theoretical orientation, consisted of the following components:

> The psyche is not a simple picture of the world (system of images), but it is also activity, that is a system of actions, operations. But both have their source in the outside world.[22]

Thus, it might appear that Gal'perin, Reshetova, and Talyzina had impaled themselves on the horns of an irresovable dilemma in designing Soviet programmed instruction. They needed to discover a way of controlling the development of psychic images and activities in the learner.

By approaching this seemingly insolvable problem from a Marxian standpoint, however, the solution became relatively obvious for Gal'perin, Reshetova, and Talyzina. Their approach was an upshot of their Marxist interpretation of educational principles which stress the importance of the learner's material activities. Here is how they interpreted the problem of control and suggested means for achieving it.

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22. Ibid., p. 18. It should be noted that the parentheses were in the original text.

> The necessity of introducing the world of things in the process of instruction was known long ago in education. . . . But unfortunately, this principle, to this time, was not freed from the views which characterized pre-Marxian philosophy on which it was based and developed. The need . . . for a material (or materialized) form of activity raises the principle of introducing things in the process of instruction to the level of Marxist philosophy because it demonstrates the need for not only things (or their substitutes) but also MATERIAL ACTIVITIES DIRECTED TO THOSE ASPECTS WHICH DETERMINE THE REFLECTIONS IN THE PSYCHE.[23]

This statement, stripped of its Marxian commentary, means something more than a Soviet endorsement of introducing material objects in the learning processes. More important than their belief in an old learning principle which can be traced back to the times of Johann H. Pestalozzi, Gal'perin, Reshetova, and Talyzina see material activities as a means for controlling the psychic development of a learner.

Next, these Soviet learning theorists striving to refine the means of control, organized programmed instructions along the lines of a system. Their cybernetic construct had three basic components: (1) an object (the learner) being controlled, (2) an object (the teacher) controlling the process, (3) and the channel of communication between the two objects.[24] In addition to offering such a broad

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23. Ibid., pp. 17 & 18. It should be noted that this author capitalized the last two lines in order to point out for the reader the key phrase in the quote and that the parentheses were in the original statement.

24. Ibid., p. 8.

design, Gal'perin, Reshetova, and Talyzina filled in many of the missing details by explaining initially how these three parts functioned in the control system. The Soviets theorized that the channel of communication is the investigatory reflex of the learner.[25] Moreover, they applied other aspects of Pavlov's research in determining certain limitations and capabilities of the learner's two basic sensory organs - sight and hearing - which process important inputs in learning.[26]

The culmination of Gal'perin, Reshetova, and Talyzina's effort to combine something old with something new was a series of specific procedures for Soviet programmed instruction. Here is a brief summary of them:

First, the teacher should determine the objectives for the programmed instruction and outline the specific steps needed to attain them. This means that the teacher would decide, for example, which images are desired in the psyche of the learner and those material activities (operations or steps) required for the development of the psychic images.[27]

Second, the teacher should explain to the student both the ends and means of instruction.[28]

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25. Ibid., p. 8.

26. Ibid., p. 8.

27. Ibid., p. 20.

28. Ibid., p. 20.

Third, the teacher should ascertain what related knowledge or skills the learner already possesses. That is to say, the teacher should check his goals and methods of instruction against the student's knowledge and skills, in order to insure that the tasks are commensurate with the abilities of each student.[29]

Finally, the teacher should organize the input. For example, he would arrange the desired data from a textbook and present this information to the learner in such a manner so that it would elicit from him the proper response (material activity.)[30]

One should note that the Soviets view the input as consisting of the data to be learned or the task to be performed and the steps or operations required to achieve them.[31]

Gal'perin, Reshetova, and Talyzina, reporting on the application of their techniques, stated that they were tested in a limited number of classroom situations and produced positive results.[32] Like most sophisticated scientists studying human behavior, however, these Soviets admitted that their knowledge about the complex process of learning was still incomplete and consequently their procedures for

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29. Ibid., p. 23.

30. Ibid., p. 26.

31. Ibid., p. 26.

32. Ibid., p. 25.

fostering it were subject to further modification.[33] Thus, it should be noted that Gal'perin and the others were not offering a finished product which could be used in all phases of Soviet instruction, but rather an initial approach unifying old psychological theories with new cybernetic ones and leading to new ways of studying the learner's psyche.

In retrospect, one could very easily criticize these Soviet psychologists for displaying even in the design of programmed instruction their almost passionate loyalty to the philosophy of Marx and theories of Pavlov. Interesting as this type of critism could be, it would probably lead to a rehashing of old issues and most likely shed more heat than light on Soviet programmed instruction. Perhaps more germane for American educators and scholars is the Soviet combination of physiological and cybernetic knowledge which has permitted the Soviets to answer a few questions about learning and, more importantly, raise a series of new issues about controlling cybernetically the development of the

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33. Ibid., pp. 24, 25 & 26. It is noteworthy that Gal'perin was selected to present a report about the psychological development of programmed instruction at the All-Union Conference. It should also be mentioned that Yu. A. Samarin, a psychologist from the University of Leningrad, is regarded by the Soviets as one of their leading learning theorists. Samarin's views are very similar to those of Gal'perin and his Moscow co-workers. But the activities of Samarin have been focused on the development of a general theory of learning. For more details about his work, see Samarin's book entitled Ocherki psikhologii uma (Essays about the Psychology of the Mind), published in Moscow in 1962.

psyche. In summary, this is what seems most significant about the efforts of Gal'perin, Reshetova, and Talyzina, and offers certain clues about the general thrust of their activities in the future. If Gal'perin, Reshetova, Talyzina, or some other Soviet psychologist could explain more thoroughly and then control the development of psychic images and activities, this would be a breakthrough in learning theory which would dwarf the initial achievements of these Soviets in the sixties.

Research and Development in Pedagogy

> Pedagogy has never achieved any degree of scientific status either in this country (United States) or in the Soviet Union. There are no "laws" describing optimal ways of instruction.[34]

Soviet Aims and Achievements

Ever since the Revolution the Soviets have had an opportunity to study firsthand the lessons of economic development. Apparently, Lenin and his followers were apt students in this subject because they learned very quickly that science and technology are two key factors in the development of a modern economy and its rate of growth is determined mainly by the scientists and technicians trained in the schools. As a result, the leaders of the Soviet Union have historically expected much from educators in the training of specialists and traditionally set very high goals for that phase of the educational processes.

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34. Levien & Maron, *op. cit.*, p. 33.

In the first forty years of Communist leadership, these aims were achieved with amazing regularity, but, more recently in the sixties, the Party confronted Soviet educators with an extremely difficult task which still remains unfinished. Their problem is described concisely by a Soviet teacher in the following manner:

> The achievement of the Party's goals requires a level of manpower training which is consistent with the recent advances in science, technology, and the advanced experience of Communistic development.[35]

Meeting this Communist aim poses an unprecedented challenge for Soviet educators because it entails instructing an ever increasing number of students and modernizing their curriculums while scientific information is rapidly burgeoning and old knowledge is continually obsolescing. Since the response of teachers to such a challenge could greatly influence the course of Soviet economic development for the rest of the twentieth century, the Communist Party has urged that all technical resources be amply and deftly tapped in the training of specialists.

The pressures resulting from the Party's mandate for adjusting the educational system to recent Soviet scientific and technological advances was felt almost immediately by Soviet teachers in higher educational institutions and

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35. T. Samokhvalova, *op. cit.*, p. 41. It should be noted that the Russian term, *pedagogika*, is translated as pedagogy. Although pedagogika could be functionally translated as education, this English term was not selected in order to avoid a semantic or cultural misunderstanding.

secondary specialized schools. Everyday in their classrooms, these Soviets were confronted with two very concrete problems: (a) How could they apply new scientific and technical knowledge in the processes of instruction? (b) How could they train a new generation of Soviet specialists and simultaneously retrain the older ones so that both groups could master the new knowledge quickly and apply it creatively? As if both problems were not enough, they were further complicated by a seeming deluge of students who needed to learn at an accelerated rate the skills of a modern specialist.

Thus it would be an understatement to say that the often repeated side effects of the knowledge explosion became credible facts of life for Soviet teachers in higher and specialized secondary educational institutions. The impact of scientific discoveries and technological innovations were acutely felt by teachers of foreign languages, mathematics, science, and technical subjects which were the essentials in the curriculums of would-be specialists. Confronted with the stark realities of increased enrollments, obsolete subject matter, and assimilating new knowledge and skills into the processes of instruction, many Soviet educators turned to programmed instruction for aid.

Their problems and willingness to try the educational technology can perhaps be shown more concretely by describing a conversation between this investigator and a Soviet instructor whose students were using teaching machines.

This investigator asked him: "How do you theoretically justify the use of programmed instruction? In reply the Soviet teacher stated bluntly: "I don't have time for that type of activity. I only know that I have many students in my classes and little time in traditional instruction to help them individually, so that they can master what seems like a never ending stream of new information about the subject. These machines and programs, however, help me to organize the subject matter and free me so that I can give more personal attention to each one of my students."[36]

In sum, one should remember while reading the following data: First, the Communists have historically realized that the performance of teachers, especially in the training of manpower, has implications reaching far beyond the narrow confines of their classrooms and into the very core of the Soviet economy. Second, the Party expected Soviet educators in the last decade to provide the nation with skilled personnel whose competencies were commensurate with recent massive scientific and technological advances. Third, traditional methods of instruction, long established in higher and secondary specialized educational institutions, appeared to be deficient in meeting the challenges of the sixties. Fourth, many teachers at these levels turned to programmed instruction for aid in resolving problems

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36. This conversation occurred in the Winter of 1968 at the Moscow Energetics Institute where the author was studying the procedures and techniques of programmed instruction for the training of future Soviet specialists.

accentuated by the rapid growth of science and technology. Fifth, unlike the United States where programmed instruction was used at all levels from elementary to graduate schools, the Soviets mainly concentrated on developing and applying this technology for instruction in foreign languages, mathematics, science, and technical subjects at higher and secondary specialized educational institutions.

Soviet Stress on Software

The data, obtained from reviewing the literature of Soviet programmed instruction, examining its physical components, and interviewing their designers, indicated that the efforts of the involved Soviet pedagogues were focused mainly on developing programmed materials. What was particularly impressive about these activities were the overall patterns of development, techniques for programming, and their underlying rationales.

Surprisingly enough, a centralized agency did not prepare and distribute Soviet software, but the teachers themselves usually designed it for their own classrooms. In some instances, other teachers adopted or, better yet, "borrowed" a program written by someone else who incidentally did not receive any financial compensation for his creation. Such a decentralized operation seemed to be in sharp contrast with the traditional Soviet educational pattern of centralized control and also with the development of American programs which were generally designed by authors who worked for a relatively few publishing firms ever alert to reaping a profit from the educational market. After noting the lack of tightly controlled and highly organized effort, one should not assume that the Soviets developed their software in a completely topsy-turvy manner without any regulation. As a matter of fact, their development of programs was regulated very subtly by the techniques and basic premises of the teachers who wrote the materials. All of this can perhaps be shown more clearly by looking at the methods of Soviet designers and their bases for them.

As indicated earlier in Chapter II, the Soviets involved with the technology view instruction as essentially an information process in which knowledge is transmitted from the teacher to the student. This viewpoint gave impetus to one important approach in the design of Soviet programs which attempted to teach laws, theorems, concepts, and relationships. In preparing materials of that type, the teachers who designed them were particularly concerned with organizing and presenting subject matter in such a way that students could master the material quickly and thoroughly.

A review of printed Russian accounts about programming, observations at the Moscow School of Programmed Instruction, interviews with its Director and students, revealed that the Soviet programmers used very similar procedures in the preparation of their software. Of all these techniques, one set of them, described by A.G. Molibog, merits a closer look because Molibog's methods were based not only on his own experiences but also his study of

Soviet practices in general. In addition, his views about programming were published and offered as models for other Soviet teachers who prepared programs.[37]

According to Molibog, "the crucial element, determining how subject matter is programmed and learned, is the structural and logical scheme (SLS) for the course."[38] He defines SLS as "a schematic description of logically organized instructional techniques which bring about the transformation of information, revealed by the teacher or the text, into knowledge possessed by the student."[39] In short, Molibog has pointed out to teachers that their overall planning is the critical factor in the development of programs.

In addition to suggesting a starting point, Molibog has outlined for teachers a detailed structural and logical scheme which is summarized in the following paragraphs:

First, one should determine how the subject to be programmed is related to other courses in the curriculum.[40] This means that a teacher should know what new knowledge

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37. Although the Soviets published many pamphlets and articles about their programmed instruction, it should be noted that in the sixties they printed only two books about this subject: one by A.G. Molibog and the other by T.I. Rostunov. It should also be mentioned that the Soviets translated and published one American text about teaching machines. Its author was Lawrence E. Stolurow. See bibliography for additional details about Soviet publications.

38. Molibog, *op. cit.*, p. 46.

39. *Ibid.*, p. 46.

40. *Ibid.*, p. 46.

must be acquired for future studies and what old information from previous courses must be synthesized with the new subject matter.

Second, the desired outcomes for instruction should be stated clearly.[41] For example, the teacher would develop objectives which describe precisely the concepts, principles, or skills to be mastered by the student.

Third, one should break down the subject matter into its basic elements of information.[42] In performing this task, the teacher would systematically divide the content for the course into major sections, basic themes, and key paragraphs. Then he would analyze them for logical and sequential relationships.

Fourth, the teacher should decide beforehand which methods of instruction, materials, and tests are to be used.[43] That is to say, the teacher ought to list how he would present each lesson, what equipment would be needed for each presentation, and how he would obtain feedback or test the students.

It should be obvious that Molibog's structural and logical scheme is really a strategy for instruction that determines how the processes of both teaching and learning are structured and organized. In some respects, his approach

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41. Ibid., p. 46.

42. Ibid., p. 46.

43. Ibid., p. 46.

is neither new nor very different, but it is very similar to what classroom teachers in the past would call a "good plan." But in one respect, Molibog's structural and logical scheme is different from past methods in that it requires detailed planning. Thus, not unlike most of the designers of Soviet software, Molibog starts with the premise that the acquisition of subject matter is the main aim of instruction, and he finishes with techniques designed to structure more rationally its processes.

But devising procedures for planning and breaking down subject matter into its logical and structural elements were only two of the important contributions made by Soviet teachers. By 1968, they had five basic options for presenting information. They were as follows:[44]

(a) a linear program characterized by information which is presented in an unchangeable sequence.

(b) a branched program designed to modify the continuity of instruction on the basis of the student's last response.

(c) an adaptive program arranged to modify the doses of instruction in terms of the student's cumulative responses.

(d) a mixed program characterized by various combinations of (a), (b) or (c).

(e) a heuristic program designed for the student to begin with a problem situation and to discover his own step by step solution for the problem.

The two distinctive characteristics of the first four programs are that they guarantee solutions for their problems and require a very logical sequence of procedures.

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44. Rostunov, *op. cit.*, p. 14.

These are: (1) a series of learning situations (statements, questions, or problems) which will elicit from the learner a specific response; (2) his answers; (3) and an evaluation of them. Even though this basic design seems very logical, it reduces learning to a system of rigid locksteps not unlike much of traditional instruction and likewise stresses the mastery of subject matter. Looking beyond today and into the future, one needs only a small amount of foresight to realize that software creating such conditions has limited prospects.

While the linear, branched, adaptive, and mixed programs are severely handicapped by their algorithmic patterns, the heuristic program has an important trait that distinguishes it from the others. This type of format does not guarantee a solution, but allows the student to discover the answers for himself and frees him from the monotonous step by step learning required by the other four. One should note that the underlying premise for the heuristic program is not mastery of subject matter, but discovery by the student. In other words, the learner is allowed to generate and discover principles, concepts, and relationships for himself. This liberates him from the rote learning of subject matter which will more than likely be obsolete tomorrow and stresses practice in thinking which will probably be more useful in the future.

On the other hand, some very far reaching implications stem from a premise that learning is a process of discovery.

If the Soviets could successfully adapt the heuristic approach to computerized programmed instruction, this would also permit them to utilize more completely their sophisticated electronic devices whose potential for instruction is barely exploited by such programs as the branched and linear ones. At the same time, this new combination could possibly make obsolete the earlier types of programmed instruction and also traditional learning procedures, both of which are geared to the mastery of content. Thus, it is not a small wonder that the Soviets have tried to refine the heuristic program.

However, it was very difficult to ascertain exactly what progress the Soviets had made in designing this software. In a publication distributed only in the Soviet Union, a teacher from Alma-Alta discussed the theoretical development of heuristic programs.[45] His basic conception, which was also presented at the All-Union Conference and apparently accepted by the participants, is as follows:

> A heuristic approach is different from the algorithmic approach because a heuristic approach is able to pose a problem before the learner and it allows him to find the solution for the problem by the shortest possible way or not discover any solution. The solution of the problem in the shortest possible way or the failure to solve the problem depends on how well the teacher is able to anticipate the learner's problem solving behavior.[46]

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45. M.M. Mukanov, Psikhologo-pedagogicheskie aspekty programmirovannogo obucheniya (Psychological-Pedagogical Aspects of Programmed Instruction), Alma-Alta: 1966.

46. Ibid., p. 13.

As for other printed sources about more practical developments, this investigator discovered none. Nevertheless, other data indicated that the Soviets had applied their theory about the heuristic approach into practice with some success. This information resulted from a rather unusual group discussion at the Moscow Energetics Institute and brought into sharper focus the concerns of the Soviets. For this reason, it may be useful to summarize here the conversation between this investigator and Soviets from the Russian Academy of Pedagogical Sciences, Moscow Energetics Institute, and H.N. Bauman Institute.

After viewing some slides about the application of computers in American programmed instruction, the Soviet viewers who were involved with similar activities were particularly interested in the level of sophistication achieved in the American design of heuristic programs. This type of software, according to these Soviets, has tremendous possibilities for computerized programmed instruction and seems destined to play an important role in both the American and Soviet schools. In addition, even though most of the Soviets were engineers, they agreed that the critical question facing them was the design of quality software not hardware. Finally, they were in agreement that the writing of heuristic programs was a very difficult task and much more troublesome than designing linear or branched materials.[47]

In summary, Soviet pedagogical activities related to programmed instruction were concentrated mainly on developing programs. Notably, two types of software emerged at different times. At first, Soviet teachers attempted to design programmed materials which were aimed at fostering the mastery of subject matter. Towards the end of the decade, however, another trend began to appear. These programmed materials were based on a heuristic approach which was aimed at allowing the student to discover his own solutions to problems. In some respects, the heuristic program is like a sword of Damocles that hangs over the heads of those educators who are concerned primarily with teaching content in an era when scientific and technical information is rapidly expanding and ever changing. Whether this new software can cut cleanly the Gordian knot of tradition and permit the Soviets to utilize more efficiently their electronic devices in instruction depends mainly upon the Soviet ability to develop and refine the heuristic program. The response of Soviet teachers to such a challenge could very well determine the tempo of automation in their classrooms and subsequently the quality of manpower training for the rest of the century.

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47. Originally, this meeting was intended to be something like a final examination for the author. However, it was decided by Professor Lebedev that it would be more useful for the author to give a presentation about American programmed instruction. Since this information was of widespread interest, faculty members from other institutions and representatives of the Academy of Pedagogical Sciences were invited by Lebedev to attend and question the author.

Research and Development in Computer Technology

> Much of the Soviet planning for the growth and development of their society, economic as well as military, hinges on computer technology and its applications (of which teaching machines are one example) . . . it seems safe to guess that as far as teaching machine hardware is concerned we are ahead of the Soviets . . . However, we must be the first to question the value of these types of comparisons even assuming that they are completely accurate.[48]

Somewhat Startling Soviet Views

In the United States, there has been considerable discussion in educational journals and the popular press about the use of computers in classrooms. Although much of the American information has been very useful for educators, some of it has been marred by misconceptions or marked by an absence of technical insight and accompanied by considerable emotionalism. In addition, little data have been presented about similar activites in other countries and particularly the Soviet Union. For these reasons, it seems appropriate to begin by reviewing a few salient technical features of the computer and by stating authoritative Soviet views about their educational aims for this device.

The basic components of the digital computers applied in Soviet programmed instruction are the following:

(1) an input device (one or more) where the information is entered into the computer,

(2) an output device (one or more) where the processed information is produced,

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48. Levien and Maron, *op. cit.*, p. 42.

(3) a memory where both the program and data are stored,

(4) a control mechanism which controls the operations in the computer by following the coded instructions in the memory,

(5) an arithmetic and logic unit which performs the operations of adding, subtracting, multiplying, dividing, and logic.

The sum of all these components and their functions is an elaborate high speed information processing system for both numerical and non-numerical data. This is the type of digital computer used by the Soviets in their programmed instruction and such a tool is probably their most important one in an age of information.

Even though a Soviet technical way of viewing the digital computer might clash with some popular American conceptions of it, this perspective offers perhaps the best vantage point for looking at Soviet devices. According to four leading Soviet scholars, the computer can process information without the participation of men and can perform automatically "the most complicated operations and simulate very delicate aspects of man's intellectual activity."[49] This type of automata, for example, can play chess, translate from one language into another and even find proofs for

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49. A.A. Feldbaum, A.D. Dudykin, A.P. Manovtsev, and N.N. Mirolyubov, teoreticheskie osnovy svyazi i upravleniya (Theoretical Bases of Communication and Control), Moscow, 1963. As translated in Russian-English Dictionary and Reader in the Cybernetical Sciences by Samuel Kotz, New York and London, Academic Press:, 1966, p. 162.

theorems in geometry.[50] The performance of such complex operations represents neither the threat nor the promise of the computer, but the reality of it. This should suggest some reasons why the Soviets are attempting to use the device in their classrooms.

In a very real sense, the Soviet school has become a new frontier for computer technicians and their electronic devices. These Soviets, according to Admiral Berg, are developing in their applications of computerized programmed instruction the sophisticated cybernetic system which will be used in the Soviet schools of the future. The general features of this system are described by Admiral Berg as follows:

> At this time, it is still too early to talk about which technical device will be used widely (in the Soviet schools). Without a doubt, however, the future belongs to a complex cybernetic system of the adaptive type built on the base of an electronic digital computer.[51]

Realizing that the development of a cybernetic system for learning is an enormous task and involves high stakes in terms of economic growth, the Soviets have been quietly and carefully experimenting with the digital computer in their programmed instruction at a number of key military and civilian educational institutions. These activities seemed to center in the following cities: Moscow, Kiev, and Novosibirsk.

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50. Ibid., p. 162.

51. Molibog, op. cit., p. 5.

Thus the Soviets in the sixties were not sitting back and waiting for the eventual onslaught of information in the seventies, but were consciously preparing for it in their applications of computerized programmed instruction. In their preparations, scientists, technicians, and educators were attempting to design the cybernetical system for the Soviet schools of the future. By the middle of the last decade, these Soviets were convinced that this learning system would be based on a digital computer. All of these developments raise a series of important questions: What types of computers did the Soviets apply in their experiments? What procedures were employed in their applications of computerized programmed instruction? What did the Soviets learn from these experiences? What remains to be done by the Soviets in designing their electronic classrooms?

Applied Rationality in an Electronic Age

Four digital computers: Ural-I, Nairi, Dnepr, and Minsk-I, were used during the initial stages of Soviet programmed instruction.[52] Although each device had its own specific capabilities, such as speed of computation and volume of information storage, all of them were relatively sophisticated computers in their day. However, they were not the best Soviet devices, but were probably used in

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52. _____, *Nekotorye voprosy izpol'zovaniya EVM kak osnovy dlya postryeniya obuchayuschikh kompleksov* (Some Problems in the Use of Electronic Digital Computers as a Base for the instruction of Instructional Complexes), Moscow, 1966, p. 11.

their experiments because they were more readily available. It is ironic that today all four of the computers are already technically obsolete.

The important characteristics of the four electronic devices, applied in Soviet programmed instruction, are summarized in the following table:

Table 1: Summary of the Traits of the Soviet Computers[53]

Type of Digital Computer	Speed of Operation per Second	Volume in Memory Cells	Digit Places
Ural I	120	2,048	18
Nairi	2,000	1,024	36
Dnepr	10,000	2,048	26
Minsk I	limited	limited	data not available

To put it mildly, the digital computers, listed in Table 1, only faintly resemble what Admiral Berg envisaged in his complex cybernetical system of the future. The digital computers for the Soviet schools of the 1970's must be much more sophisticated. However, it would be a very myopic view to focus only on the shortcomings of the Soviets in their applications of this technology. What is even more significant about their experiments is that they are providing some very valuable insights about the designs of both the machines and classrooms of the future. Perhaps what the Soviets have

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53. Ibid., p. 11.

learned in the 1960's can be explained more concretely by examining one of their initial applications of the computer.

In the following case study, there are some very concrete examples of the required techniques needed for this technological approach to learning. Nevertheless, it might be more interesting to note how the computer with its concomitant procedures shaped the very processes of instruction even in this initial experiment at the Novosibirsk Electronic Institute.[54]

But before examining these data, it is necessary to explain briefly what is meant by "concomitant procedures." The term in the context of men and machines simply means that the use of any machine requires the user to perform certain operations or follow a specific course of action. This can be illustrated quite simply by what happens in driving an automobile (a machine). If the driver wants it to perform, he must sit behind the wheel, steer it, and step on the accelerator. It should be fairly evident that the use of the digital computer also requires Soviet teachers and other personnel to master certain very important concomitant procedures and every application provides these Soviets with an opportunity to improve their skills.

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54. _____, Programmirovannoe obuchenie s primyenennyem EVM (Programmed Instruction with the Application of an Electronic Digital Computer), Novosibirsk, 1966. This is a case study taken from the above Russian source. Those readers, who desire more detailed information, should read pp. 1-35 in the report.

At the outset of the experiment, the Soviet innovators assumed that the computer could be used to perform three functions in a classroom: consulting, evaluating, and teaching. In addition, they theorized that the last one included in it the other two. According to their views, the most difficult task was the simulation of teaching and they confidently decided to use the computer for performing this more complex function.[55]

One member of the group, a classroom teacher of mathematics, prepared the subject matter for the electronic "instructor." His preparation required the aid of students who replied to questions in a mathematical examination. Relying on his past experiences in the classroom and the responses of students to the test, the teacher of mathematics constructed four standard answers. They represented the basic replies and were evaluated as follows: EXCELLENT, GOOD, PASSING and FAILING.[56] Then he developed variations for them by either changing or rearranging their wording. All of them were entered into the memory of the computer.

In addition, the mathematics teacher developed the teaching program. Then staff members at the Computer Center for the Institute translated his program into the required machine language and entered it into the computer.

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55. Ibid., pp. 2,3, & 4.

56. Ibid., pp. 3,4 & 5. Although Soviet teachers have a five point grade scale, they seldom use 1. This is the reason why the Soviets only prepared four standard answers.

Thus this phase of the application required thorough planning in which the teacher and specialists worked closely together in preparing the program for the digital computer. Indeed, there was a real difference between the nature of this planning and that in other more traditional types. It demanded the skillful blending of the teacher's knowledge with that of the specialist in computer technology.

The major consequence in the classroom, stemming from the joint efforts of the educator and the technician, was a structured learning situation in which a machine instructed simultaneously and individually a large number of Soviet students. Here is an example of the electronic teaching and the responses of learners to it:[57]

First Student

QUESTION: What is the curvature of a curve at a point?

STUDENT RESPONSE: The curvature of a curve at a point is the change in the true rate of the inclination of the curve at a given point.

COMPUTER RESPONSE: I rate (you) EXCELLENT.

Second Student

QUESTION: What is the curvature of a curve at a point?

STUDENT RESPONSE: The curvature of a curve is the rate of change in the angle's inclination in relation to the axis X drawn to this curve.

COMPUTER RESPONSE: I rate (you) EXCELLENT.

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57. Ibid., pp. 33 & 34. Excerpted from the original Soviet report.

Third Student

QUESTION: What is the curvature of a curved line at a point?

STUDENT RESPONSE: The curvature of a given curve is the rate of inclination at the point of the curve's inclination in relation to the curve with the significant change of value in proof X.

COMPUTER RESPONSE: I rate (you) SATISFACTORY, for your weak mastery of the given theme, the answer ought to be . . . the curvature of a curve at a point is the real rate of change in the curve's inclination at a given point.

Fourth Student

QUESTION: What is the curvature of a curve at a point?

STUDENT RESPONSE: The curvature is the rate of change of the angle of inclination in relation to a given curve drawn through a given point with the axis X at uniform displacement.

COMPUTER RESPONSE: I rate (you) UNSATISFACTORY. Repeat it once again.

Fifth Student

QUESTION: What is the curvature of a curve at a point?

STUDENT RESPONSE: The curvature of a curve at a given point is the angle of inclination touching the curved line drawn at a given point.

COMPUTER RESPONSE: I rate (you) UNSATISFACTORY. Repeat it once again.

One could raise many objections about this programmed learning. However, it should be remembered that the classroom conditions resulted from an initial Soviet effort to use the computer and that they represented only the first steps toward a dialogue between men and machines in their schools.

There is some irony in how the Soviets by-passed a multiple choice response and allowed the student to construct his own answer in the experiment. In addition, it should be noted that the self-originated response results from a simplified heuristic approach in designing the program, as it allows for a multiplicity of responses including even incorrect ones. This achievement made all of the smaller teaching machines with their multiple choice answers technically obsolete.

The digital computer, Minsk-I, was used to perform the function of teaching in the electronic classroom. Something similar to the teletype computer terminal, the STA-2M, served as the input/output device for the students. Each one worked at his STA-2M terminal where he entered his answer into the computer by typing on the input device and also received the response from his electronic teacher.

The Soviets apparently learned much from the use of the Minsk-I and the STA-2M. Significantly enough, they concluded that the basic arrangement of men and machines in the classroom allowed the computer to instruct simultaneously and individually a large number of students. On the other hand, in this trial situation the planners became aware of major deficiencies in the system. For example, it was obvious to them that the Minsk-I had a very limited memory capacity and the input/output mechanisms were inadequate. Thus, from this application and others like it, the Soviets have received very valuable feedback about the design of equipment and its arrangement in classrooms.

One should not be surprised to discover from what has already been outlined and illustrated concretely that the use of computers in classrooms requires considerable skill. This "knowledge" hinges on the mastery of detailed planning, specialization of tasks, design of sophisticated electronic devices for classrooms, development of programs, and overall coordinating activities. Since the Soviets have already demonstrated an amazing mastery of these techniques in their use of electronic devices for weapons systems and space exploration, it would seem very illogical to minimize their abilities to learn how to use computers in their classrooms. To put it bluntly, it would only be an illusion to think that the Soviets are <u>not</u> acquiring the necessary techniques for using electronic devices in classrooms from their experiences with programmed instruction. It might even be argued that Americans who are involved with the use of the computer in instruction could learn something from studying the Soviet efforts in their electronic classrooms.

There is another important perspective which can be gained from this description about Soviet computers and its procedures. Both are essentially mandates for change in Soviet classrooms. As very clearly indicated in the example, using the electronic device requires such accompanying changes in the pattern of instruction as the modification of teacher and student behavior, the introduction of specialists and machines into the very processes of learning. These are only a few of the more obvious results of man and machine's interaction, but they are enough to challenge the assumption that learning and teaching will be as usual in the Soviet electronic classrooms. Comprehending the facts of full-scale changes in the Soviet schools and simultaneously preparing for them are perhaps two of the most difficult tasks confronting these Soviet pioneers on the frontiers of the age of information.

"Cybernetics in the Service of Communism"

> And as far as the theoretical aspects of cybernetics are concerned, it is especially difficult to make relative comparisons. We (Levien and Maron of the Rand Corporation) know that they read our literature and are keenly aware of our published research. We know that cybernetic research is very important and active in the Soviet Union, . . . has attracted some of their most outstanding logicians, mathematicians, and engineers.[58]

Engineering Progress in the USSR

It is very difficult to determine exactly when and where cybernetics had its inception in the Soviet Union. The Communist leaders, according to Russian reports, became interested in the science as a result of two related

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58. Levien and Maron, *op. cit.*, pp. 42 & 43. Information in parentheses was added by this author.

events:[59] First, a few Soviets conducted some cybernetic research in the mid-fifties and later in 1958. Second, the Soviets translated into Russian and published in 1958 an American book, Cybernetics: or Control and Communication in the Animal and Machine, written by Norbert Wiener in 1948. Keeping with the official Soviet explanation, these activities stimulated initially the development of cybernetics in the Soviet Union. However, the account omits a few pages of Soviet history that contain a stupid ideological mistake, a bitter struggle for scientific truth, and a sudden reversal of policy.

During the ten year interval between the American publication and the Soviet translation of Wiener's book, two groups in the Soviet Union debated doggedly the legitimacy of cybernetics as a science and the final outcome of their heated discussions dramatically changed the direction of Soviet science and technology. On one side, there was a core of dogmatic Communists who dismissed Wiener's views as reactionary, and short-sighted academicians who failed to see the implications of his ideas. Their opponents were mainly Soviet scientists and technicians who understood what Wiener had written. After much discussion and persuasion, the ideologists and their academic allies shifted their positions and accepted cybernetics as a science. In retrospect, many Soviet intellectuals probably risked their

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59. A.I. Berg, (ed), Kibernetiku na sluzhbu kommuniza (Sbornik statei) (Cybernetics in the Service of Communism - Collection of Articles), Moscow: 1967, p. 314.

academic careers in the struggle to publish Wiener's text in Russian, while ironically many of his own countrymen neglected to read his book and failed to discuss it in their classrooms during the fifties.

But what is even more ironic and important about the development of cybernetics in the Soviet Union is how the Communist leaders quickly developed and broadly applied the views of this American scientist. By 1959, the Party had begun to organize a cybernetic program which signalled the start of a nation wide effort to automate the following dimensions of Soviet reality: industry, transportation, medical diagnosis, power systems, economics, law, and education.[60] According to a leading United States government expert on cybernetics, these activities are probably the most important ones happening in the Soviet Union today.[61] The Soviet cybernetic movement, reported the American, "encompasses the totality of efforts devoted to the engineering of social progress or development."[62]

The starting point for the bold and imaginative Soviet plan to engineer growth is the basic Soviet concept of cybernetics. This driving force behind the automation of Soviet reality can perhaps best be explained by examining two

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60. John Ford, "Soviet Cybernetics and International Development," The Social Impact of Cybernetics, ed. Charles R. Dechert, Notre Dame & London: Notre Dame Press, 1966, pp. 162 & 163.

61. Ibid., p. 162.

62. Ibid., p. 163.

authoritative Soviet elaborations of the underlying thought. _In Cybernetics in the Service of Communism_, one of the most recent Russian books on this subject, a group of Soviet scholars describe cybernetics as "the science of control in living and non-living systems."[63] On the other hand, A.N. Kolomogorov, a pioneer in Soviet cybernetics and one of the world's greatest mathematicians, views this science as the "study of systems of all types, of the capabilities to receive, store, and process information, and to use it for control and regulation."[64] One should note that both Soviet viewpoints include all kinds of systems and stress either explicitly or implicitly the flow of information in them. Even though the movement of data was not openly stated in the first example, it was implied in "control." This meaning will become more evident later in a diagram of a control

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63. Berg, _op. cit._, p. 314.

64. A.V. Solodov, _Tyeoriya informatsii i yeye prinyenyeniye k zadacham avtomatichyeskogo upravleniya i kontrolya_ (The Theory of Information and Its Application to Problems of Automatic Control and Regulation), Leningrad: Nauka, 1967, p. 9.

system.[65]

As with most revolutionary ideas, the cybernetic outlook, that all of reality can be viewed as systems subject to scientific study and explanation, seems so obvious and simple in retrospect. Nevertheless, key Soviets initially blocked the development of the science in the Soviet Union. But later they realized their error and applied cybernetics in a nationwide effort to automate on a scale hitherto unimagined in the Soviet Union. Their scheme included the automation of Soviet education. In addition, one needs to recall a few earlier stated facts while reading the following cybernetic data. The development and use of both Soviet programmed instruction and cybernetics are closely related

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65 Perhaps it troubles some readers that the two Soviet definitions are not exactly alike in their wording, even though they are in general agreement. Both conceptions suggest that cybernetics includes all systems and the flow of information in these systems. One needs to remember that not all educators agree as to the meaning of "education," just as all mathematicians do not agree about the meaning of "mathematics." This does not imply that the various definitions of mathematics and education are unscholarly, but it implies that these terms are important enough to generate among scholars disagreement and discussion which are probably two necessary conditions for scholarship. Even though the two Soviet definitions are not exactly alike, it would be very illogical to dismiss them as unscholarly because the first one was developed by a group of leading Soviet scholars and the second one was developed by A.N. Kolmogorov who is recognized internationally for his contributions to cybernetics. Unfortunately, it is beyond the scope of this study to list the slightest variations in the meaning of Soviet cybernetics. Those readers who wish to pursue these variations should read the special references cited in Cybernetics in the Service of Communism.

because Admiral Berg, General Rostunov, Academician Glushkov, and a wide range of other influential Soviets are leaders in both movements. Yet, all of them are united behind the same goal - to automate various crucial components in the Soviet system including education. Summing it up cybernetically, Soviet programmed instruction is their control switch for turning on electronically the Soviet schools.

The Diagnosis & Prescription

In the last decade, the "Soviet engineers of progress" began their educational task by asking this type of question: "What are the inadequacies of traditional instruction that programmed instruction is trying to remove?"[66] From their cybernetic standpoint, there were many obvious shortcomings. L.N. Landa, for example, points out exactly what was cybernetically wrong with traditional Soviet instruction in the sixties:

> The teacher does not know how the communicated information is processed in the psyche of the student and whether the desired (psychic) activities are happening during (this) process. The teacher cannot regulate his activities . . . with the actual rate of the student's (learning) progress because the teacher does not know about the psychic activities of the student.[67]

According to Landa, this leads to a situation where "the teacher blindly controls the learning conditions and his instruction is ineffective."[68] Clearly, Landa and the

66. Ibid., p. 335.

67. Ibid., p. 335.

68. Ibid., p. 335.

other Soviets who view the classroom from a cybernetic vantage point were dissatisfied with the lack of control and the concomitant absence of feedback in the classroom.

At this point, it might not be completely clear just what the cyberneticians mean by "control." Nevertheless, it should be obvious that their meaning for the term has little in common with the everyday American usage of it.[69] The distinction can perhaps be made clearer by describing what the Soviets are attempting to regulate in their programmed instruction. They think of it as a means for controlling the psychic processes of learners. Perhaps all of this can best be summed up by citing a Soviet statement of their cybernetic aim for programmed instruction:

> The application of cybernetics in the area of educational phenomena is based on this: according to its essentials, instruction represents a definite type of control, namely the control of the formation and development of the psychic processes.[70]

The Soviet attempts to apply the science in order to control the psychic processes of students might seem to be a rather startling goal for the technology. However, one should not forget that in terms of Soviet psycho-physiological theories the psyche of the learner is the primary target of any type of instruction.

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69. One needs to observe that generally there are differences between the technical and non-technical meaning of a word. In the case of control, the Soviets are using it in a very specialized way. Consider, for example, the two different meanings for "pressing a suit." In one context, it means ironing a man's costume but in another it means the process of starting a legal action against someone.

70. Berg., *op. cit.*, p. 334.

Considering the rather dismal technical view of traditional instruction and the high aims for programmed learning, it would seem that the Soviet cybernetic designers are faced with an almost impossible task. They must improve the control in the processes of instruction. Moreover, they must obtain feedback about learning so that a classroom teacher can regulate his activities with those in the psyche of his students. So stated, is it possible to design Soviet programmed instruction so that it will achieve these ends? The answer of Soviet communications engineers is an astounding "yes." According to them, however, the technology must be based on a different conception of Soviet instruction.[71]

In their new model, there are at least two discrete units: (1) the object of control (or the learner), (2) and the control object (also called the control system or the teacher). Both of them are involved in a process of transmitting and receiving messages from each other. These messages consist of two types: (1) the control response (manipulated variable), (2) and feedback.[72]

This Soviet cybernetic construct is illustrated in Figure 2:[73]

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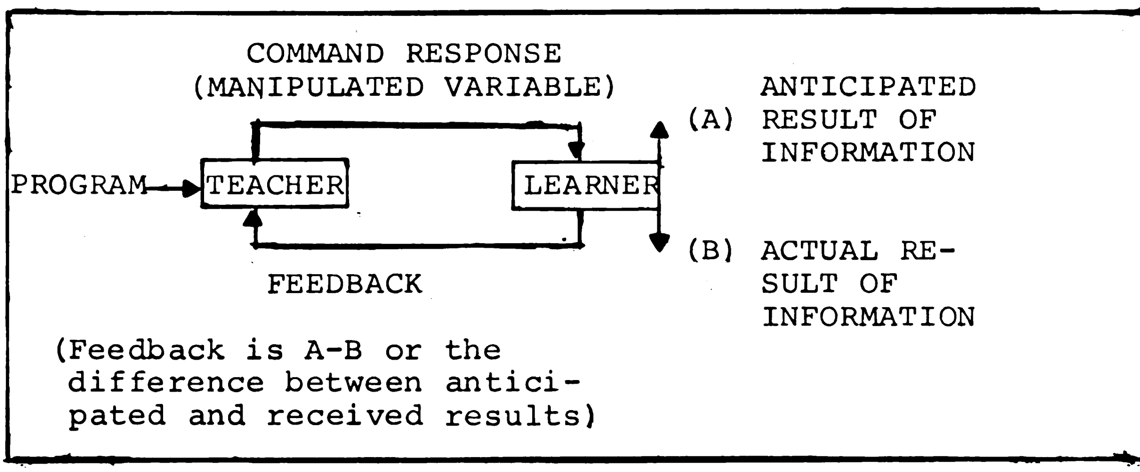
71. G.N. Aleksandrov, Nektorye ponyatiya kibernetiki i programmirovannoe obuchenie (Some Concepts of Cybernetics and Programmed Instruction), Kuibyshev, 1966. p. 2.

72. Ibid., p. 3.

73. Ibid., p. 3. The next pictured model is a control system. Those readers who desire more detailed information about how this analogy is used in other areas should read Cybernetics in the Service of Communism.

Figure 2: A Cybernetic Model for Instruction



Thus in this type of learning situation the conditions of information could be modified in both the instructor and the student. More importantly, it is theoretically possible for the teacher to modify his behavior in response to the psychic activities of the learner. Furthermore, if the behavior of the teacher is described accurately enough, it is conceivable that his functions of information could be performed by such a machine as the digital computer.

Perhaps the electronic performance of teaching operations might still seem like an impossible task, but as the data about computer technology already indicated, Soviet computers have already performed with some sophistication certain functions of a teacher. In one respect, these electronic devices are even more useful in certain types of research than the classroom teacher because computers can keep a detailed record while they are instructing students. This tool permits the cybernetician to collect massive amounts of data about such questions as the following:

(1) How much information should a teacher include in his message?

(2) How often does the teacher need to repeat key words and concepts?

(3) What are the memory capacities of each student?

(4) Which sensory organ (eyes or ears) are best suited for various types of instruction?

(5) Which pictures, printed symbols, sounds or combinations of these are the most effective in developing a psychic activity such as generalization?

(6) How should the teacher modify his responses to those of the student?

If the Soviet communication engineers could help teachers to find answers for these questions and others like them, their information could conceivably lead to the optimization of instruction. Of course, it should be added that these queries, stated by the author, are rather imprecise and Soviet engineers have already asked more precise ones. However, the main point is that the designers of Soviet programmed instruction are consciously aware of these possibilities and are systematically trying to optimize Soviet instruction by exploring them.

Thus Soviet cyberneticians have contributed a theoretical approach which leads to the automatic control of information in the processes of instruction. This conception has permitted these "engineers of progress" to raise a series of questions about how the input of information regulates the psychic processes of the learner. In addition, the introduction of the computer into the classroom has permitted the Soviets to collect for the first time detailed data concerning such questions. The combination of their control theory and computers for testing various aspects of it has moved the Soviets a few steps closer to their ultimate goal of automation in education.

Perhaps one could best summarize how key cybernetic principles were applied in the technology by borrowing from the cybernetician one of his basic techniques - the use of models to explain complex situations. The following analogy about Soviet programmed instruction seems appropriate in summarizing the past cybernetic trends and suggesting future ones for Soviet programmed instruction.

The Soviet Staff at the Cybernetic Hospital diagnosed the ailments of a very famous Soviet patient - Traditional Instructionov. According to their examination, they concluded that Comrade T. Instructionov was seriously ill and needed a series of transplants which would replace his vital organs. Subsequently, the surgeons at the Soviet hospital performed a series of operations - applications of the technology. Today, the patient is still alive and appears to be recovering slowly. Nevertheless, the Chief Surgeon, A.I. Berg,is very optimistic and predicts that the patient is on his way to complete recovery - automation in the classroom.

Summary

An initial image of Soviet programmed instruction's research and development has been projected on the preceding pages. This picture was a composite which consisted of the following parts:

Psychology: Working within the theoretical framework of closely meshed Marxian and Pavlovian principles, three Soviet psychologists: P. Ya. Gal'perin, N.A. Reshetova, and N.F. Talyzina devised an overall rationale for programmed instruction, organized its processes along the lines of a cybernetic system, designed specific instructional procedures, and tested them in the classroom. Their efforts supplied the Soviets with certain clues about the development of the learner's psyche and raised a host of new questions about controlling it.

Pedagogy: Soviet teachers involved with programmed instruction concentrated their efforts on designing and testing software. Surprisingly enough, a centralized agency did not prepare the Soviet programs. This trend seemed to be in sharp contrast with the traditional Soviet patterns of centralized administration and also with the American pattern of preparation by publishing firms. At first, the Soviets developed programmed materials designed to foster the mastery of subject matter. But towards the end of the decade, the Soviet designers were attempting to create heuristic programs aimed at allowing the student to discover his own solutions to problems. These materials offered the Soviets new possibilities to utilize more efficiently their sophisticated electronic devices.

Computer Technology: In a very real sense, the Soviet school has become a new frontier for computer technicians and their machines. These Soviets are developing in the applications of computerized programmed instruction the sophisticated cybernetic system which will be used in the Soviet schools of the future. While the Soviets have been relatively successful in these efforts, the design of their hardware still falls short of the mark envisaged by their chief designer, Admiral Berg. On the other hand, the Soviets seem to be mastering very quickly the necessary skills and techniques needed for adapting computers to the classroom. At this time, however, it is rather apparent that the introduction of digital computers into the classrooms is really a mandate for sweeping changes in Soviet education.

Cybernetics: Soviet cyberneticians have diagnosed the ills of traditional instruction and have prescribed a cure for them. Their answer is based on their conception of instruction as a control system which can be regulated automatically and also provide feedback about the psychic activities of the learner. It appears that Soviet programmed instruction is only the first phase of the Soviet cybernetic plan to automate education.

CHAPTER IV

"MECHANICAL SLAVES" IN THE SOVIET CLASSROOMS

> So far, we have embraced the machine without fully understanding it, or like the weaker romantics, we have rejected the machine without first seeing how much of it we could intelligently assimilate.[1]

Part of the Broad Sweep of History

For centuries, men have been trying to design machines that would automate human or animal feats of sheer brute strength. As early as the fifteenth century, Leonardo da Vinci had completed plans for an automatic sawmill, file-cutting machine, and other devices. By the end of the eighteenth century, the dreams of da Vinci and others had become a grim reality in England where factory owners employed machines on a scale never known before and brutally exploited thousands of workers in grimy sweatshops.[2] In the latter part of the nineteenth century and even in the twentieth century, the English pattern of industrialization with its ugly factory towns, scarring the landscape and polluting

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1. Lewis Mumford, Technics and Civilization, (Harcourt, Brace and Company, New York: 1934), p. 7. In his classic study of men and machines, Mumford defines "machines" as specific objects like the printing press or the power loom, and "machine" as a shorthand reference to the entire technological complex. In the following historical treatment, this author uses both concepts as they were defined by Mumford.

2. Goldwin Smith, A History of England, (Charles Scribner's Sons, Chicago, Atlanta, San Francisco, Dallas, & New York: 1941), pp. 491-507.

the environment, was copied in other parts of the world. Thus the conception of machines as an alternative to muscle allowed man to multiply his physical strength and led to the first industrial revolution with its legacy of human suffering.[3]

Meanwhile in the last part of the nineteenth century, another important concept of the machine emerged. The invention of the telegraph demonstrated concretely that machines were also communicative devices. Unfortunately, few men completely understood the significance of this innovation. With the automation of entire factories in the 1950's more men began to comprehend that machines could conceivably process information like the human brain and thus be employed to simulate the mental functions of man. This shift in the design of machines from automating musclepower to brainpower has made possible what Norbert Wiener has called the "second industrial revolution" in which machines, instead of men, regulate the processes of production.[4]

A Vanguard of Engineers

However, the "second industrial revolution" in the Soviet Union was not limited to industry, but spilled over

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3. Ibid., p. 506

4. Norbert Wiener, The Human Use of Human Beings, (Houghton Mifflin Company, Boston: 1954), In Chapter IX, Wiener explains that the new revolution is based on communication between machine and machine and this mechanical dialogue renders possible the new automatic age.

into the classroom during the sixties. The trend towards automation in education began in the applications of Soviet programmed instruction where machines were employed to manipulate information automatically. These innovations ranged from large digital computers to small testing devices. All had electronic components and each teaching machine was designed to receive, process, and transmit information somewhat like a classroom teacher. Thus such Soviet teaching machines as the Lastochka, Pioner, Ekzamentor, and Dnepr were communicative devices that attempted to simulate electronically key functions of teachers and ushered the age of automation into the Soviet schools.

This emergence of "mechanical slaves" raises a series of questions: (1) Where were the Soviet teaching machines produced? (2) Who designed them? (3) What were their designers striving to achieve? (4) What types of machines resulted from their designs? (5) What dominant patterns existed in the overall development of these electronic devices? (6) How did Soviet teachers react to these mechanical innovations?

In contrast to the development of teaching machines in the United States where corporate interests usually took the lead, the working models for Soviet technical devices were always created in either higher educational institutions or special research institutes. For example: the Lastochka was developed at the Kiev Civil Engineering Institute, the Ekzamenator at the Moscow Energetics Institute, and the Pioner at the Dnepropetrovski Mining Institute. Then the models were mass produced usually in nearby factories.

According to Soviet estimates, by 1966 there were about 5,000 Lastochkas, 2,000 Ekzamenators, and 1,500 Pioners being used in their schools. In addition, the Soviets had produced about 10,000 testing devices which cost approximately 3,800,000 dollars.[5] Furthermore, almost every major type of machine had been redesigned at least once and, consequently, each had at least two variations: the old and the remodeled one. Although complete data about expenditures for Soviet teaching machines were not available, it is enough to note that their collective cost, not including the expenses for computers, could be estimated in terms of millions of dollars.

More important than all of the preceding phases of research and development were the men who planned the initial stages of automation in Soviet education. During the sixties, these Soviets were generally engineers who viewed education from a vantage point unlike that of traditional teachers. Their engineering frame of reference rested on a few underlying assumptions which allowed them to do things on a scale hitherto unimagined in the schools. The most basic premises were that instructional processes can be explained

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5. A.V. Netushil, "Automatic Devices and Educational Work," Vestnik Visshey Shkoly No. 10 (October, 1966), p. 29. The Soviet author did not give the costs for the Lastochkas, Ekzamenators, or Pioners.

rationally and controlled by the use of feedback. The second set of engineering suppositions was that instruction is a process in which students and teachers perform operations and, if they are described precisely, machines can be built which will simulate their functions. For obvious reasons, the Soviet technicians were not interested in the mechanization of the learner's behavior but that of the teacher.

What the Soviet engineers were attempting to design in technical devices can be shown more concretely by examining their own descriptions and plans for the machines. An overall design was developed by a group consisting mainly of engineers and was presented at the All-Union Conference so that they could improve communications among themselves and with educators. It is noteworthy that the final draft of this clarification of concepts and explanation of terminology was prepared by A.O. Bondin - a teacher of automation and computer technology, and Yu. N. Kushelev - a designer of the first Soviet electronic teaching machine.[6]

According to Kushelev and the other Soviet inventors, the devices should be classified in five categories which designate basic functions automated by them. Here is a brief explanation of each mechanized operation:[7]

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6. Sbornik dokladov MEI Part II, op. cit., pp. 11, 12, 13, and 14. In the sixties, both Soviets were staff members at Moscow Energetics Institute.

7. Ibid., p. 12.

An information function is the reception and transmission of information without any provisions for adjustment based in feedback in the processes. An example of this is a film projector which receives a series of images from film and then presents them on a screen, but does not provide the operator with data about the viewer's reactions.

The control function is essentially testing or diagnosing student achievement. It is performed by machines which examine students and transmit feedback about their progress.

An information-control function is a combination of the two preceding ones. Teaching machines - which transmit information, receive feedback, and modify their sequence of transmission as a result of it - have these three functions built in them.

A training function is characterized by a process of drill or repetition. Such machines as the Link Trainers used to instruct pilots during World War II are examples of devices performing this operation.

An auxiliary function is the mechanization of a secondary or helping activity. A paper tape machine or a slide projector used in a student terminal for computerized instruction would be in this category.

From an engineering standpoint, all of this means that instruction consists essentially of five basic operations which can be machanized theoretically. The successful implementation of this mechanization, according to the Soviet engineers, depends upon some very important design characteristics of the hardware and software. In their opinion, the following considerations were crucial:[8]

(1) intended use of the hardware in the processes of instruction,

(2) learning principles designed in the software,

(3) specific format of the programs,

(4) sophistication of computational techniques performed by the machines,

(5) applied elements (parts),

(6) type of input,

(7) means of presenting information (audio, visual, or combination of both),

(8) and provisions for changing or adapting the programs.

In addition, these Soviet engineers noted that each of the preceding traits has some very important qualities which also needed to be considered in the design of machines.

Before examining in greater detail the specifics of this Soviet viewpoint, there are two general aspects which should not be overlooked: One is that the devices were essentially viewed as a means of communication and control, and the other is that the Soviet aim in the design was to create a tutorial relationship between the student and machine. This intended electronic dialogue obviously was a far cry from the old American ideal where Mark Hopkins and

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8. Ibid., p. 12. One trait is not listed because it is mathematical formula rating the efficiency of the machines.

his student sat on a log! In short, the Soviet engineers were committed to bringing about the "second industrial revolution" in Soviet education. For this reason, it is necessary to take a closer look at their frame of reference which has influenced the development of technical devices in the past and will influence their design in the future.

Illustration of Overall Engineering Viewpoint

In Figure 3, there is a more graphic description of how the Soviet engineers generally viewed the new tools for teachers. It shows more clearly the relationships between those functions and characteristics which were traced briefly in the preceding pages. So that all of this technical information is not presented entirely in the abstract, Figure 3 also depicts how the Soviet engineers used these data to determine the basic features in the design of the following pictured teaching machine.

Figure 3: The Ekzamenator

Figure 4: Soviet Viewpoint about Teaching Machines[9]

DESCRIPTIVE TRAITS		TYPE OF FUNCTION				
GENERAL TRAITS:	SPECIFIC TRAITS	INFORMATION	CONTROL	INFORMATION-CONTROL	TRAINING	AUXILIARY
USES IN THE EDUCATIONAL PROCESS	INFORMATION & REFERENCE					
	INFORMATION & TUTORIAL					
	MEANS FOR THE MERCHANIZATION OF COLLOQUIUM[10]					
	CONTROL (TESTING THE STUDENT & DIAGNOSING STUDENT ACHIEVEMENT[11]			X[12]		
PRINCIPLES OF LEARNING	INDIVIDUAL					
	GROUP			X		
TYPES OF PROGRAMS	LINEAR			X		
	BRANCHED					
	ADAPTIVE					
	MIXED					
	HEURISTIC					
COMPLEXITY OF DEVICE	NON-COMPUTERIZED			X		
	BASED ON COMPUTER					

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9. *Ibid.*, This system of classification was adapted from original system, p. 13.

10. Colloquium is an oral examination.

11. This means regular brief quizzes used for diagnostic and grading purposes.

12. X symbolizes the technical device, "Ekzamenator" or a "teaching machine."

Figure 4: Continued[13]

DESCRIPTIVE TRAITS		TYPE OF FUNCTION				
GENERAL TRAITS	SPECIFIC TRAITS	INFORMATION	CONTROL	INFORMATION-CONTROL	TRAINING	AUXILIARY
STUDENT INPUT	MULTIPLE CHOICE			X		
	CONSTRUCTED					
METHOD OF PRESENTATION	VISUAL			X		
	AUDIO					
	COMBINATION					
PROVISIONS FOR ADAPTATION	WITHOUT ADAPTATION					
	MANUAL ADAPTATION			X		
	AUTOMATIC ADAPTATION					
APPLIED ELEMENTS	MECHANICAL					
	ELECTRO-MECHANICAL			X		
	ELECTRONIC					

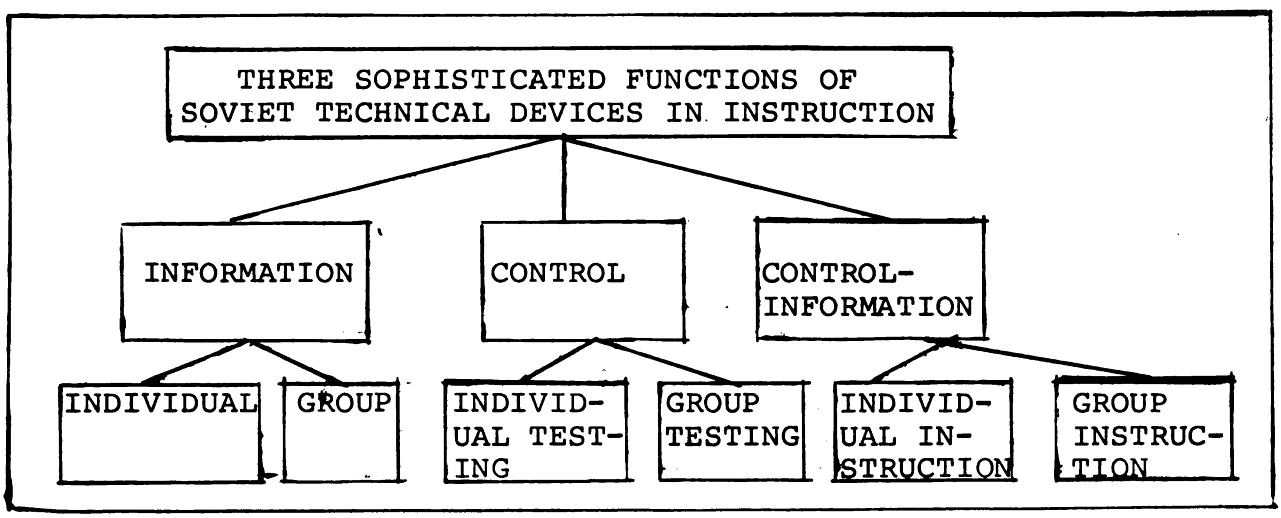
13. Ibid., This system of classification was adapted from original system, p. 14.

Instead of creating a maze of details about specific aspects of the illustrated Soviet outlook, it may be more useful to examine a broader issue at this point. The question that should be given priority is what machines resulted from the Soviet theoretical framework. By examining these Soviet products, one should be able to discover more specific details about their designs because they are extended and objectified in the machines themselves.

Examples of the Soviet Machines & Classrooms

Thus, according to the Soviet engineers, technical devices performed five functions in the processes of instruction. Only three types of machines, however, represented attempts to simulate relatively sophisticated operations of the Soviet teacher. These are illustrated in Figure 5:

Figure 5: Three Key Teaching Functions Automated by Machines



It should be pointed out that the following examples illustrate mainly those types of technical devices which simulated the more complex actions of teachers.

Information Devices: Familiar Machines Viewed in an Unfamiliar Way

From a technical viewpoint, movie projectors, tape recorders, television sets, phonographs, and film strip projectors are information devices. Although all of them existed before programs and teaching machines, they were easily adapted to transmit and receive data in programmed instruction.

Figure 6: Recorder and Retriever

A Soviet tape recorder and an automatic information retrieval device are pictured above. Both were used frequently in their language laboratories.

In addition, such components of information devices as: films, records, and tapes have tremendous capacities for storing symbols and images. As a result, the machines were also employed as auxiliary devices in learning systems where they were directed by computers. Their supporting roles are illustrated later in the chapter when computerized programmed instruction in the Radon Complex is explained.

Control Devices & an Unusual Soviet Technological Flower Called "KAKTUS"

These machines performed a teaching function which the Soviets designated as "kontrol." Though the Russian word is correctly translated into English as "control," much of the term's meaning is lost in the translation. Perhaps this semantic difficulty can be minimized by illustrating how a group of Americans, studying in the Soviet Union, learned the precise Russian meaning for "kontrol." While these students were receiving language training at the University of Moscow, their Soviet teacher announced that there was a need for greater "kontrol" and some "kontrolnaya rabota" in the processes of instruction. Translating the phrase into English, these Americans thought their teacher had proposed something unpleasant and even threatening. Finally, a puzzled student asked the Soviet to clarify what she meant. Somewhat surprised, the teacher explained that in an educational context, "kontrol" was a process in which the teacher tested and diagnosed achievement and "kontrolnaya rabota" was merely a short quiz. This is the type of function which the Soviets had in mind when they designed and used control devices.[14]

Since their first ones were developed and applied at the Moscow Energetics Institute, it became a model, copied in other Soviet schools. At this point, it may be very useful to consider how these machines were employed in the Moscow prototype for Soviet programmed instruction. A special group of technicians and teachers directed and maintained automated classrooms at the Moscow Energetics Institute. This unit with its personnel and facilities was designated KAKTUS which is simply a Russian abbreviation for the cybernetic regulation of student achievement.

Each of their two testing centers was equipped with twenty Ekzamenators. Instead of the teacher dominating these classrooms as was the case in much of traditional Soviet instruction, the electronic devices were the focal points with the learning procedures geared around them and the students. At least one technician was always present to make any needed technical adjustments or repairs. Each classroom teacher, however, was responsible for supervising the testing of his class.

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14. The incident occurred in September, 1967 and the author was a member of the class. Also it should be noted that "kontrol" and the cybernetic term "upravlenie" are translated as "control" but they do not have the same meaning as it is commonly defined by Americans. In Russian, there are two different words - upravlenie and kontrol and they designate two different concepts when they are used in a cybernetic and educational context.

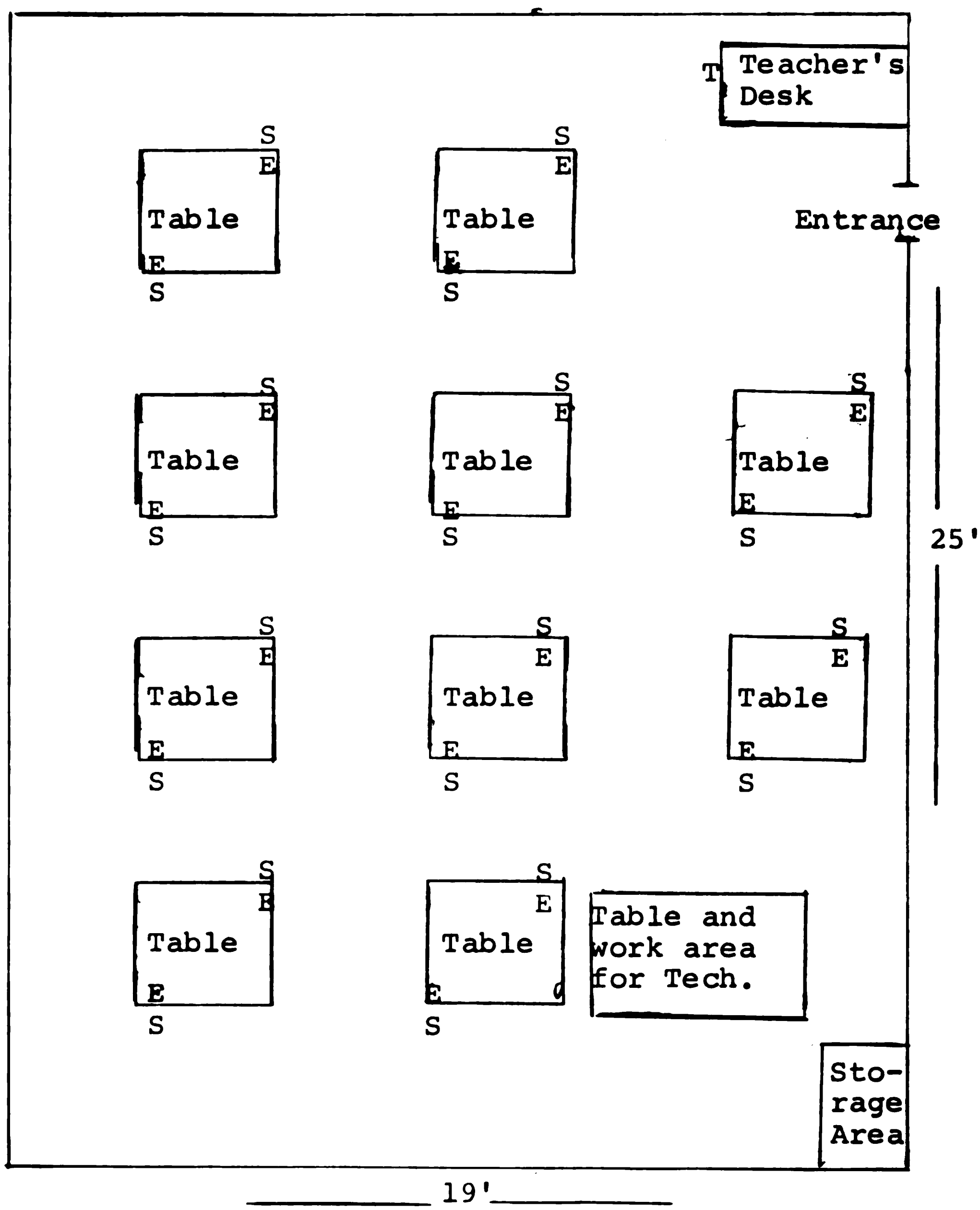
One important characteristic of the set-up was that the Soviets designed it to accommodate only twenty students. As a result, some of them had to wait outside in the corridors for their turn and the teacher signaled when a machine was vacated.

Another special feature of KAKTUS was the arrangement of devices which were located rather far apart. When the author first observed the spacing, he immediately assumed that the Soviets were attempting to reduce the possibilities of copying by the students. Although this assumption seemed logical, it was not valid. The spacing was an attempt to minimize noises and distractions which resulted from the use of the machines. If the Ekzamenators were placed close together, then noise caused by adjacent machines could have interfered with the concentration of the students.

The overall layout of a KAKTUS classroom is illustrated in Figure 7.

Figure 7: Classroom Used for Control (Moscow Energetics Institute)[15]

Explanation of Symbols: S - Student
T - Teacher
E - Ekzamenator (Technical Device)
Tech - Technician



15. Based on the author's observations.

Figure 8: A Control Device Used in KAKTUS

The Ekzamenator cost about $550.00 and usually functioned for approximately three years without major repairs. Since the costs for production and maintenance were low, the machines became relatively popular in the Soviet schools.

The program was contained in a film projected on the device's screen. The student responded to the filmed presentation by pressing buttons. This type of Ekzamenator was exhibited at the World's Fair in Montreal, Canada.

In discussions with the teachers who used the facilities of KAKTUS, these Soviets stressed that automated testing had significantly increased their feedback about student achievement and freed them from the tedious chore of grading papers. Likewise, in interviews with students, they stated a preference for testing by machines because their tests were graded immediately and each student received his score almost instantaneously. Interestingly enough, the young Soviets usually commented that the machines scored their tests objectively and fairly.[16]

Measuring the results of this application against the grand schemes of Soviet engineers, their achievements fell short of the mark. Nevertheless, the Soviets achieved the first phases of automation at the Moscow Energetics Institute. The significance of what they accomplished can be put in a proper perspective by recalling that the first airplane of the Wright Brothers did not resemble the supersonic jets of today. Given more time and opportunities to develop their plans, the Soviets were able to design better machines and to use them more effectively. But before examining this higher stage in the evolution of Soviet hardware, it may be more useful to glance at a few more control devices. Most lacked the flexibility of the Ekzamenator and were already obsolete by the end of the sixties. Some of their basic styles are depicted on the following pages.

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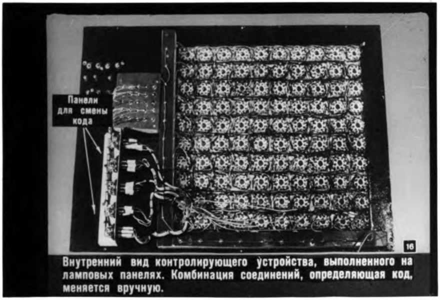
16. These students and teachers were interviewed in the Winter of 1967-68 when the author worked with I.M. Glizdov in KAKTUS.

Figure 9: A Bitter Fruit of Innovation

Although this machine was only developed in the early 1960's, it was already obsolete in 1965.

Figure 10: Concealed Complexity



Until one views the inner components, he is unaware of how complex even the earlier control devices were in design and construction.

Figure 11: A Master Panel

The desk tableau received, processed, and transmitted information from other machines for the teacher. It represented only the first stage in automation because the teacher still needed to monitor the tableau and respond to it.

Figure 12: Men and Machines Communicate with Each Other

The wall tableau informed both student and teacher of the learner's progress in the processes of instruction.

Figure 13: Testing Students Automatically

From a didactic viewpoint, this machine was used to test students. It has a special feature designed into its operation. The student is required to respond by constructing his own answer. In 1968 the Soviet engineers tended to think that a reply formulated by the student was superior to a multiple choice type of response.

Although this device was more sophisticated than the preceding two, its basic design was essentially the same. All of the testing devices were relatively inexpensive to manufacture and their maintenance expenses were very low.

Even after this initial examination of control devices, it is not very easy to dismiss them lightly. Their obvious importance is that they symbolized the first steps which are always the most difficult in the proverbial thousand mile journey, with the destination in this case being automated instruction. In addition, these machines of the early 1960's offer a baseline for measuring the distance covered by the Soviets in their quest of automation in the classrooms.

At this point, it may be very interesting to view another group of machines which suggest how the Soviets have edged nearer their goal and even accelerated their pace towards it.

The Next Step in the Soviet Ladder of Technical Progress: Information-Control Devices (Non-Computerized)

These machines were probably the most geographically dispersed and frequently applied technical means in Soviet programmed instruction. They included the Pioner, KISI-5, Repetitor, and the Ekzamenator.[17] All of them were designed to perform the functions of both testing and teaching.

The KISI-5 or the Lastochka, as the Soviets called it was designed for linear programs. The student learned by selecting a multiple choice answer. In order to signal his reaction, he pushed one of five buttons. Four of them pertained to specific replies for the task and the fifth one signaled "I don't know" to the machine. It had an auxiliary device, a collator-recorder, which collected basic data concerning the student's progress.

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17. It should be noted that the Ekzamenator is really an information-control device which was only used for testing at the Moscow Energetics Institute. In reality, the machine was underemployed at the Institute.

Figure 14: The Pride of the Ukraine

The Lastochka was constructed at the Kiev Civil Engineering Institute. With this machine the Soviets made an attempt to design for the first time a device which was not only functional but also beautiful. It was also exhibited at the World's Fair in Montreal, Canada.

The Pioner, which is pictured next, was intended to test and to develop logical thought.[18] Surprisingly enough this device could teach students how to use other machines.

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18. Methods Council of the Dneprodzerzhinsk Metallurgical School, Obuchayushchaya mashina "Pioner," (Teaching Machine "Pioner"), Dneprodzerzhinsk Metallurgical School, 1964, p. 1.

Figure 15: Teaching Men Mechanically How to Use Machines

The Pioner was used by Soviet teachers to instruct students in the sequential operations of other machines. It also recorded and indexed the learner's responses.

The other important type of information-control device was the Repetitor. There were two variations of this machine. The simplest one had a branched program which contained 600 frames of 36 millimeter film. The other style was more complex because it transmitted and received information by audiovisual means. This allowed the learner to read or listen to the programmed materials. Because of these technical features, the Repetitor has been used very successfully to teach certain aspects of languages. Later in the next chapter, there is a more detailed explanation of how the device was applied in Soviet classrooms.

In a discussion with this author, Yu. N. Kushelev and other Soviet engineers who invented the Repetitor and other small teaching machines, pointed out how such devices represented the initial stages of automation and created interest in the next stage - computerized programmed instruction. In addition, these Soviets commented on similar activities in the United States and singled out Lawrence M. Stolurow as one of the leading American developers of teaching machines.[19]

Figure 16: A Direct Descendent of the First Soviet Teaching Machine

A variation of the first Repetitor which ushered the electronic age of information processing into the Soviet schools.

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19. The discussion occurred in February, 1968 at the Moscow Energetics Institute. It should be noted that Stolurow was conducting research at Harvard University at that time.

Figure 17: A Stepping Stone to the Computer

This type of Repetitor has been widely used to teach audio-visually both Russian and foreign languages.

Without a doubt, the Lastochka, Pioner, Ekzamenator, and Repetitor were four of the best small teaching machines produced in the 1960's in the Soviet Union. Their components were superior to those found in control devices. But their significance was not limited to improved performance. More importantly, these information-control devices symbolized progress in the automation of the Soviet classrooms.

Although the small teaching machines had supplanted the testing devices in a process of natural selection, by the late 1960's it appeared that the big four were also destined for a scrap heap or museum as their mechanical predecessors. All of them were rapidly becoming technically obsolete because the computer was emerging as the Soviet cybernetic device for the classroom of the future.

The Wave of the Future (Computerized Programmed Instruction)

This phenomenon is expressed in Russian as programmirovannoe obuchenie s primenennem EVM and is translated as literally programmed instruction with the application of the electronic digital computer. Instead of shortening it to CBI or CAI (computer based or assisted instruction) like Americans, the Soviets preferred to use the entire phrase. All three symbolic representations, however, mean essentially the same, that is, using the computer to teach people.

As already indicated, one of the first Soviet educational institutions to employ the digital computer in the processes of instruction was the Kiev Higher Engineering Radio-Technical School. The machine was applied in a specially designed complex called Radon. This Soviet application of programmed instruction in the Ukraine was really an attempt to view educational problems in a new light and to shape new techniques for dealing with them.[20]

From the standpoint of closing the gap between technical know-how and the practices of instruction, the efforts in the Radon Complex raised a very interesting question concerning how the Soviets successfully overhauled the learning environment by electronic means. The following descriptive data reveal what happened in this pivotal Soviet innovation.

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20. Rostunov, op. cit., pp. 107 & 108.

In the Radon Complex, there were three essential technical components: (1) the electronic digital computer, (2) the terminals for the students, (3) and a working area for the teacher. All three were arranged so that about one hundred students could study simultaneously with one teacher controlling their learning activities.[21]

This basic design of men and machines, and the flow of information between them is shown in Figure 18.

The instructional processes were controlled by the Dnepr, created by the Institute of Cybernetics in Kiev. According to Soviet engineers, this device was relatively limited in performance, but easily adapted to classrooms because of its capacity to direct many control objects (means of connection).[22]

As a result of its technical features, the Dnepr allowed the students to study simultaneously different subjects or various levels of the same subject. For example, one individual could study physics while the other ninety-nine learned geometry.

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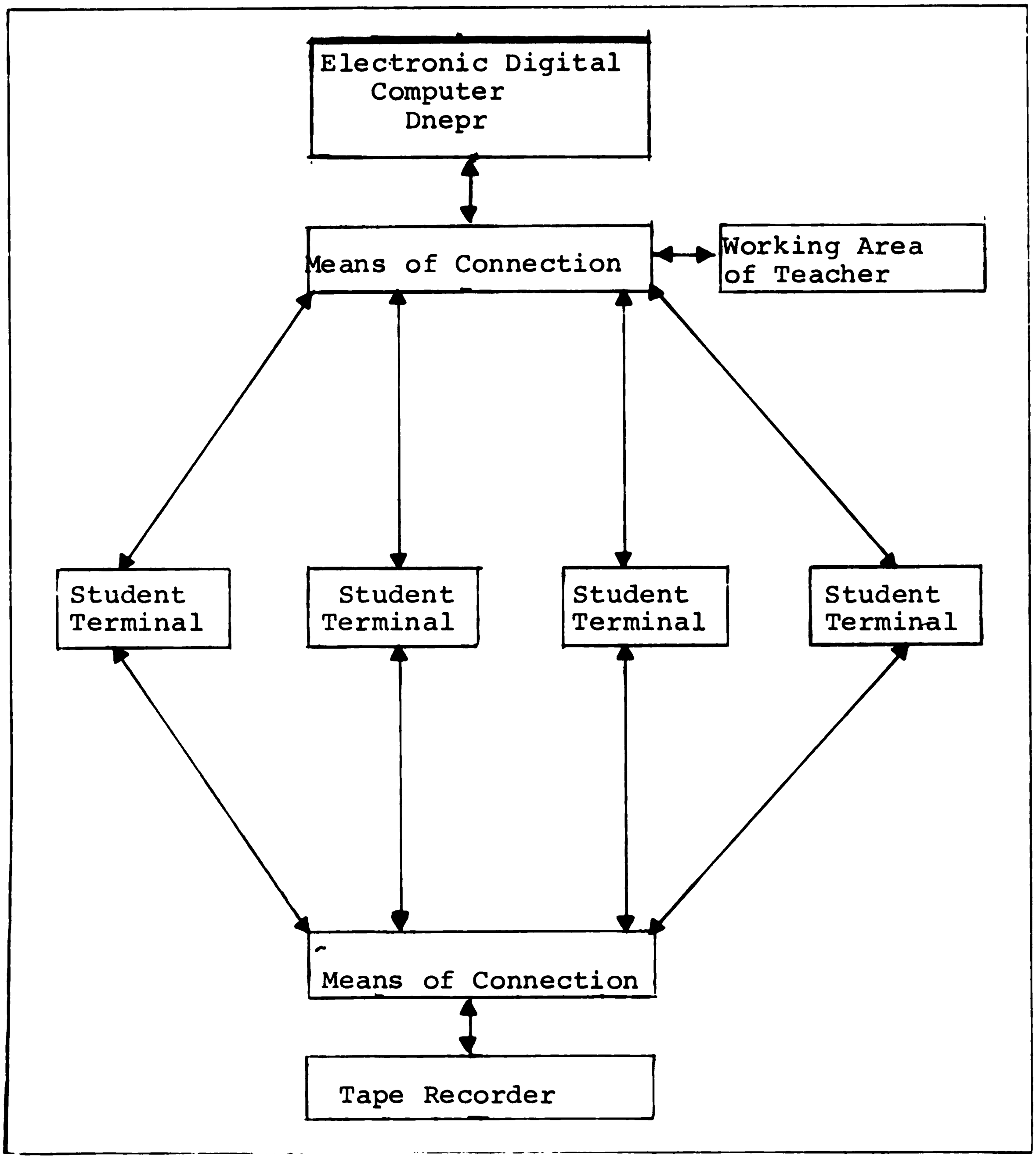
21. Yu. A. Buzunov, Obshchie printzipy postroyeniya obuchayushchikh kompleksov, Obuchayushchii kompleks "Radon," (The General Principles of Construction for Instructional Complexes. The Instructional Complex "Radon"), Kiev, 1966, p. 15.

22. Ibid., p. 14, 15 & 16.

Figure 18: An Overall View of an Electronic Class-room (Radon)[23]



23. Ibid., p. 15, adapted from original diagram, but because of limitations in space, only four terminals are depicted instead of one hundred. Also it should be noted that a tape recorder was used as an auxiliary device in the system.

Figure 19: An Electronic Teacher from Radon

The Dnepr was used successfully in the early 1960's and later was replaced by a more sophisticated computer.[24]

In restructuring the learning environment, there had to be some casualities. An important one was the demise of textbooks. In the Radon Complex, at first, the teachers still attempted to rely upon printed texts for basic means of communication. Their initial method was the address approach in which (1) the computer transmitted a particular page number in a book, (2) the learner read the message on the screen, (3) he turned to the particular place in his text, (4) after doing the task, he entered his answer into the digital computer by typing on his keyboard. Clearly, this lack of imagination led to the underemployment of technical means. It could be compared to a situation where a horse would be

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24. In an interview, P.D. Lebedev explained to the author that the Complex was being rennovated. That was in 1968.

used to pull an automobile. Later, the address system was dropped and other ways of utilizing the equipment were tried. Pictured below is an example of how old practices were merged with newer ones rather unsuccessfully.

Figure 20: From Printed to Electronic Media

A student terminal designed for the address presentation of data.

After some experimentation, the Soviets began to use other technical devices in their learning system. By the end of the 1960's, there were keyboards for the student to select or construct his symbolic response. The tasks were presented on a screen by films, filmstrips, slides, and tape recordings. Their symbols and images were controlled by the computer which could select randomly and almost instantaneously from these technical devices various parts of the programmed "lesson." This improved way of presenting information is pictured next:

Figure 21: The Basic Tools for the Learner in an Electronic Age

Depending upon one's point of view, here the student received and transmitted messages or was "massaged" by modern technology.

It appears that such outposts on the new electronic frontier as the Radon Complex were sending back some important signals for Soviet educators and all others like them who are still rather sheltered from the onslaughts of modern technology. This feedback was about what happened at the point of impact resulting from men and modern machines meeting in the classroom. Here is what seemed to be the most important bits of information in their messages:

(1) Students learned at their own pace while the computer recorded in detail their progress.

(2) Teachers were freed from many routine and monotonous chores and thus they could give more individual attention to each learner.

(3) Both of the preceding conditions were created without reducing the sizes of the classes.

(4) The physical environment of the classroom had to be overhauled to accommodate electronic technology rather than a printed one.

(5) Technicians outside the field of education, such as computer specialists and engineers, were needed to aid teachers in designing and planning the processes of instruction.

(6) The use of the computer also permitted collecting, processing, and storing an immense amount of data about how people learn.

Now what does all of this tell an outside observer about the Soviet chances of achieving their ultimate aim of automation in the rest of their classrooms? One only needs to glance again at the photographs of testing devices and then compare them with the pictures of the set-up in the Radon Complex. This comparison shows very vividly how the Soviets have surged forward since Landa and Kushelev developed their small teaching machines in 1961.

A Crucial Human Factor in Automation

As the descriptive data indicated in the preceding pages, the initial phases of automated instruction hinged upon integrating the functions of electronic devices with those of classroom teachers. Achieving this complex relationship between men and machines, however, depended upon other variables besides engineering know-how. If Soviet teachers, for example, had generally resisted the introduction of teaching machines or viewed their mechanical performance in a negative manner, these kinds of reactions would have impeded the advances of automation in the sixties and also represented a formidable obstacle in its future development. Such possibilities raise a series of questions about the general responses of Soviet educators to teaching machines. Did Soviet teachers tend to resist or welcome the use of information processing equipment in their classrooms? Were these Soviets generally satisfied or dissatisfied with the results of automated instruction?

In examining Russian studies and printed reports about programmed instruction, this investigator did not discover a broad study or survey of Soviet teachers' reactions to teaching machines.[25] On the other hand, these sources did not contain one account of a negative response, but only reports of how teachers reacted favorably to the use of information processing equipment in their classrooms. It should also be mentioned that unlike American publications in which automation was usually associated with unemployment, the Soviet authors stressed how machines could free teachers from routine tasks, and advanced no claims about machines replacing teachers.[26]

The data from interviews with Soviet educators tended generally to support the viewpoints and reactions reported

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25. It should be noted that this examination included the printed sources listed in the bibliography and library research in the Lenin and Ushinsky Pedagogical Libraries in Moscow. In addition, this author screened the issues in 1965 to 1969 of *Vestnik Visshey Shkoli* (a journal for higher education) and *Uchitel'skaya Gazeta* (a national newspaper for teachers).

26. See footnote 25 for sources.

in printed sources.[27] In questioning these Soviets, however, this investigator encountered one teacher who was opposed to mechanical innovations in Soviet education. Although she admitted that she had never used teaching machines, she was opposed to them because in her opinion the traditional ways of teaching were the best and teaching machines would never work in classrooms.[28]

A closer look at the data collected in the interviews and obtained from surveying printed sources reveals that Soviet educators generally overlooked an important dimension resulting from automation. This segment of educational reality involves both the obvious and subtle changes in behavior that are the upshot of the dynamic interaction between men and machines. In studying and reporting about teaching machines, Soviet educators generally failed, for example, to ask and then to seek answers for the following questions: How did electronic teaching machines influence the overt behavior and psychic activity of both student and teacher? Was the total learning environment including its electronic components so designed that the teacher and student realized

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27. These interviews were conducted at the Moscow Energetics Institute, University of Moscow, and Ushinsky Pedagogical Library. About one hundred teachers, including those who used teaching machines and those who did not, were interviewed by this author.

28. This interview was conducted at Moscow State University in the Fall of 1967.

their fullest potentialities? Unfortunately, Soviet educators tended to view teaching machines in terms of their traditional didactic consequences and thus failed to grapple with basic issues arising in the new electronic age.

On the other hand, this investigator discovered that there were some Soviets who squarely faced those issues concerning the consequences of automation. These professionals were engineering psychologists who studied how modern machines impinged upon man and even influenced his very psyche.[29] Their research became very practical and timely in the 1960's, because for the first time the Soviets were applying information processing devices not only in their schools but throughout society. It should be mentioned here that two of the foremost Soviet engineering psychologists in the sixties were A.N. Leont'ev and D. Yu. Panov who could be described in the terms of Marshall McLuhan as leaders in a new type of research concerned with the "massage" rather than the "message" of modern technology.[30] In short, the research of Leont'ev, Panov, and others like them could provide some very useful insights for Soviet educators and

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29. The author discovered and studied reports of their research in the Lenin Library. Later, he discussed their work with faculty members at the Moscow Energetics Institute and they singled out Panov and Leont'ev as two of their best engineering psychologists.

30. Marshall McLuhan, <u>Understanding Media: The Extensions of Man</u>, McGraw-Hill Book Company, New York: 1966, pp. 23-25. McLuhan, for example, advances the viewpoint that the medium of television is more important than its message because electronic technology shapes the very perception of the viewer.

others who are caught in a maelstorm of technological change and are very vulnerable to the abuses of modern technology.

Prospects for the Future

According to Admiral Berg, Soviet engineers, in the sixties, were trying "to amass valuable data and intelligently determine the requirements for the electronic devices of the future."[31] Their ultimate aim was to design the complex cybernetic system which could be widely used in their schools. As the data in this chapter have revealed, the Soviets began their task less than nine years ago by constructing two primitive teaching machines and ended the decade with specially designed complexes controlled by digital computers. Measuring their efforts against the goal of automation, it becomes very clear that during the sixties the Soviets rapidly moved towards their final destination.

Although this fact is significant by itself, it is more important when considered from a perspective shaped by Norbert Wiener. The whir of electronic devices and the hum of electric current surging through them in Soviet classrooms signalled to world educators that the "second industrial revolution" had reached one of the world's largest educational systems.

Now it could be argued by academicians that the Soviets will never be able to disseminate broadly their electronic innovations in instruction. Instead of wasting time by

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31. Molibog, op. cit., p. 5.

debating such an issue, it seems more reasonable to let history decide who is visionary and who is realistic. While waiting for the verdict from historians of the 1970's and the 1980's, a somewhat analogous set of historical circumstances should be considered by those who tend to underestimate Soviet scientific and technical know-how. About half a century ago, Konstantin Tsiolkovsky envisioned that man could launch automated rockets and even travel in space. While most practical observers were ridiculing the Wright Brothers for attempting to fly, this Soviet schoolteacher was calculating the thrust of rockets and building models of them.

CHAPTER V

CASE STUDIES FROM THE RED CLASSROOM

> Whole volumes and innumerable international conferences have been devoted to the social impact of space communications. Within a lifetime they may change our world out of recognition . . . they may result in the swift establishment of English (or Russian, or Mandarin) as a global language.[1]

Prelude to the Drama of Change

Only the first swells of a technological tidal wave destined to engulf Soviet society reached its schools in the sixties. These signals of an oncoming storm were visible in many aspects of Soviet education and were particularly evident in the applications of programmed instruction.[2] They revealed rather strikingly the convulsions of change resulting from modern Soviet technology.

Before examining in more detail these initial paroxysms in Soviet classrooms, it may be helpful to list a few of the specific technological innovations that caused certain tremors in Soviet instruction and to point out another part of the world that experienced similar developments.

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1. Clarke, *op. cit.*, pp. 108 & 109. The material in parentheses was in the original quotation.

2. T. Samokhvalova, *op. cit.*, p. 26. As mentioned earlier in Chapter I, the Soviets applied their programmed instruction in 250 higher educational institutions, 300 semi-professional schools, 200 vocational-technical schools, and 700 secondary schools. In addition, their efforts were concentrated in the following subject matter areas: higher mathematics, resistance of materials, electro-techniques, hydraulics, foreign languages, Russian, general technical and science courses.

In the last decade, the Soviets developed, for example, the following ideas in their applications of programmed instruction: (1) improved methods for controlling cognitive learning, (2) electronic devices for teaching, (3) automation of drill in language laboratories, (4) software packages for classroom teachers, (5) programmed material for military schools, (6) electronic simulation of reality, (7) cybernetic regulation of motor development, (8) and regional television programs beaming instruction into Soviet living rooms.

It might seem by implication that such innovations emerged only in the Soviet Union. On the contrary, they had their counterparts in the United States and all of them resulted from modern technology. Thus, instead of viewing the applications of Soviet programmed instruction like isolated tremors, one might view them as phases of a more seismic disturbance shaking the foundations of both the American and Soviet educational systems. If the Soviet technology is examined with this perspective, then the following questions become particularly relevant for American teachers, students, and administrators who are feeling similar shock waves of educational change.

Where did the initial technological upheavals occur in the Soviet Union? Why did they happen in those locations? How did the Soviets employ their programmed instruction to set in motion the forces of both educational and technical change? What did they report about their classroom confrontations in which students and teachers encountered electronic machines for the first time? In looking ahead to the anticipated good of automation resulting from the use of new software and hardware, did the Soviets overlook any serious problems following in their wake? Finding detailed answers for such questions would be a tremendous undertaking requiring many in-depth studies by Soviet and American scholars from various disciplines. Needless to say, the Soviets only began this research in the sixties and much of it remains to be done in the seventies.

As a result of the need for additional research, an attempt was made by this author to collect, survey, and then list the printed Russian accounts of various applications of programmed instruction. In addition, its uses in the classroom were observed firsthand whenever possible. Moreover, special permission was received from the Soviet Ministry of Higher and Secondary Specialized Education to study and take from the Soviet Union the special reports given at the All-Union Conference in Moscow. All of these sources are listed in the bibliography with a special directory containing the names of those Soviets involved with the technology. Thus, even though the following data are incomplete and findings are only preliminary, both could be very useful and timely for Soviet and American scholars.

Instead of removing the information from its classroom context and presenting it abstractly outside of its Soviet cultural milieu, eight case studies have been selected to illustrate the significant trends emerging in the applications of programmed instruction. Each of the eight examples contains the following kinds of data:[3]

(1) such sources as the names of the involved teachers, their schools, and any printed references;

(2) basic data about the experimental situation: location, grade level, subject matter, and date of the application;

(3) author of the program;

(4) illustration or description of the software and hardware;

(5) statistical results;

(6) teacher reaction;

(7) student feedback (as viewed by the involved Soviet teachers).

Case Study I: A Highly Praised Model

Background Data

For more than five decades, the Moscow Energetics Institute has played a pivotal role in the industrialization of the Soviet Union by providing technical knowledge and training skilled manpower needed to develop Soviet technology. Scanning the historical record for more details about the Institute's impact on Soviet society, one discovers some

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3. In some cases, all types of data are not included because they were not available to the author or were simply non-existant. For example, the author obviously did not receive the full details about applications in Soviet military schools. Also the Soviets did not usually report their results by using the various types of statistical approaches which some American educators prize so highly. See Appendixes for a more complete list of Soviet educational institutions involved with programmed instruction and details about the sources for this chapter.

very revealing quantitative and qualitative data. In 1940, the Soviet government awarded the highly coveted Order of Lenin to the Moscow Energetics Institute for its collective contributions in the struggle to electrify the nation. Furthermore, many staff members have individually received this award for such achievements as developing the first high voltage power line between Kuibyshev and Moscow.[4] Moreover, the Institute, whose output of enginners from its inception in 1909 to the Bolshevik Revolution in 1917 totalled only 74, has already graduated over 40,000 engineers in the first fifty years of Communist leadership.[5]

By 1967, approximately 25,000 students were enrolled and over 1,200 teachers were employed at the Institute.[6] Along with such quantitative growth, this engineering school had advanced qualitatively to a point where twelve professors were recipients of the Order of Lenin.[7] In addition, students and teachers, including many from foreign countries, were engaged in a wide variety of sophisticated technical and scientific pursuits ranging from studying heat engineering to participating in a joint American and Soviet research project involving the desalinization of sea water. Without

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4. Sheyberg and Shalobasov, op. cit., pp. 9-57.

5. Ibid., p. 9.

6. Ibid., p. 68.

7. Ibid., p. 68.

a doubt, the Moscow Energetics Institute had come a long way in a relatively short period of time to become, according to Soviet standards, one of the biggest and best engineering schools in the world. Thus it should be kept in mind that the following events occurred in this kind of dynamic educational milieu that permeated the everyday activities at the Institute. In other words, the ensuing case study cannot be understood apart from its broader historical context.

Description of the Application

In the sixties, one programmed approach, developed at the Moscow Energetics Institute, was selected by the Russian Ministry of Higher and Secondary Specialized Education as a model for instruction in the Russian Republic. After choosing the prototype, the Ministry notified its teachers by letter in which the official prescription for instruction was outlined.[8] Surprisingly enough, the recommendations of the Moscow administrators did not include suggestions about using teaching machines in classrooms. As a matter of fact, the Russian educational authorities suggested that teachers adopt the methods of P.D. Lebedev whose programmed instruction does not require electronic devices.

Significantly, Lebedev is no ordinary classroom innovator, but the Director of both the Heat Engineering Department and Inter-departmental Scientific and Technical Council at the Institute. In actuality, Lebedev's academic positions

8. _____, Sbornik, dokladov MEI po voprosy ob effektivnykh metodakh obucheniya (Collection of Reports about the Effectiveness of Methods of Instruction MEI) Moscow, 1966, p. 103.

are somewhat comparable to that of a department head in an American school of engineering and a director of research and development for educational innovation in an American university. In addition to his experiences as coordinator of such diverse educational activities at the Institute, Lebedev has been a special assistant to the Minister of Higher & Secondary Specialized Education and consequently has represented the Ministry at many international conferences about all types of educational technology including programmed instruction. Briefly, then, P.D. Lebedev is a very unusual Soviet teacher who is relatively well informed about the development of educational technology not only in the Soviet Union, but also in other nations.

Nevertheless, like most Soviet teachers involved with programmed learning, Lebedev is concerned mainly with improving traditional Soviet instruction. According to him, programmed techniques should be designed so that they will aid teachers in removing two basic flaws in the practices of Soviet teachers and students. With the characteristic candor of one Russian speaking to another, Lebedev describes what is generally happening in Soviet schools of higher learning:

> In higher educational institutions, traditional instruction in technical subjects has a number of weaknesses. During the semester, many students do not study their lecture notes systematically and they usually study them just before an exam. During the term, the teacher seldom knows how much the student understands about the lectures.[9]

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9. Ibid., p. 103.

Although Lebedev is describing a few typical ills of Soviet education, he is, unknowingly, characterizing not unfamiliar American educational problems of student "cramming" and teacher "lecturing in the dark." Confronted with such problems, Lebedev attempted to structure the processes of instruction so that he would receive more feedback from students and also motivate them to more systematic study.

In many respects, his programmed approach was not radically different from those of many American instructors who have attempted to improve their teaching. Instead of questioning the assumption that instruction is essentially the transmission and reception of knowledge, Lebedev, like many teachers the world over, accepted this premise and designed learning procedures based upon it.

Thus, he wrote a branched programmed text which presented the subject matter of heat engineering in small portions. His underlying strategy was to lead the student through a series of cognitive tasks that spiralled from the simple to the more complex. In dealing with the problem of obtaining feedback, however, Lebedev designed a rather unusual method for motivating Soviet students. This consisted of weekly "incentive quizzes" which provided both immediate and delayed rewards for those who mastered the subject matter from the lectures and programmed lessons. For example, if a student excelled in all of the weekly tests, he was excused by Lebedev from the final examination at the end of the semester.

It should be hardly surprising that Lebedev evaluated his approach on the basis of student achievement. He compared the grades of those who were instructed traditionally with those who learned by programmed instruction. In Table 2, there is a summary of the data resulting from the comparison.

Table 2: A Comparison of Student Achievement in Traditional and Programmed Instruction[10]

Grades of Students in Traditional Instruction		Grades of Students in Programmed Instruction	
Group	1962-63 School Year	1963-64 School Year	1964-65 School Year
1	3.47	4.46	3.94
2	3.35	3.92	3.87
3	3.98	3.92	4.00
4	3.30	4.07	4.00
5	2.80	3.46	4.00
6	3.80	4.29	4.13
7	3.98	4.58	4.16
Average Grades	3.44	4.10	4.02

It should be pointed out that the students were arranged in the different groups because Lebedev was aided by seven graduate assistants who taught the laboratory sections of the course. It is also noteworthy that approximately twenty per cent of the students were excused from the final examination.

10. Ibid., p. 113. Although Soviet teachers use the following five point grading system: 5 = excellent, 4 = good, 3 = satisfactory, 2 = unsatisfactory, and 1 = failure, they seldom use 1. The usual symbol for failure is 2.

Lebedev, his teaching assistants, and students reported in separate interviews that they were very pleased with the programmed course.[11]

From the viewpoint of his students, teaching assistants, and the Ministry of Education, Lebedev developed a successful instructional approach. However, from the vantage point of many American educators who tend to value more precise statistical data, Lebedev has not offered enough evidence to support his claim of success. Important as it may be, this question of supporting data only obscures a more basic issue involving Lebedev's key supposition that instruction is mainly the transmission and reception of knowledge. Such an assumption undergirds his officially approved working model developed at the Moscow Energetics Institute.

Nevertheless, Lebedev's application of programmed instruction is somewhat like a microcosm reflecting much of the larger educational universe resulting from the technology. What is perhaps most important is that Lebedev heightened the participation of the learner in the processes of instruction. It should be noted, however, that the increased activity was not spontaneous, but resulted from detailed planning by the teacher who seldom consulted the students about the ultimate goals for teaching and learning.

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11. The author discussed the merits of programmed instruction with Lebedev, his assistants, and students in very informal situations while working with them in the laboratories and classrooms at the Institute. The students liked the incentive of not having to take the final examination and the teaching assistants were particularly impressed with the quizzes because they provided almost instant feedback and were not difficult to grade.

In this respect, Soviet programmed instruction is not much different from much of traditional American education which is being increasingly and often militantly rejected. Apparently, repercussions similar to American student discontent with authoritarian practices had not been felt in the Moscow Energetics Institute in the years of the sixties.

Case Study II: New Medicine from an Old City

Background Data

Kuibyshev, formerly Samara, is an important port on the Volga and a main junction on the Trans-Siberian railway. This industrial center specializes in engineering activity, electrical power, oil refining, and food processing for the Urals and Western Siberia. The city is also the site for the Kuibyshev Medical Institute which became famous in Soviet educational circles for introducing information processing devices into Soviet medical classrooms. One of the machines, the highly publicized Iremna, could even teach medical students how to diagnose various illnesses.

But this school is also listed in Soviet medical research literature for other firsts besides hardware. Staff members at the Institute developed the first programs and guidelines for their use in Soviet medical schools. As a result of these pioneer experiments in programmed instruction, the Kuibyshev Medical Institute became a Soviet model for applying technical devices in medical classrooms and, more importantly, a source of ideas for other medical schools.

Data About the Application

Already in the early 1960's, teachers at the Institute in such departments as pharmacology, histology, general surgery, and the clinical disciplines attempted to write teaching programs simulating real medical problems and requiring students to think critically about solving them. One of the Soviet pioneers in this method of instruction was Professor A.A. Lebedev, who, incidentally, is also an authority on various other phases of medical education.

At the Institute, the programmed materials were used in various types of devices: Lastochka, Iremna, and other smaller machines. These mechanical innovations presented examinations and provided independent study for the students. The software in the technical devices was usually prepared by an individual teacher for his own class. However, there were a few exceptions when members from a particular department cooperatively designed the programs. The clinical staff, for example, created some jointly.

Apparently, the teachers at the Institute were relatively successful in their attempted simulations of medical situations. The following example of a patient suffering from a hernia and the possible results of various treatments illustrates rather strikingly how these Soviets with a little imagination and considerable medical knowledge created some rather realistic and challenging problems for future Soviet doctors:

Clinical Situation

A patient about 50 years old has a strangulated internal hernia. The strangulation occurred about 4 hours ago. What is your treatment?

Possible Treatment

1A. Put the patient under observation.
1B. Operate on the patient.
1C. Manipulate the hernia back into place.

(The student decides on a treatment and turns to page or section 1A, 1B, or 1C.)

Consequences of Treatment

1A. Your decision to put the patient under observation was incorrect. After an hour under observation, the patient has a severe pain in the abdomen, a weak pulse of 120, and swelling of the abdomen. These symptoms indicate Shchetkin. Think about your decision and return to the original question.

1B. Yes, it is necessary to operate on the patient. However, when they were bathing the patient in a reclining position, the hernia slipped back into its proper place. What is your next decision?

2A. Allow the patient to return home.
2B. Perform a laporotomy.
2C. Operate on the hernia.
2D. Hospitalize the patient for observation.

1C. Apparently, your decision was incorrect. While manipulating the hernia, the manipulation caused a severe pain in the patient's abdomen. This indicates a symptom of inflamation of the peritoneum. Now, if you understand why you were wrong, return to the original question.[12]

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12. _____, *Struktura obrazovaniya spetsialistov v oblasti meditsiny i programmirovannoe obuchenie v meditsinkikh uchebnykh zavediyakh* (The Structure of Education for Specialists in the Area of Medicine and Programmed Instruction in Medical Schools), Kuibyshev, 1966, p. 15.

In addition to creating this type of program, teachers at the Institute also made other significant contributions to the development of programmed instruction. Perhaps the most important was devised by Professor G.L. Ratner who studied the various applications at the Institute and other Soviet medical schools, and developed from his findings the initial guidelines for the technology's use in medical education. In his project, Ratner was assisted by G.N. Aleksandrov of the Kuibyshev Electro-Technical Institute of Communications.

Ratner's initial recommendations centered on the applicability of programmed instruction according to subject matter areas and also more specific teaching tasks in medical instruction. The former is summarized in Figure 22 and the latter is depicted in Figure 23. Although Ratner and Aleksandrov's reactions, listed in these tables, reveal much useful information about the technology, their viewpoints about the essentials of instruction in Soviet medical schools are perhaps even more noteworthy.

Figure 22: Possible Uses of Programmed Instruction in Medical Schools.[13]

Explanation of Symbols: + indicates the applicability of programmed instruction and - indicates its inapplicability.

	Seven Types of Programmed Instruction						
Characteristics of Subject Matter Area	Self Study	Testing	Problem Situation	Tasks in Labs	Film & Film-Strips	Basic Texts	Classroom & Course Materials
Clinical Disciplines	+	+	+	+	+	+	-
Subjects of a Descriptive Nature	+	+	+	+	+	-	-
Minor Subjects (Physics, etc.)	+	+	+	+	+	+	+
Major Subjects (Biology, etc.)	+	+	+	+	+	+	+
Applied & Practical Subjects (Surgery, etc.)	+	+	+	+	+	+	+

13. *Ibid.*, Adapted from original chart pp. 10 & 11.

Figure 23: Instructional Problems in Medical Schools and Programmed Instruction.[14]

Explanation of Symbols: + indicates the possible use of programmed instruction and - indicates the impossibility of using it.

TYPES OF INSTRUCTIONAL PROBLEMS	Six Types of Programmed Instruction: Programmed Texts for Self Study	Programs for Group Tests	Programmed Problematic Tasks	Programmed Tasks for Labs	Programmed Films & Film-Strips	Programmed Materials for the Classroom & Texts
I. INSTRUCTION FOR CONCEPTUAL KNOWLEDGE:						
presenting the concept in real form or model	+	-	-	-	-	+
discovering the essential characteristics of the concept	+	+	+	-	+	+
recognizing the concept among others	+	+	+	-	+	+
stating the concept's meaning	-	-	-	-	-	-
applying the concept in a practical task	+	+	+	+	+	+
II. INSTRUCTION FOR KNOWLEDGE OF LAWS, PROCESSES & THEIR DYNAMICS:						

14. *Ibid.*, Adapted from original chart pp. 10, 11 & 12.

Figure 23: (Continued)

TYPES OF INSTRUCTIONAL PROBLEMS	Six Types of Programmed Instruction					
	Programmed Texts for Self Study	Programs for Group Tests	Programed Problematic Tasks	Programmed Tasks for Labs	Programmed Films & Film-Strips	Programmed Materials for the Classroom & Texts
presenting the real processes or models of them	-	-	-	-	+	+
describing the process	-	-	-	-	-	+
determining the sub-processes	+	+	+	-	-	+
developing a symbolic model	+	+	+	-	-	+
analyzing the model	+	+	+	-	-	+
recognizing the conditions for application	+	+	+	-	+	+
applying the knowledge	+	+	+	+	+	+
III. <u>INSTRUCTION FOR THE COMPUTERIZED APPLICATION OF KNOWLEDGE</u>:	+	+	+	+	+	+
IV. <u>INSTRUCTION FOR SKILLS</u>	-	+	+	+	+	+
V. <u>INSTRUCTION FOR TECHNIQUES</u>:	+	+	+	+	+	-

15. *Ibid.*, Adapted from original chart pp. 10, 11, 12.

As the data clearly indicated in both Figures, Ratner and Aleksandrov generally viewed Soviet programmed instruction in a very favorable light. Of course, there were a few phases where these Soviets noted that using the technology was not feasible. In their reports, however, they clearly stated that programmed instruction was not the cure-all for the ills of Soviet medical schools. At the same time they added that this method was a very useful approach for analyzing and revising instructional tasks.[16]

One needs only to consider a few results of the applications at the Kuibyshev Medical Institute in order to understand why the technology has possibilities. First, it provided teachers with means for organizing subject matter areas and, even more importantly, stimulated these Soviets to reexamine their basic assumptions about learning. Second, the applications permitted the introduction of information processing devices into the very classrooms of Soviet medical schools. Finally, by combining machines and programs, the teachers were able to simulate real medical situations for their students. Even though their initial combinations were somewhat primitive, they suggested many new possibilities for more sophisticated types of simulation.

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16. A.A. Lebedev, Pervye itogi primeneniya elementov programmirovannogo obucheniya v kurse farmakologii meditsinskogo vuza (First Results of the Application of Elements of Programmed Instruction in the Course of Pharmacology in a Medical School), Kuibyshev, 1966, p. 11.

Thus, in an age demanding instant information, Soviet medical schools are not places of refuge from the requirements of the technological era. The activities at the Institute are only harbingers of major changes in Soviet medical education. As a matter of fact, Ratner and Alexandrov stated in their guidelines that incorporating computers into the practice of medicine is mandatory for contemporary medical practitioners. What seems so surprising and even ironic about all of these developments is that they were ushered into the classroom at such an unlikely location, the old city of Samara.[17]

Case Study III: Automating A Critical Skill

Background Data

In sharp contrast with American schools where the study of foreign languages is seemingly treated like an unwanted child, these subjects have a very high priority in the Soviet curriculum. There are some very practical reasons why the Soviets value symbolic skills so highly and why teachers attempted to accelerate the development of them by using programmed instruction. Here again, in searching for causes one must look within the Soviet classroom for didactic ones and beyond its confines for others.

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17. As a result of a chance encounter with a Soviet graduate student in the Lenin Library in Moscow, the author learned that certain Ukrainian medical schools were also developing and applying programmed instruction. The author did not locate any references describing these applications. However, considering that the Ukraine is a hot bed of activity for programmed instruction, this possibility deserves further exploration in another study.

From a Soviet viewpoint, the ability to read a foreign language, such as English, French, or German, is an essential tool which every scientist and highly trained technician should possess. This skill, for example, permits a Soviet electrical engineer to double his sources of information and thus to figuratively leap over difficult problems by finding the answers for them in foreign scientific and technical publications. How careful attention to foreign research can save time and money was described earlier in Chapter I by citing the views of Dr. Walter Buckingham, a former consultant to the U.S. Senate-House Economics Committee.[18] On the face of things, it seems that the Soviets are somewhat justified in stressing the study of other vernaculars by specialists and their resulting skills are paying off in handsome research dividends.

But there is still another more important reason for the Soviet concern about the use of symbols. This is so obvious that it is frequently overlooked. In the Soviet Union, there are approximately 100 different national groups who speak about 60 languages. This simply means that Russian is not the native tongue of many Soviet citizens and they learn it as a second or even "foreign" language. Thus, for

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18. Walter Buckingham, Automation Its Impact on Business and People, New York: The New American Library, 1961, p. 33. While the author was at the Moscow Energetics Institute, he noted case after case where the Soviets used American research to good advantage. The Soviet government even provides inexpensive translating services for their scientists and technicians. In these respects, the Soviets are much less ethnocentric than their American counterparts.

the purposes of national unity, the teaching of Russian is extremely significant.

In addition, it plays a crucial role in the education of another very special minority group. An ever growing number of foreign students need to acquire Russian very rapidly before they can study their specialities in Soviet educational institutions.

Now, one should be able to understand more clearly why the Soviets emphasize Russian and foreign languages in their schools and why the quality of instruction in both of them is so critical.

Even though at first glance it would seem that Soviet teachers have been rather successful in the past with these subjects, their teaching methods have lagged behind the times and have been criticized recently as inefficient. For example, it takes considerable time and effort to master another tongue in traditional instruction where precious hours are squandered in detailed, abstract grammatical analyses and a few minutes are spared for verbal exercises. The results of this approach in many cases are so disappointing and justly deserve the harshest criticism.[19] At the same time,

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19. In a speech at the Moscow Energetics Institute in December of 1967, Admiral Berg criticized how foreign languages were taught in traditional instruction. On the other hand, the author met a very talented teacher of English who introduced him to her students. They spoke excellent English. However, this Soviet teacher taught in a special school and stressed more or less an audio-lingual approach. It should be added that in teaching Russian to foreign students the Soviets have made great strides in modernizing their methods. The author was very fortunate at the Moscow Energetics Institute where he had an exceptional teacher of Russian and was the only pupil in the class. It was a tutorial situation which stressed the spoken language and consequently accelerated the author's reading ability.

with the multiplication of knowledge, there is a need to expand and add scientific thought and subject matter in the Soviet curriculum. With these demands impinging on the already crowded schedule of a school day, there is even less justification for the old ways of language teaching.

Unless the Soviets suddenly decide to demote the study of languages in their schools, which for obvious reasons would be unlikely, their teachers must devise new approaches which telescope this instruction into shorter periods of time and increase the audio-lingual activities of their students.

Faced with this dilemma in the sixties many Soviet teachers turned to machines and programs for help. In the applications of them, these Soviets attempted to compress language learning by heightening the active participation of students. As a result of their experiences, Soviet instructors discovered that the technology was very useful in drill and pattern recognition exercises.

The following case study illustrates concretely how programmed instruction was used and what resulted in these classrooms.

Data About the Application

During March and April of 1965, members of the Russian Department at the Moscow Energetics Institute tested technical devices and programs in classes where foreign students were studying a very difficult phase of Russian. In the experiment, there were three different groups consisting of those students (a) who had never studied verbs of motion,

(b) who had recently (during 1962-65) studied them in traditional instruction, and (c) who had studied them in traditional instruction before 1962 but not since then. All of these participants spoke either an Indo-European or Mongolian language as their native tongue.[20]

In the application, all three groups used teaching machines called Repetitors which present information on their screens and also have six buttons for student responses. As already described in Chapter IV, the machines are designed so that the signal from the student determines the sequence of tasks in the learning situation. If he responds correctly to the question, the next problem appears on the screen. On the other hand, an error by him signals the machine to repeat its presentation. In addition, these devices have another special feature. They have a special button designated "help" that presents additional information of an explanatory nature.

The software was prepared by teachers in the Department and they were aided by technicians who adapted it for use in the teaching machines. In their finished product, the first ten frames were particularly crucial because they contained an explanation of the involved grammatical rules and directions for operating the hardware. Although the devices had a capacity for handling six different responses including one for additional help, the programs were developed for only five types of answers (four possible choices and a

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20. _____, Sbornik dokladov MEI, _op. cit._, p. 35.

fifth one requesting more data).

The following example was excerpted from the materials studied by the students.[21]

Frame 10: Determine which verb of motion should be used in the following sentence:

The Moscovite . . . to the virgin lands. (A pause of a few seconds follows. In this span of time, the student answers the question mentally or just thinks about it. Then the device presents Frame 11.)

Frame 11: Complete the sentence with a verb and select it from the following verbs:

The Moscovite . . . to the virgin lands.

1. carried
2. walked
3. rode
4. was carried

Frame 12: You answered incorrectly. (If the student pushed button 1, this reply was presented on the device's screen and the student tried again.)

Frame 13: You answered incorrectly. (If the student pushed button 2, this reply was presented on the device's screen and the student tried again.)

Frame 14: You answered incorrectly. (If the student pushed button 4, this reply was presented on the device's screen and the student tried again.)

Frame 15: In the problem, four answers are given. You pushed button 5. Work more attentively! (If the student pushed button 5, this reply was presented on the device's screen and the student tried again.)

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21. *Ibid.*, p. 44 & 45.

Frame 16: Verbs of motion have either a determinate or determinate aspect . . . (If the student pushed the button for help, this explanation was presented on the device's screen and the student tried again after reading and studying the explanation.)

Frame 17: You answered correctly. (If the student pushed button 3, this reply was presented on the device's screen and a new question followed frame 17. The student skipped frames 12, 13, 14, 15 and 16.)

Understandably, the translation does not capture the subtleties and nuances of the verbs in their original Russian context, because they simply do not exist in English. However, the illustration does reflect accurately an important format of Soviet software and a very special trait of their devices used in language classes. The Soviets rely on branched programs and machines which are regulated to provide a pause of a few minutes between the question and the answer. In the intervening period, the student is expected to construct his own reply. Soviet language teachers tend to view this type of answer as more realistic and consequently more useful than one which is prompted by the electronic device. If the reader tries to recall how many everyday conversations are carried on by people who are cued by multiple choices, then he can understand why these teachers and designers of hardware have attempted to create as much as possible a dialogue with the machines. At this point, it is necessary to recall that Glushkov is trying to design a machine which talks to its operator. If Glushkov and the others could create a cybernetic device responding to voice commands, it would offer some amazing possibilities for use in the teaching of languages.

In order to evaluate their efforts, the staff of the Russian Department selected three groups comparable to the ones in programmed instruction. The new participants learned the same subject matter and were given an identical examination. However, the same teachers taught them by using conventional methods. According to the Soviet reports, the students in traditional instruction averaged about six hours in the classroom before mastering the verbs and the others in programmed instruction needed about one and a half to two hours of study time.[22]

In a series of subsequent interviews in 1968, the teachers of Russian at the Institute stated that the technology saved time for them and their students.[23] Furthermore, the staff members described how the innovation was used mainly for drill and review. In regards to the machines, these Soviets explained why the Repetitors with their mechanical limitations had limited prospects for the future. Finally, various members of the Russian Faculty indicated that they were eager to try the computer in their classrooms. Even more significant were the comments from the students who were learning languages with the aid of programmed

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22. Ibid., p. 41.

23. Since the author studied Russian at the Institute, he met formally and informally with teachers and students. Thus this information was obtained over a five month period.

instruction.[24] These Soviets and foreigners reacted very favorably when questioned about the technology. Even those who were achieving rather poorly stated that the machines were very "objective" and "helpful." Perhaps what is more important than these technological testimonials is the fact that both the students and teachers were still using the hardware and software in 1968.

Looking back over the details, one should not focus only on such conventional didactic consequences as teaching verbs of motion quickly at the Moscow Energetics Institute. It seems more important to note that the involved teachers introduced the new information technologies into language classrooms and began to rely upon this hardware and software for improving instruction.

Nevertheless, while the Institute's language teachers and others like them in the Soviet Union are slowly moving towards computerized instruction, a steady stream of new scientific and technical information is impinging on the already tightly scheduled Soviet curriculum. As a result, the pressure is increasing on Soviet language teachers to update and telescope their instruction into an even shorter period of time. Perhaps the teachers at the Institute are

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24. It might seem to some readers that these students would not be critical in their comments to the author. This apparently was not the case because on many occasions these students were very open with him. One needs to remember that they are engineering students who do not have many of the popular fears and misconceptions about electronic devices.

only offering a technological straw in the wind to those who are being swept away by the tremendous force of change. However, the underlying Soviet trust in educational technology, found in the application of programmed instruction at the Moscow Energetics Institute and other locations, should not be surprising to anyone who has read about the dreams and aspirations of the Soviet people. In the past, they have viewed electrification as the means to Communism and tractors as the salvation of Soviet agriculture.

Case Study IV: Writers Without "Pat Formulas" and Profit

Background Data

Who writes the Soviet programs and what motivates their authors to create them? Quite obviously, the first place to look for answers is the software where the names of its creators are listed. Another valuable source of data is professional educational journals where various problems in programming are discussed. When one examines both types of information, he discovers some rather startling insights about the Soviets who are involved in this kind of technical writing and the procedures which they employ.

After examining Soviet programs, reading the comments of their authors, and interviewing them, the following illustration was selected to show more concretely a few of the dominant trends in the development of Soviet software. Paradoxically, this case study is focused on an attempt for educational reform that began in a little known educational institution in Byelorussia and spread to the far corners of the Soviet Union.

The official name of the Byelorussian school is the Mogilev Machine Construction Institute. It should also be mentioned that the Institute is located in the industrial city of Mogilev famous for its heavy engineering and chemical plants. Hardly surprising, the Institute trains many of the technicians who are employed in these industries.

At first glance, it may seem that an investigation of educational activities in such a provincial town could offer very little information about the emergence of an educational technology in the Soviet Union. Regardless of the reader's first impressions, one teacher in such an unlikely environment as the machine-dominated one at the Institute created a software package which is used today in many other Soviet schools. While designing it, he also challenged some of the most cherished assumptions embedded in the almost sacrosanct rites of traditional Soviet instruction.

Along with being an iconclast who failed to worship conventional Soviet wisdom concerning language teaching, this Soviet teacher by his actions has unknowingly raised some very serious questions about how Americans create and market their software. Here is a brief account of what happened in Mogilev.

Data About the Application

In 1965, an instructor at the Mogilev Machine Corporation Institute - N.I. Tupalskii - was teaching technical

German. In his report he described that he was diligently employing the traditional methods and materials. Nevertheless, Tupalskii was very dissatisfied with certain aspects in this type of instruction. For instance, students were studying many hours, but their resulting language skills were not commensurate with their efforts. According to Tupalskii's diagnosis of the situation, the unsatisfactory state of affairs stemmed generally from the conventional methods of instruction and particularly, from the required text for the subject. This printed anachronism was prepared in the early 1950's and, although the textbook had been reprinted many times, it had never been revised. These versions or editions were also being widely used in other Soviet technical schools.

Tupalskii was so discontented that he did something which teachers everywhere dream of doing. In late 1965, he wrote his own textbook for his students. The new Soviet author reported that he began the task by systematically examining the basic curriculum requirements for technical German and considering the needs of his students. In developing the overall design for the text, Tupalskii allotted 198 hours for all the learning activities inside and outside the classroom. Here is how he blocked out the time: (1) 24 hours for programmed homework, (2) 86 hours of programmed learning in the classroom, (3) and 88 hours for supplementary exercises.[25]

Within this framework, Tupalskii then designed the software consisting of both primary and secondary materials. The former was a programmed textbook containing ten chapters with a total of 86 lessons and the latter included 10 films, 76 slides, 3 quizzes, and a final examination.[26]

Using the terminology of American educators, Tupalskii was aiming for a highly structured learning situation. Putting it very bluntly, he intended "to run a very taut ship" in technical German and had created the means for accomplishing his goal. In reporting his results with programmed materials, he stated that they had provided him with more feedback about the learning processes of the students. In terms of their performance with the special language, he added that the learners had increased significantly their vocabularies and translating skills with less effort and in a shorter period of time than in traditional instruction.[27]

Obviously, Tupalskii was satisfied with these aspects of the application. In addition, other Soviet teachers reacted favorably to his programmed approach. Later, it was published by the Soviet officials and more teachers adopted his methods.

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25. _____, K voprosu o teorii i praktike sozdaniya programmirovannykh uchebnykh posobii (About the Question of Theory and Practice in the Creation of Programmed Materials), Mogilev, 1966, p. 26.

26. Ibid., pp. 26 & 27.

Although it is interesting to know the preceding details about the development of software for technical German, their overall patterns are more significant because they suggest two important characteristics in the production of Soviet programmed materials. Just as Tupalskii wrote his own programs for his classes, most of the Soviet software was written by classroom teachers to meet their own local needs. In contrast with the United States where programmed materials are often prepared by publishing companies with their eyes on a national educational market and their minds carefully calculating possible monetary rewards, Tupalskii and the other Soviet programmers did not receive financial compensation for their efforts. Even when their creations were published and distributed to other Soviet teachers, these Soviet writers did not stand to profit one "red kopeck". What appears to be so ironic about all of this is that apparently the Soviet method of producing software stresses the participation of classroom teachers and is more decentralized than the American way in which publishing firms play the decisive role.

Even though it might appear that the basic issue is the "profit scheme" versus a "socialistic one," the crucial questions for educators should be which system provides the best learning programs and fosters innovations in software. It would seem that a comparative study of the Soviet and

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27. <u>Ibid</u>., p. 30.

American approaches in the development of programmed materials could provide much useful information for both American and Soviet educators.

In the early stages of the evolution of the technology, it appears that the participation of Soviet teachers has been stressed. However, it also seems that their role has been greatly influenced by the formats of the programs and existing techniques. As Tupalskii pointed out, there is a danger in relying too heavily on technical rules. This is how he summarized the problem in designing software.

> However, it does not mean that the talent of the better teacher and scholar can be replaced by a series of technical rules, methods, and recommendations. A high quality text, which can be called correctly a programmed one, is only achieved by combining inspiration and mastery, theory and practice, talent and work.[28]

While this case study was about the development of software in Mogilev, there is no question that other Soviet programs were created in a very similar manner. First of all, they were written mainly by classroom teachers for local use and were not "profitable ventures" for their designers. Secondly, Soviet programmers, like Tupalskii, were consciously striving to create software of high quality by doing something more than following "pat formulas" in manuals.

Without a doubt, the creation of imaginative and high quality programmed materials, whether they are printed in books or stored in computers, is one of the great educational

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28. *Ibid.*, p. 30.

challenges confronting Soviet teachers. As stated earlier, how the Soviets respond to this challenge will probably determine the success or failure of their programmed instruction.

Case Study V: Cold War Warriors With a New Weapon

Background Data

Even though the United States and Soviet Union claimed that they were only designing weapons for defense, the fact remains that during the sixties both superpowers developed more armaments than needed to destroy each other. With this capacity for overkill, there was an even greater need in both countries for leaders who could make difficult political decisions without miscalculations and technicians who could keep the war machines functioning without breakdowns. Far-fetched as it may seem, the lives of many Americans and Soviets became dependent upon how effectively their highly trained civilian and military specialists controlled the lethal machines in each nation's arsenal. A serious error, for example, by an electronic technician could conceivably start a chain reaction triggering a nuclear armed missile on its automatic journey and resulting in perhaps the ultimate horror - World War III.

Faced with such a delicate balance of terror and dire need for almost flawless human performance in the maintenance of the precarious equilibrium, key Soviet military leaders turned to programmed instruction for aid in training skilled manpower. Their experiments with the educational technology in military classrooms suggest a series of questions that should concern anyone who noted how the opening of the seventies was marked by the emergence of even deadlier weapons systems. How did the Soviets employ programmed instruction in their military schools? Did the technology really make a difference in the performance of men who were trained to man the lethal Soviet military weapons and to trigger them into action?

The following case study provides some concrete data about the use of programmed instruction at the Red Banner Academy for Armored Forces and, more importantly, connotes some hypotheses about the training of Soviet military personnel. It should be noted that this school is located in Moscow and is somewhat like the United States Army's crack training center for armored warfare at Fort Knox, Kentucky. Unlike its American counterpart, however, the Soviet military academy offers advanced programs leading to both master and doctor's degrees.

Obviously, this investigator did not obtain comprehensive data about the educational institutions serving the Soviet military establishment nor about the Armored Academy. Just as there is an aura of secrecy surrounding key American military operations, there is a similar one enveloping the activities of the Soviet armed forces.

Data About the Application

The first experiments with programmed instruction at the Academy were conducted during the 1964-65 school year and were designed to determine the feasibility of the educational technology. These efforts consisted of some very systematic applications in core subjects: higher mathematics, electrical and automatic equipment in tanks.

The teachers grouped the soldiers according to three basic methods of instruction: (1) Group A was made up of trainees who were instructed by lectures. (2) Group B consisted of trainees who used programmed instruction. (3) Group C contained trainees who taught themselves by reading pamphlets and books.

After the training cycle was completed, the future Soviet officers were tested. The results indicated that 15% of Group B (soldiers who learned by programmed instruction) answered correctly all ten questions and only 9% of Group A (soldiers who listened to lectures) achieved perfect scores. The achievement of soldiers in Group C was the poorest of all groups. As a result of these data, the teachers at the Academy were convinced that the technology had possibilities for improving instruction. But they were still uncertain about when and how to apply it most effectively.[29]

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29. _____, *Kiterii otsenki effektivnosti i rezul'tati statisticheskogo analiza programmirovannogo obucheniya*, (Criteria of Evaluation of the Effectiveness and Results of a Statistical Analysis of Programmed Instruction), Moscow, 1966, p. 7. It should be added that none of the students who instructed themselves achieved perfect scores. It is also noteworthy that in a curve of normal distribution about 2-1/2% of a group achieve perfect scores.

In order to answer such questions, another set of experiments was conducted at the Armored Academy. The future Soviet tankers in these experimental conditions learned only by programmed instruction. Once again, there were three groups and their schedules during the training cycle were as follows: Group I had 116 hours in general scientific and engineering subjects. Group II studied specialized and technical subjects for 306 hours. Group III was instructed in general military courses for 140 hours.

The preparations for all three sections of programmed instruction were very extensive. Staff members from eighteen different departments had to develop the programs. Twenty-seven (27) of them were written by these teachers and each one was about one hundred (100) pages in length. These materials were designed for such technical subjects as braking gears, basic theory and construction of armored transport carriers, direct electrical current, electrical measuring devices, electrical and automatic weapons systems in tanks, higher mathematics, thermodynamics, basic theory of electrical circuits and automatic control. It was reported by the involved Soviets that the amount of time required to prepare the preceding texts far exceeded what was usually needed to plan for a similar block of hours in traditional instruction.[30]

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30. Ibid., pp. 9, 10, & 11.

In contrast to usual Soviet practices, most of the programs were designed for multiple choice responses. But about one-fourth of them were developed for an answer constructed by the student.

When the armored personnel in these three groups were tested, the staff at the Academy discovered much to their dismay that the achievement of the students did not increase significantly over those who studied previously under traditional instruction. Thus, it became apparent that programming the entire block of time allotted for instruction was not the answer.

In the next training cycle, the same subjects were taught by combining both programmed and traditional instruction. Under these conditions, the trainees progressed at a faster rate and learned more than any of the previous groups. Consequently, the Soviets at the Academy concluded that a combination of programmed and traditional instruction was the most effective way of teaching their armored personnel.[31]

Even though the teachers at the armored center were generally pleased with the results of programmed instruction, they added that it still needed some improvements. These Soviets, for example, suggested that teachers should be allotted more time to plan for this new approach and the learners should be tested at a later date in order to determine how much of the information was retained.

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31. Ibid., p. 11.

Clearly, the teachers at the Armored Academy measured the success of programmed instruction not on the basis of flawless performances by every trainee involved in the experiments. Instead, the technology was viewed as successful when it enabled more future armored officers to achieve perfect scores in examinations than those who were tested after studying under traditional methods. Nevertheless, it should be remembered that the results of a group in which only fifteen percent of its members responded correctly to all items in a test were offered as evidence of superior instruction. If one considers what knowledge tank commanders must possess and how skillfully they must apply it, he can only doubt whether it is possible to train men to control infallibly more complex weapons.

Regrettably, there were no data discovered in the research, nor conclusions to be reached from this author's conversations with Soviet technologists, that sufficient safeguards have been built into these systems to preclude the possibility of costly human error.

At this point, it might be asked where do such military educators as those at the Armored Academy and in other schools go from here? Until these Soviets and their counterparts throughout the world stop equating national security with the proliferation of arms and start thinking that it might be impossible to train men to respond impeccably under the stresses and strains of crises, it seems that the Armored Academy and other institutions like it are leading mankind in a race to oblivion. Unfortunately, neither programmed instruction, nor traditional instruction, nor self-instruction, nor any combination of them at the Moscow School emerged as a formidable obstacle which might impede this sucidal contest.

Case Study VI: Instant Instruction in Soviet Living Rooms

Background Data

What radical changes do Soviet engineers and educators foresee as a result of their experiments with programmed instruction? Where are such patterns for the future being nurtured in the Soviet educational system? The following case study was selected because it offers some initial information concerning these kinds of questions. Essentially, the sources for the data were printed in Russian reports and discussions at the Moscow Energetics Institute with communications experts.

Until foreign observers begin to take seriously the activities in Soviet extension-correspondence institutes, it is very likely that their investigations, aimed at uncovering the significant stirrings of technological change in the Soviet schools will be focused on the wrong places. Of all the reasons why such institutions merit serious investigation, there are several which should be mentioned here: First, extension-correspondence institutes have grown very rapidly in terms of student enrollment during the Soviet drive for industrialization. Second, this segment of the

Soviet educational system has been a recent locale for some rather far reaching innovations in instruction.

The centers for these experimental efforts in the sixties have been the All-Soviet Extension-Correspondence Institute in Moscow and the North-Western Polytechnical Correspondence Institute in Leningrad. However, before one falsely equates such Soviet schools with those in the United States, it is necessary to describe briefly a few traits that distinguish them from their American counterparts. In the Soviet Union, there are 471 correspondence schools affiliated with higher educational institutions, and also 23 independent extension-correspondence institutes having their own branches in various cities. The Correspondence Institutes in Leningrad and Moscow are examples of independent schools with branches in many other cities and both offer courses leading to degrees in a wide variety of specialities.[32]

Another distinctive characteristic of these Soviet institutes is how they require their students to attend classes in regular classrooms and perform experiments in laboratories located on their campuses. Such sessions and consultations complement the written assignments, completed in the learner's home and then mailed to an institute where they are

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32. A.V. Nikolskii, Printzipi programmirovannogo obucheniya studentov-zaochnikovi vechernikov (Principles of Programmed Instruction and Control of Extension-Correspondence and Evening Students), Moscow, 1966, pp. 2-7.

checked by a teacher and afterwards returned to the correspondent.[33]

As one reads the following account of how programmed instruction was employed at the North-Western Polytechnical Correspondence Institute, it is important to bear in mind the special features of this type of Soviet educational institution because they constitute an important set of factors in the experimental situation.

Data About the Application

In designing programmed instruction, the staff members at the North-Western Polytechnical Correspondence Institute began with the premise that their students were in some respects unlike those who attended regular university classes. This meant that correspondence courses had to be designed for men and women who were employed in industry during the day and studied at night when they were fatigued.[34] As a result, each programmed lesson had to be developed so that it could be mastered in a limited amount of time and without taxing a student who was probably tired.

Instead of initially testing programmed instruction in a wide range of subject matter areas, the designers selected

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33. _____, Nekotorye voprosy programmirovannogo obucheniya (Some Problems in Programmed Instruction), Leningrad, 1966, p. 3. Perhaps the information about Soviet correspondence schools whets the appetite of the reader for more data about them. If this is the case, he should read the classic American study of the Soviet schools, Education and Professional Employment in the USSR, (pp. 234-237) by Nicholas DeWitt or read the Russian sources cited in this case study.

34. Ibid., p. 3.

for their experiment one course dealing with the resistance of materials and modified it in the following manner:[35] First, the existing lessons were broken down into self-contained paragraphs that contained a few sentences explaining a key principle or concept and two or three questions testing the student's understanding of the explanation. Second, the paragraphs were arranged in a logical sequence and grouped into chapters. Finally, answers for each question were prepared and placed at the end of the appropriate chapters.

The teachers at the Institute measured the effectiveness of the new software by comparing the grades of students in the programmed course with the marks of those who learned previously by traditional methods. In reporting the results, the Soviets stated that the students who studied with programmed materials received on the average higher grades than those who were instructed by the old methods.[36] These are the specific conclusions which the Soviets drew from their experiment:

> Certain aspects of programmed instruction aided these students significantly in their studies: (1) the breakdown of subject matter into small, logical, self-contained doses; (2) the maximum effort to avoid duplication; (3) and the continuous self-control of the information's flow and its sequential mastery.[37]

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35. _Ibid._, pp. 3,4, & 5.

36. _Ibid._, p. 6.

37. _Ibid._, pp. 3 & 4.

More importantly, the initial application of programmed instruction set in motion other forces leading to further innovations at the Institute and also in the Soviet Union. Locally, more programs were designed for other courses and a special center equipped with control-information devices, was created to teach students in foreign languages and mathematics. Nationally, an unusual "marriage" of technical means resulted from the experimental activities in Leningrad.

This merger involving television and programmed instruction was consumated in the early sixties at a special conference sponsored by the North-Western Polytechnical Correspondence Institute. Undoubtedly, the event was a milestone in the history of modern education because Soviet educators, engineers and government officials met and developed specific plans for utilizing educational television and programmed instruction in the Soviet Union.[38]

It should be pointed out that one of the ultimate goals for the new nationwide learning system was revealed to this investigator in a very interesting interview at the Moscow Energetics Institute. In the conversation, A.V. Netushil, a communications expert at the Institute, described how

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38. The following issues of Vestnik Visshey Skholi: January, 1965; October, 1966; June, 1968; November, 1968; March, 1969; and April, 1969: contain more detailed information about the rapid development of educational television for correspondence and other schools. The issue of January, 1965 has an informative article about the Leningrad Conference and provides an informative baseline for measuring Soviet progress with programmed instruction and educational television.

every Soviet home in the very near future would be equipped with some type of transmitting device, similar to a teletype machine, which would be connected with the family's television set. These two devices, according to Netushil, would permit the Soviet viewer to learn by programmed, televised instruction in his own living room.[39]

At this point, perhaps some readers are ready to dismiss Netushil's views as just another "communist pipe dream." Nevertheless, before making this type of judgment, it might be worthwhile to consider his ideas from several different vantage points: Educationally speaking, Netushil is neither an ordinary Soviet engineer nor a simple classroom teacher describing an educational dream, but a top-notch Soviet communications expert who designs sophisticated cybernetic systems, and also a firstrate Soviet scholar whose research deals with the theoretical aspects of information theory. More significantly, Netushil's projections about technological innovations in Soviet communications are rather conservative in comparison with the communications systems that the Soviets are developing for international use.[40] Putting it differently, Netushil and other Soviet engineers like

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39. The interview was conducted in February of 1968. It should be mentioned that Netushil studied in the United States and has written extensively about his impressions of American educational technology.

40. See opening quotation for this chapter and read pages 108, 109 and 110 in Arthur Clarke's The Promise of Space, for further details about these Soviet developments.

him, of course, are dreamers, but they are men who have regularly made their dreams about technology a reality and are continually changing Soviet technological realities. For these reasons, one should take rather seriously the ideas of such Soviets as Netushil.

In conclusion, the data indicate that the Soviet extension-correspondence schools and particularly the North-Western Institute in Leningrad have been involved with developing some important innovations with programmed instruction and television. This combination of technical means, making technically feasible the possibility of turning every Soviet living room into an electronic classroom, has nation-wide implications and the possible coupling of both television and educational technology with communications satelites has international implications. Thus, it seems that foreign observers cannot afford to overlook what has happened in the sixties and been planned for Soviet correspondence students of the seventies and eighties.

Case Study VII: Cybernetic Coaches

Background Data

In the preceding case studies, the data revealed how Soviet educators were devising ways to obtain feedback about what was happening in the psyches of students. After reading the various reports, it might seem that the Soviets were only interested in the cognitive aspects of learning and were concerned just with "teenagers" and adults who were studying technical and scientific specialities. If one has such an impression, it is a very false view because the Soviets did not restrict their efforts to just these groups and subject matter areas.

The next example illustrates another dimension in the application of Soviet programmed instruction. This phase involved young children and the cybernetic control of their muscular activity. The ensuing information is essentially about how a group of teachers used a programmed approach to help young children develop their athletic skills. There is a strong possibility that these data will force some readers to come to grips with perhaps a latent bias that the learning processes must be geared for the printed media. Therefore, it might be very useful to keep in mind that programmed instruction was not always limited by the Soviets to traditional classrooms where the basic source of information for the student was a textbook.

Data About the Application

In the Soviet Union, there are approximately fifteen higher educational institutes of physical culture. Two of the most important schools are located in Leningrad and Moscow. It would seem that they would be the places to investigate for innovations in cybernetics and programmed instruction. Here again, what seems most probable is really most improbable because the leaders in these developments are from a lesser known school, the Georgian State Institute of Physical Culture, located in Tbilisi, Georgia. The Georgian contributions have apparently been in the development of new theories for the technology and the testing of them in "classroom" situations.

At first glance, it seems that the staff at the Institute of Physical Culture has selected two rather conventional topics for its research: human voluntary motor skills and their development. What is unusual about their approach is that they have attempted to explain in cybernetic terms how these movements can be developed and how they can be controlled cybernetically. From this framework, these Georgian teachers have devised certain principles of learning and methods for implementing them. Both have been tested in "classroom" situations where youngsters between the ages of ten and eleven were taught how to play football and to race a bicycle. Even though it might seem strange from an academic vantage point, all of these activities are considered by the Georgians as aspects of programmed instruction.

One of the most interesting combinations of theory and practice was developed by L.B. Chkhaidze who is an academician at the Georgian Institute of Cybernetics and A.F. Torondzhadze who is a teacher at the Institute of Physical Culture. They began their experiment by analyzing from a cybernetic point of view how certain muscles function and which motor skills and habits are required for bicycle racing. After completing the first phase, Chkhaidze and Toronkzhadze devised some methods for controlling cybernetically the development of the needed muscular activities. Essentially, what the two Soviets were striving to create, was a set of step by step procedures which would provide a student with feedback while he was learning the necessary motor skills and habits.[41]

Since Chkhaidze and Torondzhadze needed to develop a learning system in which information was transmitted and received almost instantaneously, they could not use printed media for the messages. Therefore, these Soviets turned to an electric means of communication. In the application, an oscillograph was used to supply the feedback for the learners.

Here is a brief description of the components and how they functioned in this Georgian brand of programmed instruction:

(1) A tension measuring device was attached to the pedals of the bicycle.

(2) Then this instrument for measurement was connected to an oscillograph which displayed visually the signals caused by the force exerted on the pedals.

(3) An instructor explained to the students how the technical devices worked and how a bicycle should be pedalled in a race.

(4) After the explanation, the instructor demonstrated how to pedal properly and how to use the feedback from the oscillograph.

(5) Finally, each student pedalled the bicycle and modified his movement according to the feedback which he received from the oscillograph.

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41. _____, Opyt razrabotki i primeniniya metodov programmirovannogo obucheniya v nekotorykh vidakh sporta (Experiment in The Development and Application of the Methods of Programmed Instruction in Some Types of Sport), Moscow, 1966, p. 2.

42. Ibid., pp. 4,5,6 & 7.

Thus Chkhaidze and Toronzhadze were able to program a learning process and give each student an opportunity to control his own motor activity while he learned new skills and habits. According to Soviet reports, the children enjoyed learning in this type of programmed instruction.[43] In addition, it attracted the attention of other physical education teachers because students did not learn improper habits which they had to unlearn, and new technical means were created to provide immediate feedback.

All of this illustrates once again how the Soviets took advantage of cybernetic constructs in the applications of their programmed instruction. At the Georgian Institute of Physical Culture, however, the staff extended this science by applying it for the first time in Soviet physical education. The result was a viable learning system with almost instant feedback for the learner. Although its mechanical components were relatively simple technical devices, the whole complex constituted a set of conditions allowing for versatility and individualized instruction.

Also the example shows concretely that the Soviets tend to define "programmed instruction" rather broadly. Perhaps this Soviet viewpoint about the technology upsets those educators who view the term only from perhaps a narrower academic perspective. If this is the case, then perhaps the most appropriate postscript to the preceding data and their interpretation might be the following epigram

43. Ibid., pp. 5, 6 & 7.

used by historians to describe a group of people who also failed to grasp the diverse, new meanings in their epoch: "They forgot nothing and they learned nothing!"

Case Study VIII: The Birth of an Electronic Prodigy

Background Data

In its educational form, the digital computer has existed in the Soviet Union less than a decade. Yet Admiral Berg, Academician Glushkov, other top Soviet scientists and technicians have acknowledged that this mere child of modern technology represents the wave of the future in the Soviet schools. Their informed views cannot be dismissed lightly nor accepted blandly. At least, they should raise such basic questions as the following: Why are computers viewed by Soviet experts as ideal teaching machines? What type of functions can they perform in classrooms? Does their performance warrant the optimism of the Soviets?

Instead of seeking answers in scholarly projections about the device's bright future, it might be wiser to return to its humble beginnings because the computers of the future will be the offsprings of those in the past. But it is very difficult to describe exactly where and which digital computer was first used in a Soviet classroom. The reason for the uncertainty is that the machine was apparently born in multiples and in various locations. Or stating it more concisely, this innovation in Soviet instruction was developed almost simultaneously in Moscow, Kiev and Novosibirsk.

The following case study is about an initial effort to use the cybernetic device in a Siberian school. The description should provide some hard data about the performance of computers and also a partial explanation of the Soviet optimism about its prospects.

Data About the Application

The Novosibirsk Electro-Technical Institute is one of the most important higher educational institutions in Siberia and also a key school in the Soviet system. The significance of the Institute becomes more apparent when one considers that in 1965, approximately 13,000 students were enrolled in the school and 1,500 specialists graduated from it and in 1970 approximately 20,000 students are enrolled and 2,500 of them will graduate from the Institute.[44]

In addition, there is a sense of urgency at the Novosibirsk school because its graduates are needed quickly to staff many key positions in the industrial, scientific, and military institutions of both Western and Eastern Siberia. With the threat of Chinese soldiers along the Siberian border, it should be rather obvious why this school is playing a pivotal role in contemporary Soviet history.

Thus, it would be a real understatement to say that the staff has been under considerable pressure to accelerate the learning processes of students and to increase the enrollment.

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44. _____, Ob opyte vnedreniya programmirovannogo obucheniya i tekhnicheskikh sredstv v uchebnykh protsess (about the Initial Experiments with Programmed Instruction and Technical Means in the Processes of Education), Novosibirsk, 1966, p. 1.

In response to these pressing needs, a research and development program concerning the use of the digital computer in instruction was started early in the 1960's. Participating in the projects were classroom teachers, personnel from the computer center, and other technicians at the Institute.

In their first experiment sometime in the middle 1960's, these participants designed a learning system in which a computer questioned a student and evaluated his response. Here is briefly what happened in the man and machine dialogue:[45]

QUESTION FROM THE COMPUTER:	At individual terminals, each student would receive a question from the device.
STUDENT RESPONSE:	Then each learner would answer the question by typing on a teletype device which would transmit these data to the computer.
COMPUTER EVALUATION:	After receiving the information, it was processed and an evaluation of either excellent (5), good (4), satisfactory (3), or unsatisfactory (2), was transmitted to each student.

According to the Soviet reports, ten students answered ten questions apiece. Therefore, one hundred (100) different replies were evaluated by the machine. At the same time, their responses were also submitted to a qualified teacher who then graded them. In order to determine the validity and reliability of the computer's evaluations, they were compared with those of the teacher. Because of space limitations, Table 3 shows only the partial results of the

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45. Ibid., pp. 19, 20 & 21. See example of Soviet software in Chapter III for more details.

comparison. It should be mentioned that the rest of the data supported what is depicted below:[46]

Table 3: Comparison of Grades by the Teacher & Computer

Number of the Question	Student Replies to the Questions	Grades by Teacher	Grades by Computer	Time Needed by Computer
1	1	4	3	8.00 minutes
	2	5	5	5.5 "
	3	4	4	6.5 "
	4	3	3	8.25 "
	5	2	3	8.2 "
	6	3	3	7.4 "
	7	4	3	8.0 "
	8	5	5	6.1 "
	9	4	3	8.1 "
	10	3	3	7.25 "
2	1	5	5	1.0 "
	2	4	5	1.8 "
	3	3	3	3.25 "
	4	3	3	5.25 "
	5	2	2	5.50 "

As the comparison clearly indicated, most of the grades given by the computer and the teacher were congruent. These results and others like them led the Soviets to believe that the computer could be effectively used in the processes of instruction. Nevertheless, it was also apparent that, even though the teacher was freed from certain routine operations, other tasks for teachers and technicians were created by the computer.

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46. *Ibid.*, p. 22. It should be noted that the difficulty of the question influenced the time needed by the computer. For example, if the question was complex, it took the student a longer period of time to formulate his answer.

Generally speaking, the applications of computerized programmed instruction at Novosibirsk and in other locations were models for automation in which certain teaching functions were performed by computers. Furthermore, it appears that the Soviets intended to design a teaching machine which carries on a dialogue with the learner. This means that the Soviets were attempting to develop a teaching machine not "cramming facts into the heads of students," but allowing them to develop their own responses. Obviously, such a task in electronic design is extremely complex and the efforts of the Novosibirsk engineers represented only a small step in what the Soviets generally consider as the right direction.

Either an Epilogue or a Prologue to the Future

Confronted with the fact that scientific knowledge increased exponentially during the last decade, and the prospect that this type of information will burgeon even more during the seventies, the Soviets desperately turned to modern technology for aid. In their educational efforts to cope with a seemingly never-ending and ever increasing stream of knowledge, the Soviets concentrated mainly on developing programmed instruction which hopefully would help them control cybernetically the flow of data in their classrooms.

Quantitatively, the Soviets tested various types of this technology's hardware and software in over 250 higher educational institutions, 300 semi-professional schools, 200 vocational-technical institutes, and 700 secondary schools.

Qualitatively, Soviet authorities, including among them such leading figures as V.P. Yelutin, Admiral Berg, General Rostunov, and V.M. Glushkov, viewed the applications as successful innovations and mandates for the further development and dissemination of programmed instruction.

Instead of describing generally and analyzing detachedly the practical uses of the technology in an abstract manner isolated from their educational and historical context, eight case studies were presented in this chapter. they consisted of the following examples which illustrated concretely key characteristics and trends of Soviet programmed instruction: (1) a model for Soviet instruction selected by the Ministry of Education (Moscow Energetics Institute), (2) some new concepts and guidelines for medical education (Kuibyshev Medical Institute), (3) a set of techniques for designing software (Mogilev Machine Construction Institute), (4) the automation of language drills and practices (Moscow Energetics Institute), (5) the emergence of educational television and programmed instruction for correspondence students or plans for turning Soviet living rooms into electronic classrooms (North-Western Polytechnical Institute), (6) the development of coaching practices for the cybernetic era (Georgian State Institute of Physical Culture), (7) a new method for improving the skills and techniques of Soviet soldiers (Red Banner Military Academy for Armored Forces), (8) and computers teaching students to think for themselves, but not cramming useless information into their psyches, (Novosibirsk Electro-Technical Institute).

In short, these illustrations hopefully revealed the striking convulsions of educational change resulting in Soviet classrooms from the use of modern technology.

CHAPTER VI

NEITHER SOVIET GIANTS NOR WINDMILLS

> "Take care, sir," answered Sancho, "those over there are not giants but windmills, and those things which seem to be arms are their sails, which when they are whirled round by the wind turn the millstones.[1]

A Final Perspective

Unlike the romantic archetype, Don Quixote, who falsely interpreted his technological environment and consequently pitted himself against windmills, Lenin basically comprehended the significance of twentieth century technology and viewed it as an important ally. Envisaging a Communist utopia in which kilowatts of electricity would perform the laborious tasks of men, Lenin met with the other Bolsheviks in the early 1920's and persuaded them to adopt a plan for the electrification of Russia.[2] With their decision, Lenin and his followers set in motion a technological revolution which unleashed the powerful forces of automation in the Soviet Union.

In sharp contrast to the political revolution of the Bolsheviks that lost much of its drive during the last fifty years, their technological revolution has far surpassed the goals set by its original planners five decades ago.

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1. de Cervantes Saavedra, Miguel, Don Quixote of La Mancha, as translated and edited by Walter Starkie, (Mentor Books: New York, 1957), p. 42.

2. See Chapter I, pp. 1 & 2 for details about the meeting.

Already by the end of the 1950's, the automatic production of electricity -- once viewed as a new and revolutionary aim -- had become commonplace in the Soviet Union. Consequently, another series of technological advances, stemming from the extensive use of electricity to manipulate information, followed in the 1960's. Then, Soviet society reached a new stage of development that was marked by a series of serious problems and spectacular achievements.

These feats were particularly evident in the Soviet industrial, educational, and military complexes where computers, instead of men, were used to regulate automatically the flow of information in key processes. Even certain functions of government, such as planning and controlling the economy, were partially performed by electronic devices. Moreover, the Soviets had designed communications systems that could move electronic images and symbols almost instantaneously throughout the world and in outer space. Essentially, the mechanical machine -- which can most easily be defined as an imitation of human muscle -- lost its dominating position among the tools of the Soviets; while electronic devices -- which imitate the processes of the brain -- became increasingly important in the Soviet Union.

With the critical transition from a mechanically to an electrically oriented society, however, there also emerged a cluster of consequences confronting the Soviets. Somewhat like an individual buying a television set, sooner or later Soviet society had to pay for its new technological possessions and modify its life style in order to utilize effectively the new items. But unlike the appliance buyer who can easily calculate his costs and adjust his social activities on the basis of other men's past experiences, the Soviets had to determine without the aid of established precedent both the social and economic costs for their growing dependency upon computers, television systems, communication satelites, and many other electronic devices.

Faced with the possibility of paying some very high prices that included changes of great magnitude, it was no accident that Communist planners began to seek answers for the following kinds of questions: Was the advance of automation bringing material abundance soon enough or only creating a rising tide of expectations which could not be fulfilled? Were the technological changes raising the spectre of mass unemployment and creating problems of leisure? Was dehumanization becoming the fate of individuals as more decision making was shifted from people to machines? Which widely held Soviet values were being changed or reaffirmed under the impact of a steady stream of information from the electronic media? Which institutions were showing signs of strain and needed to be updated for the age of information? What did these developments imply for the total system in terms of internal and external security? In short, Communist leaders and planners needed to know how modern technology was shaping both the individual and his institutions, and to judge which changes were desirable.

Clearly, the risks involved in moving the Soviet Union from a mechanically based industrial state to a post-industrial economy stressing the production of information were too great to be left to chance. In the late fifties, the Communist Party entrusted the Scientific Council for Cybernetics with the task of guiding the nation through this complex process. Under the leadership of Admiral A.I. Berg, the Council has attempted to develop both plans and means for controlling cybernetically the changeover in every key component in the Soviet system.

In implementing their plan to automate important aspects of Soviet reality, key Soviets like Admiral A.I. Berg, General T.I. Rostunov, Academician V.M. Glushkov, and Minister of Higher and Secondary Specialized Education, V.P. Yelutin became particularly concerned with obsolete theories and practices in the educational system. According to them, much of traditional instruction was outdated and needed to be updated. In an attempt to remove this obsolescence, Soviet engineers and educators designed a rather sophisticated educational technology for automating the processes of instruction. Briefly, then, Berg and the other Soviet designers did not view this innovation only in terms of its educational consequences, but looked upon it as a cybernetic means for modernizing a crucial segment in the Soviet economy.

Thus the mechanical age with its promises and disappointments had culminated and the electrical era with its new opportunities and problems had emerged in the Soviet

Union during the last five decades. By the end of the sixties, the Soviets with various applications of their electric technology had made such advances that their technological environment was almost as different from that of Lenin's epoch as his world differed from the days of Peter the Great. Paradoxically, Lenin and his later disciples had overcome many of the stagnant traditions of Tsarist Russia -- a nation in which the past encumbered the people more perhaps than anywhere else on the continent -- and also created problems of obsolescence in their own revolutionary institutions. Among those key components in the Soviet system that badly needed modernization, the Soviet schools stood out as establishments designed basically in and for the past mechanical age. Soviet educators, like Don Quixote centuries ago, were surrounded by a new technological milieu. Would they also misunderstand it and tilt at their modern windmills?

In Retrospect

In the past, neither Soviet nor foreign scholars have extensively investigated the impact of modern technology on Soviet education. This lack of scholarship is understandable because the more concrete technological manifestations, the electronic teaching machines, have been developed rather recently in the early 1960's. Fortunately, the Soviet development of teaching machines attracted the attention of two American researchers, R.E. Levien and M.E. Maron of the RAND corporation. In their 1964 report, prepared for high ranking US Government officials, Levien and Maron focused mainly on the electronic devices and suggested further studies of them by American scholars.[3]

The present investigation, however, is an exploratory study within the broader field of Soviet educational technology. Specifically, it concerns the development and use of programmirovannoe obuchenie, (Soviet programmed instruction), a Russian concept encompassing both the techniques and devices for automating instruction.[4] The idea for the research was provided by surveying Russian reports in Vestnik Visshey Shkoli that contained surprising data concerning Soviet progress in the automation of instruction.[5] The purpose for the study was to extend and amplify insofar as possible these Russian accounts by Samokhvalova and others, and the American investigation by Levien and Maron.

It was hypothesized that Soviet scientists, technicians, military leaders, and educators had further refined and utilized programmirovannoe obuchenie since the completion of Levien and Maron's investigation in 1964. In addition, the Russian account by Samokhvalova suggested indirectly that the two American investigators did not have access to important data about related research and development in

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3 Levien and Maron, op cit , p 7

4. See Chapter I for details about translation of this Russian term

5. Samokhvalova, op. cit., pp. 23-44. Also see Bibliography for detailed listing of the Soviet journals.

Soviet psychology, cybernetics, and computer technology.[6] All of this suggested a relatively large information gap about the Soviet plans for and means of automating instruction.

Furthermore, it seemed that the lack of knowledge about Soviet educational technology was part of a larger, more complex problem. The difficulty was perhaps best summed up by Walter Buckingham, a consultant for the U.S. Congress: "There is no greater scientific bottleneck today than that of translating Russian scientific periodicals."[7] Moreover, he stated that this bottleneck had caused American researchers to lose valuable time solving problems which their Soviet counterparts had already resolved.[8] Nevertheless, it was felt by this investigator that although the possibility of reducing costly repetition in American research was reason enough for systematically studying the automation of Soviet instruction, there was another more important purpose for the study. That the mistakes of Soviet teachers might be unnecessarily repeated in American classrooms seemed like a very high price to pay for lack of information.

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6. Samokhvalova, op. cit., pp. 23-44.

7. Buckingham, op. cit., p. 33.

8. Ibid., p. 33.

This investigation, therefore, was mainly designed to provide American educators with answers for the following questions: Who were the leaders in the Soviet struggle to automate instruction and what positions did they occupy in Soviet society? Who were the major theoreticians for the movement and what were their basic conceptions of the technology? What were the major events in its historical development? What did the Soviets achieve in their related research and development in cybernetics, engineering of devices, psychology, and pedagogy? What kinds of machines and techniques did the Soviets use in the applications of their programmed instruction? Where did they apply these innovations and what resulted from them? What were the Soviet intentions concerning the future use of their hardware and software?

Clearly, the purpose of this research was not to make a highly specialized or detailed statistical study of the Soviet technology. Neither approach was warranted by existing scholarly needs. Aside from Levien and Maron's report about teaching machines and a relatively few translated accounts, the bulk of the literature was printed in Russian and most of it was available only in the Soviet Union. Obviously, there was a critical need for a body of translated information upon which other American educators and specialists could build. This required the investigator to go to the Soviet Union, collect materials there, translate them, synthesize the key ideas, observe firsthand the techniques and devices whenever possible, and listened to on-the-spot reactions of participating teachers and students. Thus, the basic methods were to permit the Russians to "speak" for themselves by their actions, printed and oral words, and then to translate as much of this as possible into English for American educators, decision makers, scientists, technicians, and other specialists involved with the automation of instruction in the United States.

In order to arrange the data into meaningful patterns, six primary themes, dealing with programmirovannoe obuchenie and encompassing the time span from 1961 to 1969, were presented in the following order: (1) background information about Soviet society, (2) an outline of the basic conceptual framework, (3) a brief historical account of major events and developments, (4) an examination of related research in Soviet psychology, cybernetics, computer technology, and pedagogy, (5) an explanation of the designs and uses for the electronic devices ranging from small teaching machines to digital computers, (6) and case studies of the technology's application in Soviet classrooms.

The results of the preceding descriptions and analyses are summarized as follows:

The Soviet Setting

In order to understand why the Soviets began to automate instruction in the sixties, it is necessary to note how the Soviet research establishment and its output of knowledge have burgeoned during the last two decades. Of all the scientists and technicians trained for the past three centuries in both Tsarist Russia and the Soviet Union, the majority of them were living in the 1960's and involved in some phases of Soviet research and development. Moreover, the output of knowledge, produced by Tsarist and Soviet scholars from the early 1700's to 1945, was doubled by Soviet researchers working from 1946 to 1965.

This massive expansion of professional manpower and spectacular growth of knowledge has been a driving force that has caused an acceleration of technological innovations which in turn have multiplied the scientific knowledge of the Soviets. But the upward spiral of information and innovation also had such an impact on Soviet society that many of its traditional patterns became obsolete. By the early sixties, technological advances had created some unprecedented stresses and strains on the Soviet educational system.

There was a new generation of students who needed to master the deluge of data and inventions that would probably become outmoded in a decade or so. While Soviet educators were trying to meet the needs of a new technological age, their efforts attracted the attention of scientists, technicians, and military leaders. Such influential Soviets as Admiral A.I. Berg and Academician V.M. Glushkov pointed out that there were obstacles impeding the flow of information in the educational system and the traditional ways of instruction seemed to be ineffectual in coping with the situation. Thinking that such inadequacies could impede the development of Soviet manpower and thus the economy, a group of Soviets began to design a type of educational technology for regulating automatically the flow of information in instruction.

Nevertheless, the automation of Soviet classrooms ranks as one of the most ambitious educational and technological tasks ever undertaken by any society. This development could conceivably involve as many as 72,000,000 full or part-time students in schools located in 8,600,870 square miles of territory. To complicate their problems even more the Soviets could not afford to waste much time because studies of trends revealed that the volume of Soviet scientific and technical knowledge would increase at least eight times by the end of the twentieth century. Thus, the obstacles seemed formidable, but if they could be surmounted, the opportunities for Soviet development would be almost unlimited.

Theories and Theoreticians

The search for the driving forces behind the movement to automate Soviet instruction led directly to men with ideas, not machines. Among the ranks of these theoreticians, there were such highly honored and respected Soviet figures as: Admiral A.I. Berg, the Chairman for the Cybernetic Council; Academician V.M. Glushkov, the brilliant cybernetician who introduced computers into the planning stages of the Soviet economy; General T.I. Rostunov, the superintendent of a crack military academy in the Ukraine; and P. Ya. Gal'perin, a Moscow University professor considered by the

Soviets as one of their leading educational psychologists. In addition to the notables, there were lesser known teachers, engineers, and other professionals who also attempted to elaborate the basic theories for the technology. All of these Soviets generally tended to conceive of teaching and learning from a cybernetic vantage point which stressed information and the automatic control of it. On the whole, their theories reflected rather sophisticated thinking. Apparently, ideological considerations did not limit the theoretical possibilities which these Soviet theorists explored.

As a result of the participation of engineers, cyberneticians, educators and other professionals in establishing a theoretical foundation, it was very difficult to outline exactly the boundaries of their overall construct. The lines of demarcation for *programmirovannoe obuchenie* were not smooth and even, but jagged and projected into other conceptual areas. Consequently, the Soviet conception of this technology included such diverse phenomena as: (a) the automation of certain teaching functions by programs and electronic devices; (b) the know-how used to design and develop the hardware, software, and the very processes in which they were applied; (c) a myriad of applications in classrooms; (d) and a series of historical events highlighted by dramatic turning points where the path of *programmirovannoe obuchenie* intersected with the cybernetic movement and other technological advances in the Soviet

Union.

Historical Highlights

The attempt to trace the broad technological landscape produced a rough map showing the important historical landmarks in the development of the Soviet innovation. These symbols represented such events as:

(1961) the invention of two electronic teaching machines in Moscow;

(1962) the emergence of Admiral Berg and the Scientific Council for Cybernetics as the leaders for the *programmirovannoe obuchenie* movement in the Soviet Union;

(1964) a display of hardware in the Exhibition for Economic Achievement in the USSR;

(1964-1966) a series of preliminary meeting and conferences held in the various republis;

(1966) the First All-Union Conference about Programmed Instruction and the Application of Technical Means to the Educational Processes;

(1966) an endorsement of the technology by the Minister for Higher and Secondary Specialized Education in the USSR and new plans for a broader utilization of programs and teaching machines;

(1967) the total number of graduates from a special Soviet school for programming techniques reached the 2,000 mark;

(1967) an exhibition of teaching machines in the Soviet pavillion at the World's Fair in Montreal;

(1968) the systematization of means for disseminating programmed instruction and other technological innovations by the staff at the Soviet Information Center for Programmed Instruction.

Research and Development in Related Areas

When the historical phenomena were viewed from the perspective that technology is something more than hardware, such a viewpoint suggested another area for investigation. This phase of the study revealed a composite image of the innovation's underlying research and development and the overall picture consisted of the following parts:

Psychology: Working within the theoretical framework of closely meshed Marxian and Pavlovian principles, three Soviet psychologists: P. Ya. Gal'perin, N.A. Reshetova, and N.F. Talyzina devised an overall rationale for *programmirovannoe obuchenie*, organized its processes along the lines of a cybernetic system, designed specific instructional procedures, and tested them in the classroom. Their efforts supplied the Soviets with certain clues about the development of the learner's psyche, raised a host of new questions about controlling it, and suggested some new ways for achieving this control.

Pedagogy: Soviet teachers involved with the technology concentrated their efforts on designing and testing software. Surprisingly enough, a centralized agency did not prepare the Soviet programs. This trend seemed to be in sharp contrast with the traditional Soviet patterns of centralized administration and also with the American pattern of preparation by publishing firms. At first, the Soviets developed programmed materials designed to foster the mastery of subject matter. But towards the end of the decade, the Soviets designers were attempting to create heuristic programs aimed at allowing the student to discover his own solutions to problems. These materials offered the Soviets new possibilities to utilize more efficiently their sophisticated electronic devices.

Computer Technology: In a very real sense, the Soviet schools have become new frontiers for computer technicians and their machines. These Soviets are attempting to develop in the applications of computerized programmed instruction the sophisticated cybernetic system which will be used in the Soviet schools of the future. While the Soviets have been relatively successful in these efforts, the design of their hardware still falls short of the mark envisaged by their chief designer, Admiral Berg. On the other hand, the Soviets seem to be mastering very quickly the necessary skills and techniques needed for adapting computers to the classroom. At this time, however, it is rather apparent that the introduction of digital computers into the classrooms is really a mandate for sweeping changes in Soviet education.

Cybernetics: Soviet cyberneticians have offered a diagnosis of traditional instruction's ills and suggested a cure for them. Their approach is based upon a conception of instruction as a control system in which the processes of information are regulated according to the psychic activities of the learner. It appears that the Soviet experiments with programmed instruction represent only the first phase in the Soviet cybernetic plan to automate instruction.

Soviet Hardware

With the practical application of cybernetic principles in automating industrial porcesses during the fifties, more Soviets began to comprehend that machines could conceivably process information like the human brain and thus be employed to simulate the mental functions of man. This shift in the design of machines from automating musclepower to brainpower has made possible what Norbert Wiener has called the "second industrial revolution" in which machines, instead of men, regulate the processes of production. In the sixties, the movement from mechanical to electrical machines spilled over into the Soviet schools.

As the data about Soviet teaching machines indicated, the Soviets commenced the task of automation in education less than nine years ago by constructing two primitive teaching machines and ended the decade with specially designed complexes controlled by digital computers. Measuring their efforts against their goal of automating instruction, it became very clear that the Soviets rapidly moved towards their final destination.

Although this fact is significant by itself, it is more important when considered from the perspective shaped by Norbert Wiener. From such a viewpoint, the whir of electronic devices and the hum of electric current surging through them in Soviet classrooms should signal to educators everywhere that the "second industrial revolution" has reached one of the world's largest educational systems.

But the future course of this revolutionary movement in the Soviet schools was not entirely clear at the end of the sixties Instead of predicting its outcome in the seventies and the eighties, it seemed more reasonable either to suspend judgment until more detailed data have been gathered about the Soviet economic plans for the transition or to wait for the verdict from future historians However, it should be kept in mind that the data in the present investigation suggested few reasons for underestimating the Soviet technical ability to automate instruction on a broader scale On the contrary, this study underscores Soviet engineering know-how with teaching machines and programs.

Case Studies From Soviet Classrooms

According to the views of Admiral Berg and other Soviet leaders, the Soviets were trying to amass basic data in their applications of programmed instruction so that engineers and educators could design the complex cybernetic systems which could be used in their schools of the future. In pursuit of this goal, the Soviets tested their machines and programs in various types of educational settings These included 250 higher educational institutions, 300 semiprofessional schools, 200 vocational-technical schools, and 700 secondary schools. The data about the experiments reveal that the Soviets generally concentrated their efforts in the following subject matter areas: higher mathematics, resistance of materials, electro-techniques, hydraulics, foreign languages, Russian, general technical and science courses. In addition, it seems hardly surprising that Soviets were particularly concerned about applying the technology in those higher, vocational, and secondary educational institutions which educate technicians and scientists.

Instead of removing the technology from its classroom context and presenting it completely outside of its Soviet cultural milieu, eight case studies were selected to illustrate the significant trends emerging in the applications of programmed instruction. These examples included the following: (1) a highly praised model of Soviet instruction selected by the Ministry of Education (Moscow Energetics Institute), (2) new concepts and guidelines for medical education (Kuibyshev Medical Institute), (3) a set of techniques for designing software (Mogilev Machine Construction Institute), (4) the automation of language drills and practices (Moscow Energetics Institute, (5) the emergence of educational television with programmed instruction and plans for turning Soviet living rooms into electronic classrooms (North-Western Polytechnical Institute), (6) the development of coaching techniques for the cybernetic era (Georgian State Institute of Physical Culture), (7) a new method for improving the skills and techniques of Soviet soldiers (Red Banner Military Academy for Armored Forces, (8) and computers designed to teach students to think for themselves without "cramming" useless information into their psyches (Novosibirsk Electro-technical Institute).

In qualitative terms, the results of these applications and others like them led such influential figures as V.P. Yelutin, Admiral Berg, General Rostunov, and V.M. Glushkov to view the technology as a successful innovation. In addition, the data indicate that these Soviets and their followers viewed the applications of programmed instruction as mandates for its further development and wider utilization.

Implications for Soviets and Americans

Nothing in what is summarized on the preceding pages is intended to imply that a social or even an educational millennium has been ushered into the Soviet Union by its embrace of modern technology. As a matter of fact, it has been repeatedly pointed out that a legacy of obsolescence for the Soviets and their institutions has followed in the wake of automation. What does suggest itself in the investigation, however, is that the Soviet Union is facing a cybernetic crisis in key sectors of its economy and much of the problem stems from the following conditions:

(1) The massive advances of Soviet science and technology are causing a tremendous increase in the volume and complexity of information to be communicated, assimilated, and applied by Soviet citizens at every level of society.

(2) The number of full and part-time students is steadily climbing in the Soviet Union. In addition to the usual number of young people, the enrollment totals are including more workers displaced by automation and professionals made obsolete by the knowledge explosion. All of them are requiring periodic retraining and updating of their skills.

(3) On the whole, the theories, practices, tools, and facilities for Soviet teachers are not changing as rapidly as other aspects of Soviet society and consequently are becoming somewhat anachronistic. As a result, Soviet education is failing to meet the needs of citizens who must cope with a variety of changes resulting from the rapid advances of science and technology.

Furthermore, it has been suggested in the previous chapters that Admiral Berg, Academician Glushkov, and other Soviets looked upon programmirovannoe obuchenie as a cybernetic means for updating and modernizing Soviet education. In fact, the data clearly show how the Soviets wasted little time in designing and testing the technology's techniques and machines. But while the advocates of Soviet programmed instruction accepted the belief that new approaches and devices must be developed and used for automating classrooms, these innovators were only a minority. On the other hand, though the group was relatively small in numbers, its goals were endorsed by Party leaders and its members included perhaps some of the most influential Soviet scientists, educators, and military leaders. Nevertheless, some doubt should remain as to how Berg, Glushkov and the others will fare in their efforts to obtain acceptance and utilization of the technology by the majority of Soviet teachers. Briefly, then, the Soviets successfully achieved the first stages of automated instruction in the sixties, and, with their more systematic efforts to disseminate the innovation, moved towards the next phase at the end of the decade; but the final outcome depends considerably on the reactions of Soviet teachers in the seventies.

Moreover, this investigation has uncovered other implications which extend far beyond the Soviet schools. For instance, the data reveal that the use of cybernetic principles and digital computers in programmirovannoe obuchenie brought about some sweeping changes in the design of the learning environment, and the behavior of both the teachers and students. Such results raise some very basic issues about the preparation of teachers for electronic classrooms and the overall design of the learning environment in automated instruction. Can those planning the dissemination of the innovation safely assume that existing schools are best suited for automated instruction or that the traditional training of teachers has prepared them to operate in an electronic classroom? It may be that the Soviets and others like them, invigorated by the winds of change, are driving a technological troika at almost breakneck speed into a blinding blizzard of educational tradition.

There is no thought here of implying either opposition or acceptance of computers and programs in the processes of instruction. What is emphasized now and has been underscored throughout this study is how the new tools of instruction, like traditional textbooks, have resolved some difficulties and caused others. More specifically, the data indicate that in every case where either innovative techniques or machines resolved an instructional dilemma, both paradoxically caused at least one new problem in instruction. This investigation has uncovered a pattern of paradoxes entailing some easily overlooked, but far-reaching implications for Soviet, American, and other educators either contemplating the use of sophisticated hardware and software or already employing them in their schools. Such implications, however, involve a series of problems beyond the scope of the present study. The following problems, nevertheless, merit more intensive and specialized examination in future studies by American and Soviet scholars.

Implications of Cybernetic Methods and Devices

From the vantage point of a cybernetician, the Soviet Union has essentially become over the years a very complex information network with many nodes of institutions and lines of electronic communications. This sophisticated message system has mainly resulted from a number of major technological developments. Initially, the Soviets tied together basic economic, political, social, and educational units with power grids, telephones, and radios. Next, the difficult task of systematically linking the same components together by computers and television was started in the late fifties by the Soviets. Nonetheless, they had already made significant advances in electronically coupling their economy with the government by the early sixties. At that time, however, the Soviet schools remained relatively isolated from the inroads of electronic devices and lagged cybernetically behind the times. In short, while the use of computers and television was becoming almost commonplace in Soviet industry and government, the utilization of both innovations in Soviet classrooms was only a dim pedagogical vision at the close of 1963.

Surprisingly enough, parts of yesterday's educational dream for the Soviet schools had become cybernetic realities by the end of the sixties. As the data in this study indicate, the goals of Soviet planners were partly fulfilled by a series of technological advances involving either directly or indirectly *programmirovannoe obuchenie*. First, the digital computer was experimentally used to teach simultaneously large numbers of students in Kiev, Moscow, and Novosibirsk. Second, educators in Leningrad, followed quickly by others in urban areas, developed regional educational television and special programming techniques for it. Third, the participants at the All-Union Conference in Moscow designed plans for using computers and television in a special educational telecommunications system which would cybernetically link the schools with the rest of society by electronically moving their classrooms to factories and farms.

It should be noted that besides demonstrating the technical feasibility of employing computers and television in more traditional ways of instruction, the Soviets began systematically their research and development for extending classrooms beyond the narrow confines of conventional school buildings. Such technical achievements and radical plans for utilizing them have implications reaching into the far corners of the Soviet Union and across its boundaries. Already, the flurry of Soviet technological activities has posed a series of new educational possibilities and problems for Soviet educators that many of their counterparts throughout the world will confront sooner or later.

Before educational and political decision makers can carefully balance the risks against the opportunities offered by cybernetic approaches and devices in education, there are still many important questions which should be asked and then answered as fully as possible. Among the more general ones about the Soviet educational model for the electronic age, the following have emerged in this investigation: First, what were the important political, economic, social, and educational consequences that resulted from the initial efforts to link electronically basic Soviet institutions? Second, what are the specific Soviet cybernetic plans for education in the seventies and how do these goals complement the aims for the Soviet economy, government, and the rest of society. Third, was the tempo of automation in education viewed by Admiral Berg and other leaders as too retarded, adequate, or too accelerated in the sixties? Fourth, what were some of the specific educational, social, political, and economic practices that became obsolete as a result of automated instruction? Fifth, how do the Soviets plan to deal educationally with such side effects as obsolescence in institutional and individual patterns of behavior?

In addition, this study advances a host of specific questions about sophisticated electronic teaching machines that are particularly relevant for Soviet educators and others like them who are entering into the cybernetic age:

(1) What are the Soviet educational plans for television and computers in the seventies?

(2) Who will write the programs for the planned telecommunications system?

(3) Who will check these materials for accuracy or, more specifically, who will watch the programmers?

(4) Will the Communist leaders continue to allow widespread teacher participation in the design of sophisticated software for other subject matter areas, as these Soviets did with the hard sciences and languages, or will Party ideologists write these materials?

(5) Will the Soviets be able to design heuristic programs for digital computers and free students from the rigid system of locksteps found in much of programmed and traditional instruction?

(6) What progress have the Soviets made with the construction of their national computer network and will it be able to accommodate their educational needs for the seventies?[9]

(7) Are the Soviets planning to extend their classrooms beyond their boundaries into other countries via communications satelites and, if so, how will the domestic Soviet cybernetic systems for education be interwoven with these overseas developments?

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9. In a 1968 conversation with John Ford, a US Government expert on Soviet cybernetics, this investigator was informed by Ford that the Soviet construction of their computer network was apparently moving along on schedule and the system would probably be completed sometime in the seventies. In addition, Ford mentioned that this network could be used for educational purposes as well as economic ones.

Sooner or later, other educators besides those in the Soviet Union will be confronting the same technological developments in their own countries, asking themselves similar questions, and trying to determine the implications of their corresponding activities. In the midst of those consequences suggested earlier, there are possibly more important ones which, according to other data in the present study, will also demand their attention. It is perhaps best that these implications be placed first in a broad historical context and then in the concrete setting of the Soviet classroom.

Implications of Human-Electronic Learning Systems

For almost two centuries, men have been using machines that automated human or animal feats of sheer brute strength. The conception that machines are an alternative to muscle has allowed man to multiply tremendously his physical energy and to set the stage for perhaps an even more dramatic development. This drama is just beginning and involves actors performing in a series of contemporary settings and with new "props." Instead of acting out the scenes in grimy factories with massive machines simulating muscle power, the action has shifted to living rooms, offices, classrooms, and many other places where men are extending and amplifying their brain power by the use of sophisticated electronic devices.

As the data in Chapter IV reveal clearly, the Soviets began to forge a close union between humans and machines in their schools during the sixties. This symbiotic relationship became evident in classrooms where teaching machines were employed to instruct Soviet students. In Chapter IV, it was also pointed out that while Soviet educators generally ignored the implications of the new man-machine symbiosis in education, Admiral Berg, Academician Glushkov, and others like them understood very well the significance of linking together human intelligence with that of machines. As a matter of fact, Berg has even suggested that nerve cells in the brains of teachers and students could be electrically linked with those in a computer and this direct electrical interaction could multiply the intelligence of both learners and teachers. Obviously, such developments have far-reaching implications for Soviet teachers, students, and even their American counterparts who are relying more and more on electronic means of communications in classrooms.

It should be stressed here that the Soviets are far beyond the talking stages in the design of complex interlocking human-machine learning systems. According to the data in Chapter IV, Pavlov and his Soviet disciples have already explained basically how the brain functions physiologically and pinpointed where these operations are performed. In addition, it was noted in Chapter III and IV how Soviet engineering psychologists have been studying and designing systems in which men and electronic devices interact very closely and also how Gal'perin and other learning theorists have explained learning in terms of a control system. All of this means that the Soviets already possess a rather detailed map of the brain and view "learning" somewhat like the regulation of automata. Such starting points make it feasible for the Soviets to explore a host of new possibilities that include sending via electrical impulses regulatory messages directly to the brains of learners and recording by computer their detailed reactions. It seems rather apparent that the Soviet explorations of these opportunities warrant careful study by both Soviet and American educators.

Here again, there are a series of paradoxes following in the wake of Soviet advances. The contradictions involve many of the existing Soviet learning theories and practices which apparently seem obsolete in light of recent developments. What has resulted from the research of Soviet physiologists, psychologists, and cyberneticians is perhaps best summed up by Admiral Berg. After surveying the Soviet educational scene during the sixties, he concluded rather bluntly:

> It is no secret that at the present time we still know very little about the general laws of psychic activity, about the students' processes of learning, and that (we) are still far from an elaborated theory of learning.[10]

In short, Berg and other Soviets, viewing individual instruction as mainly a problem of regulating the flow of information in the brain, found most of the traditional explanations and procedures for learning to be inadequate and

10. Berg., *op. cit.*, p. 34.

perhaps even irrelevant for Soviet education in the new electronic era.

This viewpoint obviously challenges many of the basic assumptions of Soviet educators and their contemporaries in other parts of the world, and raises a series of difficult questions for Soviet researchers and those in other countries. How does the human brain receive, classify, store, and transmit information? How can learning be programmed through a process of direct electrical impulses on the brains of learners? How could the computer control and regulate these signals? Should educators employ such means and, if so, for what political ends should learners be programmed? The last question suggests another series of problems which are perhaps more pertinent for Americans and Soviets finding themselves in the midst of technological advances unknown even in the science fiction world of big brother. Here again, it is perhaps best to put these events first in a broad historical context and then in their more specific Soviet milieu.

Implications of Social Engineering

In the thirties, an observer could easily distinguish the American economic system from that of the Soviets because planning was evident at almost every level in the Soviet Union and not too obvious in the United States. This distinction was soon blurred by the American mobilization during World War II and almost disappeared with a series of technological innovations that were applied almost equally in both the United States and the Soviet Union during the fifties and sixties. Today, sophisticated survey techniques, linear programming, simulation of complex processes by computers, input-output analyses, and other ways of handling data are employed by industrial planners from Pinsk to Pittsburgh and by their political counterparts in the White House and Kremlin. As a result, American and Soviet decision makers are now able to assimilate massive amounts of detailed data much faster, to make more complex plans, and to supervise their implementation with more sophisticated electronic reporting devices than ever before in history.

With the development and use of programmirovannoe obuchenie in the sixties, the new breed of Soviet engineers, utilizing the recently developed techniques and electronic devices for processing information in industry and government, descended upon the Soviet schools. As the data in Chapter II show quite clearly, there are the members of the Scientific Council for Cybernetics at the top and cyberneticians throughout the ranks of this technological movement. Like most engineers everywhere in the world, both the Soviet leaders and their followers tend to look upon the advancements of science and technology as signs of progress. But unlike many other scientists and technicians limited perhaps by their own specialized views or economic resources, Admiral Berg and the other leading advocates of programmirovannoe obuchenie have very broad, impressive plans for automating the largest country in the world and, more importantly, their views are economically supported by the nation's power elite, the Communist Party. Thus, the members of the Scientific Council for Cybernetics are, indeed, prime examples of those social engineers who are setting in motion the forces of technological change throughout the world and then regulating them for a variety of national leaders with different political philosophies.

Clearly, this type of regulation requires planning which essentially involves making value judgments about the allocation of resources. In turn, such decisions are major factors in determining the quality of life in both present and future societies. The importance of those judgments is perhaps best summarized by Daniel Bell who states: "The World of the year 2000 has already arrived, for in the decision we make now, in the way we design our environment and thus sketch the lines of constraints, the future is committed."[11] Whether one likes or dislikes it, the fact remains that Admiral Berg and other social engineers have made decisions about the design of the Soviet educational environment, sketched some new constraining lines, and more or less committed its future.

It could be argued that necessity dictates the Cybernetic Council's planning for technological change. This argument is supported by both general historical and

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11. Bell, op. cit., p. 639.

specific educational data. First, the explosions at Hiroshima and Nagasaki indicated quite suddenly and vividly that not all technological progress is completely valuable to human beings. Second, the evidence in the present investigation reveal that the development and use of programmirovannoe obuchenie involves some educational choices with dangerous consequences. Consequently, it seems that the automation of Soviet instruction is too important a task to be left to mere chance.

Nonetheless, even the best intentioned plans for modernizing Soviet education suggest a series of conflicts between national and individual interests. Historically, socialist planners in the Soviet Union have generally favored the rights of the state over those of the citizen. This has been particularly evident in their plans for the Russification of minorities. On the other hand, the opposite ideological approach of relying on the invisible hand of competition to regulate society has also deprived individuals of their civil liberties. In the first half of the twentieth century, for example, the American government's basic laissez-faire approach to the problems of minorities helped to block millions of black Americans and other racial groups from achieving their rightful place in society. All of this suggests that the crucial issue is not planning versus laissez-faire, but the values implied in either the plan of action or the lack of it.

In respect to the automation of Soviet instruction, such a viewpoint leads to a series of questions about the implicit and explicit values in the Cybernetic Council's plans for education. Are these Soviet planners sacrificing civil liberties for the interests of the state? How does Admiral Berg and the others envision the Soviet schools in the year 2000? Is their technological view of the future Soviet educational system compatible with a more individualistic or nationalistic vision of Soviet society? It would appear that these and further questions about the Scientific Council for Cybernetics could help Americans better understand the general directions in which the Soviet schools and society are moving.

Concluding Remarks

This initial investigation of the men, their theories, techniques, and machines involved in the automation of Soviet instruction has thus brought to light a number of problems that certainly warrant further study by American scholars. On the one hand, such a finding is in agreement with what Levien and Maron concluded in their pioneer study of Soviet teaching machines.[12] On the other hand, much of the preceding data and most of the implications drawn from them are quite different from those offered by Levien and Maron.

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12. Levien and Maron, *op. cit.*, p. 7.

Unlike them, this investigator had access to more Russian printed sources and the opportunity to view firsthand the development and use of programmirovannoe obuchenie. As a result, there has emerged in the present investigation more specific and recent information about the participants, their views, methods, electronic devices, and the impact of this technology. Such details could provide either American or Soviet scholars with an up-to-date factual base from which they could develop more specialized studies.

In this regard, it could be both useful and profitable to place the following general topics prominently on the agenda for future American scholarship:

1. the role of modern technology and science, rather than ideology, in shaping such contemporary Soviet institutions as schools, industries, and governmental units;

2. the Soviet cybernetic crisis and the responses of the Scientific Council for Cybernetics to it;

3. the emerging human-electronic symbiotic relationships in Soviet classrooms;

4. the role of social engineers, like Admiral Berg, in Soviet education and their influence on it;

5. and the Soviet efforts to refine and disseminate the theories, techniques, and devices used in programmirovannoe obuchenie.

In addition to the general suggestions, it could be particularly important to know more about the following Soviet activities: the national computer network, the plans for the telecommunications learning system, the progress in implementing them, digital computers utilizing heuristic programs, Gal'perin's conception of learning as a control system, results of research about the human brain's information functions, efforts of engineering psychologists and others to link directly cells in the brain with those in the computer, and the Scientific Council for Cybernetics' plans for education in the seventies. These are only a few of the more specific areas of Soviet research and development which could be particularly relevant for American educators and also other scholars.

Finally, past Soviet technological achievements, like Sputnik, have shocked many Americans and disturbed the delicate balance of power between the United States and Soviet Union. The evidence throughout the preceding chapters indicate that at least several aspects related to the development and use of *programmirovannoe obuchenie* could add more weight to the Soviet side of the scale and cause it to tip towards Moscow. For this reason, there is perhaps a sense of urgency in commencing American studies of the computer network linking the Soviet Union, its research and development of a telecommunications system for instruction, the plans of the Scientific Council for Cybernetics, and other similar Soviet activites.

Thus ends this study about the automation of Soviet instruction. As stated in the beginning, the description and analysis are not complete and final, but are presented in the expectation that they may provide the stimulus for further American probes into the nature of Soviet educational technology. Hopefully, the present investigation has provided American educators with new knowledge and also reminded them of an old insight which Edward T. Hall advanced over a decade ago:

> The educator has much to learn about his own systems of learning by immersing himself in those that are so different that they raise questions that have never been raised before.[13]

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13. Edward T. Hall, The Silent Language, (Fawcett Publications, Inc., Greenwich, Conn., 1959), p. 54.

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A P P E N D I C E S

APPENDIX A

BACKGROUND INFORMATION ABOUT STUDY

Unlike most foreign visitors in the Soviet Union, this investigator had the opportunity to live like a Russian. This meant sharing his room in a university dormitory, viewing the world from his Soviet framework, and interacting intensely according to his cultural patterns. In turn, such intimate relations as sharing a meal, attending the wedding of two young student friends, visiting the homes of professors, and meeting their families enabled the investigator to penetrate beyond the surface and into the existential core of Soviet life and education. Of all the investigator's experiences in the Soviet Union, these had perhaps the greatest influence upon him and his study.

In addition to the more spontaneous activities, there were other more formal ones which shaped this investigation. Once again, they represented opportunities not usually available to most foreign observers in the Soviet Union. As an exchange student, this investigator attended classes at both the University of Moscow and the Moscow Energetics Institute. Participating like a Russian student in the processes of higher education exposed the author to other dimensions of

Soviet life which are seldom revealed by official visits and interviews. In short, such firsthand educational experiences provided the investigator with many insights into the everyday realities of Soviet education.

These educational activities stemmed mainly from a plan of study developed by the investigator and officials at the Moscow Energetics Institute. This document is translated and summarized as follows:

It is required of Bryce Franklin Zender to fulfill the following:

A. To become acquainted with the work in the classrooms and the equipment of programmed instruction at the Institute;

B. To prepare a summary of the theoretical reports given at the First All-Union Conference about Programmed Instruction and to give a report to the Scientific Technical Council of the Inter-Departmental Laboratory of the Institute;

C. To prepare a presentation about the progress of his work and to report to the Scientific-Technical Council of the Inter-Departmental Laboratory

D. To report about the theme of "International Systems of Education."

For the present theme of research of Bryce Franklin Zender and for the completion of his study, the following measures are recommended:

I. Consultations at the Moscow Energetics Institute with the following comrades according to the designated topics:

A.	Konfederatov, I. Ya.	Questions of Pedagogy and Psychology
B.	Tetelbaum, I. M.	Questions of Double Coded Controlled Cards and the Use of Computers
C.	Lebedev, P. D. Illarionov, A. G.	Questions of the Method of Programmed Control Without Machines

D. Glizdov, I.M. Question of the Use of KAKTUS (KAKTUS is the name of the administrative unit which controls the special classrooms where programmed instruction experiments are conducted. This is the area where I interviewed students and teachers.)

E. Chemodanova, E.D. Questions of Application of "Repetitor" (The machine "Repetitor," is used in teaching Russian.)

F. Netushil, A.V. Question of Teaching and Control Machines

G. Attendance of the lectures and consultations with the lecturers in the University of Pedagogical Mastery.

II. Trips in Moscow:

A. The Exhibition of Achievements of the National Economy;
B. Information Center for Programmed Instruction;
C. Faculty of Programmed Instruction in the Polytechnical Museum.

It should be mentioned that the Soviets were very cooperative in helping the author to fulfill the joint plan. They devoted considerable time to consultations in which they explained the technology, suggested additional printed reference, and even gave the American investigator their personal copies of books and journals. Furthermore, the Ministry of Higher and Secondary Specialized Education in the USSR of Higher and Secondary Specialized Education in the USSR permitted the author to take from the Soviet Unio copies of the papers presented at the All-Union Conference. Moreover, the author was permitted to study the references in the Lenin and Ushinsky Pedagogical Libraries.

On the other hand, there were some problems which the investigator encountered with this research. First, it was not an easy task for the investigator, a teacher and student of pedagogy, to be the first American student in a Soviet school for engineers that has a comparable reputation as the Massachusetts Institute of Technology. Second, the close ties between the development of programmed instruction and the activities of the Soviet military also created certain obstacles. For example, the investigator was not allowed to view the Radon Complex because it was a part of the Kiev Higher Engineering Radio-Technical School of the PVO Strany (Air Defense Force).

APPENDIX B

METHOD FOR TRANSLITERATION

The method for transliterating the Russian alphabet was adapted from the system used in Scientific Abstracts and Computing Reviews.

APPENDIX C

A DIRECTORY OF SOVIET PERSONNEL

The names of the individuals, their institutions, and a brief description of their activities associated with programmed instruction are listed alphabetically. The entire list and individual entries in it are not offered by the author as a complete listing of personnel and a detailed record of their activities. But the following information is offered as an initial and up to date source. The information was derived from the author's readings of Soviet printed materials and his conversations with various Soviets. Perhaps this initial directory will aid future scholars who will be able to add more names, to fill the gaps in information, and to describe the activities in greater detail.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Abarabarchuk, A.A.	Odessa Higher Engineering Naval School	Probability & Multiple Choice Responses*
Abaturova, L. A.	(address unknown)	Algorithmic Analysis of the Brain
Agur, U.M. (Dotzent)	Talin Polytechnical Institute	Applications Without Machines*
Akulich, A.I.	Bobruiskii Forestry School	Technical Devices*
Aleksandrov, G.N.	Kuibyshev Electronic Institute of Communication	Medical Education,* Cybernetics & Types of Responses
Alimpiev, A.V.	Kuibyshev Polytechnical Institute	Teaching Machines*
Amelishko, M. V.	Grodnenskii Agricultural Institute	Applications Without Machines in Physics*
Androfagin, A. F.	Kuibyshev Polytechnical Institute	Means of Formalizing the Process of Instruction*
Artem'eva, S. F.	Voronezhskii State University	Problems of Innovation*
Arkhangel'skii S.I. (Professor)	Moscow Energetics Institute	Technical Services
Aukum, A.A.	Latvia, S.S.R.	Simple Automatic Technical Devices*
Azhikin, G.I. (Director)	Russian Republic's Educational & Methodological Office	Practical Applications & Technical Devices*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Balashova, L.I.	Tajik State Univ.	General Principles*
Ball, G.A.	(address unknown)	General Theory & Electronic Computers*
Belik, G.I.	Kharkov Institute of Mining Machine Construction	Electronic Computers*
Belonovokii, A.C.	(address unknown)	Statistical Analysis*
Belorlazov, I.A.	Scientific Methodological Office Ministry of Education, Higher & Secondary Specialized Education	Applications in Secondary Education*
Belov, V.P.	Armavir	Control Machine*
Berg, A.I. President of the Joint Committee for the Problem of Programmed Instruction	Scientific Council for Cybernetics (Moscow)	All phases
Bespal'ko, V.P.	Moscow State University	Criteria for Evaluation*
Bespaly, G.A.	Kiev School No. 15	Technical Devices*
Beteev, V.A.	Kuibyshev Pedagogical Institute	Mental Activity and Physics Materials
Bezotesnaya, L.M.	Odessa Pedagogical Institute	Recall*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Bezvesel'nyi, E.S.	Ukrainian Polytechnical Correspondence Institute	Applications Without Machines*
Blank, E.I.	Bel'trkil Pedagogical Institute	Material for Electrotechniques
Bogdashin, B.I. (Teacher)	Krasnoiarsk Pedagogical Institute	Writing Programs
Bogomolov, A.I.	(address unknown)	Applications in Higher Education
Bogoroditskii, N.P. (Professor)	Leningrad Electro-Technical Institute	Practical Applications in Technical Subjects
Boldyrev, V.F.	Krasnoiarsk Institute of Non-Ferrous Metallurgy	Descriptive Geometry*
Boldysheva, T.N.	Tomsk Pedagogical Institute	Psychology*
Bondareva, A.A.	Nazarovo School No. 8	Secondary School Materials
Bondin, O.A.	Moscow Energetics Institute	Teaching Machines*
Bozkovich, E.D.	(address unknown)	Russian Language*
Braihichenko, N.A.	Leningrad Higher Military Naval Eng. School	Writing Programs for Mathematics and Mechanics

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Bulko, V.N.	Voronezhskii State University	Drill*
Butt, M.T.	Mytishch Region No. 2 Moscow School	Results of Application*
Burunov, Yu. A.	Kiev Higher Engineering Radio Technical School	Electronic Computers Complexes
Chechel', E.G.	Kharkov State University	Foreign Languages*
Chemodanova, E.D. (teacher)	Moscow Energetics Institute	Russian Languages*
Chetberukhon, N.F.	Moscow Aviation Institute	Materials for Descriptive Geometry*
Chilikin, M.G.	Moscow Energetics Institute	Administrator of School and Popularizer of Educational Technology
Chkhaidze, L.V.	Georgian Institute of Physical Culture	Sports*
Chubuk, Yu. F.	Ukraine	Scientific Organization of the Educational Process
Churakova, R.G.	Kuibyshev School No. 123	Mathematics in Secondary School*
Danilochkina, G.A.	Kuibyshev Pedagogical Institute	Mathematics in Secondary School*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Denicov, A.E.	Kiev Engineering Construction Institute	Technical and Control Devices*
Detterer, A.V.	Tomsk Pedagogical Institute	Research and Development
Dmitriev, A.E.	Moscow State Pedagogical Institute (Lenin)	Russian in Primary Schools*
Dmitriev, S.K.	Novosibirsk Electro-Technical Institute	Electronic Computer
Doroshkevich A.M. (Dotzent)	Moscow Polygrahic Institute	Principles of Writing Programs*
Dovgyallo, A.M.	Ukraine Academy of Science (Cybernetics or Psychology)	Electronic Computers and Programmed Instruction Theory
Drachev, V.K.	Sevastapol Instrument Making Institute	Algorithmization of Economic Theory*
Draitzel, N.W.	Moscow State Pedagogical Institute	History*
Edel'man, S.L.	Krasnoiarsk Pedagogical Institute	Writing Programs*
Erdniev, P.M.	Kalayk Pedagogical Institute	Principles of Teaching and Learning
Esaulov, A.P.	Leningrad State University	Psychological and Pedagogical Principles
Fialko, E.I. (Professor)	Kiev State University	Practices in Higher Education
Fradkin, L.S.	Riga Aviation School	Application in Technical Subjects

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Gal'perin, P. Ya. (Professor)	Moscow State University	Psychological Theory*
Gbozdev, Yu. V.	Kiev Automobile & Roadway Institute	Tape Recordings and Television*
Gel'fand, N.D.	Ukrainian Scientific Research Institute of Ped.	Algebra in Secondary Schools
Gel'man, B.M.	Professional-Technical School No. 5 Kaluzheskii	Technical Devices "Kaluga"
Glizdov, I.M.	Moscow Energetics institute	Control and Technical Devices*
Glushkov, N.M. (Academic)	Ukraine Academy of Science	Cybernetics
Gnedenko, G.V. (Academic)	Ukraine Academy of Science	Mathematic Models
Godynckaya, I.I.	Ryazanskii Radio Technical Institute	Multiple Choice Method*
Golovchak, S.G.	L'vov School No. 33	Electro-Radio Techniques*
Golovina, M.B.	Chelyabinsk Pedagogical Institute	Technical Devices and Trigonometry*
Golubev, G.G.	Checheno-Ingush Autonomous, S.S.R.	Technical School Applications*
Gorchev, A. Yu.	Alma Alta Pedagogical Institute	Foreign Languages*
Gorkun, M.G.	Kiev Technological Institute of Light Industry	Foreign Languages*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Grabel'kovskaya, L. Ya.	Pavlodarsk Industrial Institute	Materials for Physics*
Grabovskii, A.M. (Dotzent)	Odessa Polytechnical Inst.	Independent Study*
Granik, G.G.	(address unknown)	Diagnosis of Errors & Russian Language*
Illina, T.A.	Moscow State Pedagogical Institute (Lenin)	Secondary School Materials
Illarionov, A.V.	Moscow Energetics Institute	Applications Without Machines*
Isanin, L.V.	Leningrad Evening Machine-Building School	Technical Devices*
Ivanov, A.A. (Professor)	Odessa Polytechnical Institute	Materials for Electrotechniques
Ivanov, S.V.	Voronezhskii University	General Secondary Schools
Kalikinskii, Yu. A.	(address unknown)	Methods and Psychology
Kamariokh, E.M.	Kazemsk School No. 39	Tape Recorders in Automotive Subjects*
Karpov, K.B.	First Moscow State Pedagogical Institute of Languages (C.H. Thorez)	Foreign Languages*
Kashin, M.P.	Ministry of Education (Russia)	General Secondary School*
Khar'kovskii, Z.S.	Moscow State Pedagogical Institute (Lenin)	English Language*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Khendre, E.M.	Talin Polytechnical Institute	Simple Technical Devices*
Khokhol, V.N.	Chernovets School No. 6	Technical Devices*
Klimova, H.S.	Kuibyshev Electro Technical Institute of Communication	Programs for Higher Mathematics*
Klyuev, V.V. (Dotzent)	Cherkasak Pedagogical Institute	Mathematical Analysis Basis for Writing Papers
Kobozev, M.N.	Krivorozhskii School of Mining Equipment	Electro-Techniques*
Kochkova, G.R.	Leningrad School No. 43	Use of Perforated Cards in Primary Schools
Kolomietz, V.I.	Dnepronetrovsk School No. 16	Teaching Machines*
Komkov, I.P.	Minsk Pedagogical Institute of Foreign Languages	English Languages*
Kondakov, V.A.	Kuibyshev Pedagogical Institute	Mental Activity and Physics Materials*
Konfederatov, I. Ya.	Moscow Energetics Institute	Higher Education & Teacher Education*
Kopeleva, N.P.	Moscow State Pedagogical Institute (Lenin)	Primary School Applications in Arithmetic*
Korndorf, B.F.	Academy of Foreign Trade	Foreign Languages*
Kositskii, G.I.	Second Moscow Medical Institute	Physiology*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Kostyuk, G.S. (Corresponding Member	Russian Academy of Pedagogical Science	Pedagogical Theory
Kotov, V.E.	Odessa Pedagogical Institute	Recall*
Kraizmer, L.P.	North-Western Polytechnical Correspondence Institute	Correspondence Applications*
Krupich, V.I.	Moscow State Pedagogical Institute (Lenin)	Mathematics in Secondary School*
Krupitzkii, E.I.	Minsk School No. 6	Applications in Technical School*
Krylov, M.D.	Moscow Electro-Mechanical School	Applications*
Kryuchkova, G.M.	Moscow Medical School	Medical Education*
Kullanda, K.M.	University of Friendship of Nations (Moscow)	Medico-Biological Discilpines*
Kul', I.G. (Dotzent)	Tartur State University	Models in Educational Process
Kurilenko, I.N.	Minsk Pedagogical Institute	Without Machines for Education*
Kushelev, Yu.N. (Dotzent)	Moscow Energetics Institute	Teaching Machines*
Kuvshinov, N.I.	Tomsk Pedagogical Institute	Psychology*
Kuz'mina, B.A. (Professor)	(address unknown)	Secondary Specialized Schools

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Landa, L.W. (Corresponding Member	Academy of Pedagogical Science	Psychology*
Lavinskii, E.P.	Kuibyshev Electro-Technical Institute of Communication	Applications Without Machines*
Lebedev, P.D. (Professor)	Moscow Energetics Institute	Applications Without Machines*
Lur'e, E.A.	Academy of Air Defense	Audio-Visual Forms*
Lysenko, V.K. (Professor)	Odessa Higher Naval Engineering School	Applications for Naval Officers
Lyshohinskii, G.P. (Professor)	Novosibirsk Electro-Technical Institute	Technical Devices*
Makarova, E.I. (Dotzent)	Kiev State University	Cybernetics
Maliev, Yu. N.	Kuibyshev Aviation Institute	Applications Without Machines*
Mamet, A.S.	Leningrad School No. 10	Applications in Technical Schools*
Mamontov, P.P.	Tomsk Pedagogical Institute	Theory*
Marchenko, E.K.	Riga High Command Engineering School	Automatic Machines Models
Markhel',I.I.	Omsk School (Zuhkov)	Technical Devices*
Mashbitz, E.I.	(address unknown)	Programmed Instruction Theory

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Mashuta, V.F.	Kharkov	Question of Innovation
Matyushkin, A.M.	Odessa Pedagogical Institute	Physics in the Secondary Schools*
Mel'nikov, I.A.	Moscow State Pedagogical Institute (Lenin)	Physics in Secondary Schools*
Melyukov, A.I.	Krasnoyarsk Pedgogical Inst.	Corresondence Courses for Higher Mathematics
Merzon, E.D. (Dotzent)	Leningrad Institute of Engineers of Water Transport	Descriptive Geometry*
Mikhailenko, V.K.	Kiev Engineering Construction Institute	Descriptive Geometry*
Mikhailov, S.S.	Moscow Medical Stomotological Institute	Medical Education*
Mikhnushev, A.G.	Kiev Higher Engineering Radio-Technical School	Practical Applications*
Mochalov, R.V. (Dotzent)	Chitinsk Pedagogical Institute	Materials for Physics*
Molibog, A.G.	Minsk Higher Engineering Radio-Technical School	Author of Recent General Texts and Technical Devices*
Morgunov, I.B.	Ministry of Higher and Secondary Specialized Education USSR	Electronic Computer
Mukanov, M.M. (Dotzent)	Kazan Pedagogical Institute	Psychological-Pedagogical Aspects

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Moroz, L.I.	Scientific Research Institute of Professional Technical Education	Results of Applications
Napalkov, A.V.	(address unknown)	Algorithmic Analysis of the Brain
Netyskil, A.V. (Professor)	Moscow Energetics Institute	Technical Devices*
Nikitina, Z.N.	Leningrad Physics Mechanical School	Application in Technology of Metals*
Nikolaevskii, G.K.	Kharkov Automobile Roadways Institute	Technical Devices and Problems of Innovation
Nikol'skii, A.V.	All-Union Correspondence Polytechnical Institute	Correspondence Schools*
Okishev, H.P.	Taganrogskii Radio Technical Institute	Small Teaching Machines*
Osipova, E.A.	Dnepropetrovsk Pedagogical School	Technical Devices and Foreign Languages*
Ozhogiz, V. Ya.	Kiev Engineering Construction Institute	Control Devices*
Punin, V.I. (Dotzent)	Kuibyshev Aviation Institute	Materials for Descriptive Geometry*
Panov, P.V.	Kharkov Automobile Roadways Institute	Problems of Innovation*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Parail, E.L. (Dotzent)	Odessa Polytechnical Institute	Independent Study*
Parfenova, L.B.	Moscow State University	Algorithmic Analysis of the Brain
Pell', V.G.	Moscow State University	Films and Photography*
Pentyurin, V.S.	Leningrad Physics Mechanical School	Correspondence*
Petukhov, V.I.	Riazanskii Radio-Technical Institute	Regulation and Models*
Plotkin, S.I. (Teacher)	Krivoroshskii Aviation School	Problems of Methods*
Podlasnyu, I.P.	Poltava Pedagogical Institute	Structure of Steps*
Pozharov, P.I.	Konstantinovckoe Professional-Technical School No. 20	Electro-Techniques and Practical Applications*
Preobrazhenskii, P.G.	Kharkov School No. 19	Technical Mechanics*
Publev, Yu. V.	Odessa Polytechnical Institute	Information Techniques
Pzetskii, N.N.	Kiev State University	Standardization of Programs and Control*
Rakhmatulin, R.D.	(address unknown)	English language*
Rakigyanskaya, Z.I.	Moscow State Pedagogical Institute (Lenin)	Writing Programs*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Ratner, G. L.	Kuibyshev Medical Institute	Medical Education*
Regel'son, L. W.	Moscow State University	Learning Systems and Systems Approach
Reingard, P. A. (Dotzent)	Dnepropetrovskii State University	Descriptive Geometry
Repkin, V. V.	Kharkov State University	Psychological Principles
Reshetova, A. A.	Moscow	Psychological Theory*
Romanova, I. A.	Kiev Higher Engineering Radio-Technical School	Applications in Physics*
Rorova, G. V.	Moscow State Pedagogical Institute (Lenin)	English Language*
Rostunov, T. I.	Kiev Higher Engineering Radio-Technical School	Author of Recent Texts Experiments being Conducted in School*
Rot, A. M.	Uzhgorodskii State University	Cybernetics in Foreign Languages*
Rozenberg, N. H.	Scientific Research Institute of Pedagogy (Ukrainian)	Information Theory Approach
Russkikh, V. N.	Nazarovo Secondary School No. 4	Simple Technical Devices*
Rvachev, V. L. (Professor)	Kharkov Institute of Mining Machine	Technical Devices*
Ryakhovskii, G. D.	Kiev State University	Algorithms for the Educational Process

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Samarin, Yu. A. (Professor)	Leningrad State University	Psychology
Savel'ev, A.Ya.	Moscow Higher Technical School (Bauman)	Electronic Computer*
Savinkov, V.M.	Academy (Dzherzhinskii)	Electronic Computer*
Sayusheva, V.A. (Representative)	State Committee Council of Ministers USSR	Professional and technical Education
Sereda, G.K.	Kharkov State University	Aspects of Psychology (Memory)*
Shadurin, R.S.	Georgian Institute of Cybernetics	Growth of Scientific Knowledge
Shanon, A.I.	Moscow Radio-Technical School	Use of Radio-Technical Equipment*
Shoherban', Yu.Yu.	Kirovogradskii Pedagogical Institute	Pedagogy*
Shenshev, L.V.	Academy of Pedagogical Science (Russian)	Technical Devices*
Shidlovskii, V.A.	First Medical Institute	Medico-Biological Disciplines*
Shilo, V.N.	Kazan High Command Engineering School	Writing Programs*
Shpilev, P.N.	Novosibirsk Institute of Engineers of Railway Transport	Writing Programs*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Shtol', M.N.	Chelyabinsk Pedagogical Institute	Classroom Lecture Applications*
Sikharulidze, Sh. (Dotzent)	Tbilis State University	Writing Programs*
Skaletzkaya, I.A.	L'vov School of Food Production	Without Machines and Organic Chemistry*
Sorokin, A.A. (Dotzent)	Leningrad Higher Military-Naval School of Radio-Electronics	Descriptive Geometry*
Sotskov, B.S. (Corresponding Member of Academy of Science of USSR	Moscow Aviation Institute	Technical Means*
Starkov, A.I.	Voronezhskii University	English Language*
Strezikozin, V.P. (Representative)	Ministry of Education	Primary School Applications*
Stupal', F.A. (Dotzent)	Kharkov Polytechnical Institute	Technical Devices*
Suprun, F.K.	Leningrad Electro-technical Institute	Innovation*
Suzdal, V.G. (Dotzent)	(address unknown)	Writing Programs*
Sychevskuya, Z.V.	Scientific Research Institute of Pedagogy	Physics in Secondary School

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Talyzina, M.F.	(address unknown)	Psychological Theory*
Tatur, Yu. G.	Moscow Engineering Physics Institute	Electronic Computers* Technical Devices
Taurach, G.I. (Dotzent)	Kiev Engineering Construction Institute	Statistical Analysis*
Terskii, L.W.	Krasnoyarsk Pedagogical Institute	Concepts of Application in History*
Tatelbau, I.N.	Moscow Energetics Institute	Applications of Computer*
Tikhonov, I.I. (Dotzent)	Military Political Academy (Moscow) Programmed Instruction Training Center (Moscow)	Training Teachers*
Tkachenic, G.I.	Academy of Science	Cybernetics or Psychology and Electronic Computers*
Troitskii, B.I.	Alta Polytechnical Institute	Achievement*
Tupal'skii, N.I.	Mogilev Machine Construction Institute	Writing Programs*
Turbovich, L.G.	Leningrad Institute of Engineers of Railway Transportation	Pedagogical Theory for Technical Subjects
Utkin, I.B.	Tusar Autonomous SSR	Russian and Arithmetic in Primary Schools*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Vainboim, P.I.	Leningrad Electro-Mechanical School	Technical Devices*
Vaisburd, F.I.	Suerdlousk School of Communication	Methods of Writing Programs
Vebrac, E.L.	Tulskii Polytechnical Institute	Methods of Writing Applications*
Venttzel', E.S. (Professor)	Air Force Academy (Zhukov)	Branched Programs for Mathematics and Technical Disciplines*
Vlasov, I.B.	Sverdlovsk	Theory & Practice of Programmed Instruction
Volkova, E.N.	Voronezhskii University	English Language*
Vysokodvroskii, I.A.	Leningrad School of Aviation Equipment	Cybernetical Systems*
Yelyutin, V.P. (Minister)	Higher and Secondary Specialized Education USSR	All Phases of Educational technology
Yudina, O.N.	Academy of Pedagogical Science (Russian)	Diagnosis of Errors*
Yushchenko, E.L.	(address unknown)	Progressive Instructional Theory
Zagainov, A.V.	City of Shadrinsk	Use of Teaching Machines*

* indicates that an application of Soviet programmed instruction was involved in the activity.

NAME AND TITLE	INSTITUTIONAL AFFILIATION	PROGRAMMED INSTRUCTION ACTIVITY
Zakharebich, G.P. (Representative)	Ukrainian Ministry of Higher & Specialized Education	Applications in Ukraine*
Zaletaev, M.V.	Information Center for Higher Education (Moscow)	Technical Means for Higher Schools and Diffusion of Innovations
Zalevskaya, A.I.	Alma-Alta Pedagogical Institute of Foreign Languages	Foreign Languages*
Zhinkin, H.I. (Professor)	(address unknown)	Progressive Instructional Theory and Practices
Zinov', S.I. (Professor)	(address unknown)	Applications in Higher Education

* indicates that an application of Soviet programmed instruction was involved in the activity.