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EDUCATIONAL PSYCHOLOGY IN THE U.S.S.R

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PREFACE

IN the Introduction to *Psychology in the Soviet Union* (1957) it was noted that the project of publishing translations of papers by Soviet psychologists originally arose from an interest in the educational applications of research. In fact a more general survey resulted because, in the absence of some knowledge of present trends in psychology in the U.S.S.R.—and this was the first book of its kind—work in educational psychology could neither be adequately presented nor assessed. During the past five years the position has considerably changed. The number of books and articles available in English has grown¹ and more translations are in preparation here and in the United States. It is possible, therefore, to take for granted a knowledge of the general framework of Soviet psychology and to confine a selection to papers with a direct bearing on education.

The nature of educational developments in the Soviet Union is now well known, particularly the emphasis on intellectual development and learning within what is basically a non-streamed common school system. Less well known, however, is the psychological outlook which informs the whole system of education and the nature of research into the learning process which has undoubtedly contributed towards successful educational expansion. Material bearing on this question has appeared in various symposia but there has as yet been no general picture of the scope of Soviet educational psychology, the methods of work in this field and the steps made towards formulating a coherent

¹ e.g., A.R.Luria, *Speech and the Development of Mental Processes in the Child*, ed. Joan Simon (London, 1959), and *The Role of Speech in the Regulation of Normal and Abnormal Behaviour*, ed. J.Tizard (London, 1961); and the symposium *Recent Soviet Psychology*, ed. Neil O'Connor (London, 1962). In the United States three volumes have been published by the Josiah Macy Foundation under the general title *The Central Nervous System and Behaviour*, ed. M.A.B.Brazier (1959, 1960, 1961); these bear chiefly on neurophysiology and include papers by A.R.Luria, E.N.Sokolov and others. There has been a reprint of A.R.Luria, *The Nature of Human Conflicts* (New York, 1960) and papers read at a conference on psychotherapy held in Moscow in 1956 have been published, *Psychotherapy in the Soviet Union*, ed. R.Winn (New York, 1960; London, 1962). The most recent review of other translations, and of some of the Russian literature, is by Josef Brozek, *Annual Review of Psychology*, Vol. 13, 1962, with bibliography.

PREFACE

learning theory. It is hoped that this volume will in some measure fill the gap. It has been planned with educationists and teachers particularly in mind, a number of the papers being specifically addressed to practising educationists and others bearing closely on school practice.

Like its predecessor, the book has been prepared with the active co-operation of the Institute of Psychology of the Academy of Educational Sciences of the R.S.F.S.R. The head of the department of educational psychology and deputy director of the Institute, Professor N.A.Menchinskaia, after consultation with Professor A.A.Smirnov, director of the Institute, and other colleagues, sent a list of relevant papers. From this a preliminary selection was made which was later somewhat modified after a month's visit to the U.S.S.R. in September, 1961, discussions with psychologists in Leningrad, Moscow, Kiev and Tbilisi, and visits to research institutes and experimental schools.

While Professor Smirnov, Professor Menchinskaia and Professor A.R.Luria have given particular help and encouragement, we are also indebted to many others who have provided information and assistance—to Professors Leontiev, Bogoiavlenski, Elkonin, Zankov and Dr. Krutetski in Moscow; Professors Ananiev, Samarin and Kovalev in Leningrad; Professor Kostiuik and Dr. Milerian in Kiev; Professor Natadze of the University of Tbilisi, Professors Bhjavala and Norakidze and Dr. Grigolava of the Uznadze Institute of Psychology in Georgia. Special assistance has again been given in many respects by Dr. Salimova of the Academy of Educational Sciences.

For advice about particular translations we are indebted to Professor M.M.Lewis of the University of Nottingham, to Professor S.G.M.Lee, Dr. Joselin, Dr. Kerr and Mr. Flemming of the University of Leicester, and to Mr. Page of the Gateway Boys' School, Leicester.

We are grateful to the publishers for assistance, and for suggesting preparation of this volume in view of the interest aroused by the earlier collection. That brought in many comments which have also helped towards preparing these further translations. We hope they will be of equal interest and use.

BRIAN SIMON

TRANSLATOR'S NOTE

IN *Psychology in the Soviet Union* the Russian words *psikhika* and *psikhicheski* were translated as 'psyche' and 'psychic'. Subsequently when translating work by A.R.Luria I sought his advice and he designated use of 'mind' and 'mental' which has accordingly been adopted here. The word *umstvennyi* is also usually translated as 'mental', though sometimes as 'intellectual'.

There is room for confusion in the case of other key terms. The word *obuchenie* can be translated as either 'teaching' or 'learning' which itself creates some difficulty. If in this context it is given as 'training', as is sometimes done, this substitutes for 'psychology of learning', 'psychology of training', indicating the approach of a particular school of psychology which finds no adherents in the U.S.S.R. The word *uchenie* can likewise be rendered as 'teaching', 'doctrine' or 'theory' in different contexts; if *uchenie Pavlova* (Pavlovian theory) is transposed into 'the Pavlov doctrine' a misleading impression is given.

There is a similar variety of terms for 'education', those most frequently occurring in psychological literature being *pedagogicheskii* (best translated as educational, as in 'educational psychology') and *obrazovanie* (literally 'formation', or development, though also used for primary, secondary, etc., education).¹

This in itself indicates how many are the pitfalls in translation, leaving aside variations in the structure of the two languages, and may help to put the reader in the picture. While adherence to terminology is essential there must also be efforts to convey the sense and feel of passages in English. The overriding problem is to strike a middle course between promoting obscurity by too literal a translation (Russian authors are not nearly so prone to circumlocutions as would sometimes appear) and officious tidying up of the text.

Occasionally summaries have been made of the opening section of a paper: these are enclosed in square brackets. The translation of the

¹ This last it would seem is among nineteenth-century adaptations from the German (e.g. *obrazovanie*=*bildung*). Other words for education are *vospitanie* (usually used more in the sense of 'upbringing' though formerly standing for 'training') and *prepodovanie* (instruction, teaching, in a more institutional sense, i.e. in Ministry of Education, teaching staff).

TRANSLATOR'S NOTE

paper by Z.I.Kalmykova was done by Yuri Berilka. Every other paper has been checked with Mr. O.Kovasc who adds to a knowledge of Russian experience of teaching in schools in the U.S.S.R., and some key passages have been checked with the authors.

The system of transliteration used is that adopted by the British Museum, with one main exception (for 'y', instead of 'ui', 'y' is used as by the American Library of Congress as this is more generally accepted). But in rendering Russian proper names it does not do to be too pedantic in using apostrophes and additional letters (i.e. substituting 'Rubinshtein' for 'Rubinstein', 'Leont'ev' for 'Leontiev'). Otherwise there has been adherence to the system even though it does mean substituting for the well known 'Vigotsky' the version 'Vygotski'.

JOAN SIMON

ABBREVIATIONS IN REFERENCES

WHERE there are two figures in the text [20:200] the second is a page reference. References are given at the end of each paper, usually, following the originals, in alphabetical order according to the Russian alphabet; but according to the English alphabet when those for one chapter have been extracted from among many at the end of a book.

For place of publication M=Moscow, L=Leningrad. All publications so referred to, and papers in journals, are in Russian. English translations are noted when they have been located.

VP=Voprosy Psikhologii, Akademia Pedagogicheski Nauk (Questions of Psychology, Academy of Educational Sciences, R.S.F.S.R.)

Izvestia APN=Izvestia Akademii Pedagogicheski Nauk (Transactions of the Academy of Educational Sciences, R.S.F.S.R.)

Doklady APN=Doklady Akademii Pedagogicheski Nauk (Papers of the Academy of Educational Sciences, R.S.F.S.R.)

Uchenie Zapiski APN=Uchenie Zapiski Institut Psikhologii Moskva (Journal of the Institute of Psychology, Moscow)

SP=Sovetskaia Pedagogika

(Soviet Education, published monthly by the APN)

The Russian titles of the other main journals referred to are:

Naukovi Zapiski Institutu Psikhologii, Kiev (in Ukrainian)

(Transactions of the Ukrainian Institute of Psychology, Kiev)

Trudov Tbilisskovo Instituta Pedagogicheski Nauk (in Georgian)

(Papers of the Tbilisi Institute of Education)

Uchenie Zapiski LGPI im. A.I.Gertzena

(Journal of the Herzen Pedagogical Institute)

The journals of other pedagogical institutes have similar titles.

S.C.R. Psychology Bulletin, published by Society for Cultural Relations with the U.S.S.R.

INTRODUCTION

THE course of psychological research during the past forty years in the main areas of study is well outlined in a two volume symposium, *Psychological Science in the U.S.S.R.*, published in 1959–60 in Moscow. Of the detailed papers contributed by leading psychologists one is included here, “The Psychology of Learning”, together with other shorter papers from various books and journals on the general question of learning and development and specific aspects of teaching and learning in school. One way of putting all these into perspective and indicating the resources on which they draw is by outlining the scope of the Soviet symposium and referring to some of the more recent publications of the authors concerned, a number of whom are represented in the present volume.

The historical and social approach to human psychology adopted by Soviet psychologists is covered by A.N.Leontiev, a collection of whose work has appeared under the title *Problems of the Development of Mind* (1959): it is from this that his paper in the present volume is drawn. Research relating to sensation and perception is outlined by B.G.Ananiev, whose most recent work is *The Psychology of Sensory Cognition* (Moscow, 1960), by E.N.Sokolov, author of *Conditioned Reflexes and Perception* (Moscow, 1958) and others. Of particular importance and originality are researches into the evolution of speech and the formation of mental processes, summarised by A.R.Luria who needs no introduction to psychologists in this country and the United States; he is represented in the present collection by a chapter from a short book making the results of some of these researches known to teachers.

Special attention has been directed to the question of memory, the paper on this subject being fittingly contributed by A.A.Smirnov, who has latterly been particularly concerned with research into the interrelations of image and word in memorising in school work; he has edited a recent symposium of this work *The Psychology of Memory* (Moscow, 1958). It is much regretted that pressure on space prevented publication of papers on this important subject suggested for inclusion here.

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Research into a wide variety of aspects of the psychology of thought is summarised by G.S.Kostiuk, of the Institute of Psychology, Kiev, who is represented here by a paper on education and the development of personality, and a theoretical contribution on the principle of determinism in psychology comes from the pen of the late S.L.Rubinstein.¹ Latterly such research has been underpinned by more specific investigations of the physiological mechanisms of speech summarised by N.I.Zhinkin, who had a volume under this title published in 1958, of the speech mechanisms of thinking covered by A.N.Sokolov, and of the conditioned reflex foundations of higher mental processes covered by E.I.Boiko, editor of the symposium *Studies of Higher Neurodynamics in Relation to Problems of Psychology* (Moscow, 1957).

A development of particular relevance to education is research into the formation and structure of mental actions, associated with the name of P.Ia.Galperin; the theoretical propositions arising from this have been the subject of widespread discussion in recent years. Hitherto the approach to individual differences has been primarily by way of investigating typological features of the nervous system, research directed for the most part by B.M.Teplov, the recent results of which have been published in two volumes of papers, *Typological Characteristics of Higher Nervous Activity in Man* (ed. B.M.Teplov, Moscow, 1956, 1959). But there has been growing attention to the formation and structure of abilities, research in this field being described by N.S.Leites. It is in this region, on the borders of physiology and psychology, that some of the most interesting research has been taking place, though it falls outside the scope of this book. There are also summaries of research devoted to the nature and formation of character (V.A.Krutetski), attitudes (V.N.Miasishchev), emotions (P.M.Iakobson), while study of the formation of personality in relation to the work of schools has also taken an important place (L.I.Bozhovich). Here, again, is work that was recommended for inclusion in the present collection but for which unfortunately space could not be found.

A comprehensive survey of research into the mental development of children up to the age of entry to school is contributed by D.B. Elkonin, author of *The Psychology of the Child from Birth to Seven* (Moscow, 1960), who is represented here by a paper on teaching reading. Other contributions cover research into the mental development of children in special schools (Zh.I.Shif), of deaf children (I.M.Soloviev) and the cognitive activity of the blind (M.I.Zem-

¹ His last two published works were *Being and Consciousness* (Moscow, 1957) and *The Principles and Direction of Psychology* (Moscow, 1959) which sets out the main arguments of the former in more detail for students of psychology.

INTRODUCTION

tsova), while the main paper on psychopathology is contributed by A.R.Luria. There are contributions from Georgian psychologists; the theory of the psychology of 'set' is outlined by A.S.Prangishvilli, the experimental foundations by R.G.Natadze who is represented here by a paper on the formation of scientific concepts in school.¹ Other summaries of research have to do with the psychology of labour, which is receiving increasing attention, the psychology of sport which has long been a subject of interest, comparative psychology, the history of psychology and so on.

It is within this general framework that educational psychology finds its place and in educational psychology, as Professor Smirnov noted in 1955, 'questions of teaching and learning occupy a central position'.² At the same time he also drew attention to the lack of study of the interrelations between learning and development, of abilities and aptitudes, of the psychology of labour. In the intervening years attention has been turned to these questions, as some of the papers printed here testify. These are arranged in three sections. The first includes papers bearing on the interrelation between learning and development; the second is devoted to a comprehensive survey of research into the psychology of learning over the past three decades; in the third are grouped special studies which for the most part bear closely on the work of the schools.

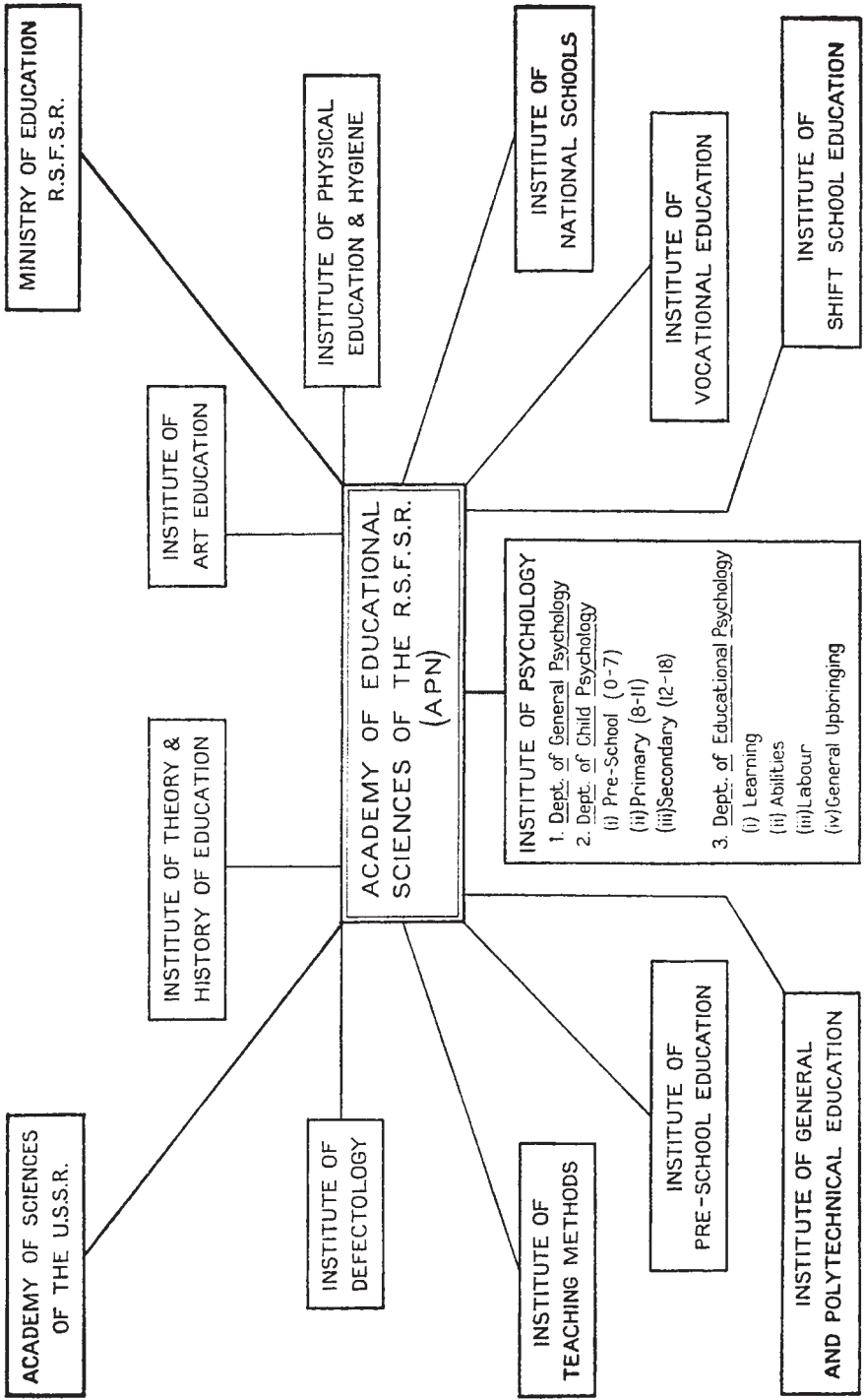
It may be useful to preface these with a short description of the organisation of research, some account of work in progress in child and educational psychology in the main institutes and a few general impressions.

I

The Institute of Psychology of the Academy of Educational Sciences of the R.S.F.S.R. in Moscow is the most important centre of psychological research. That it forms part of an academy of educational sciences reflects the fact that education is seen as the main field for the application of psychology. The composition of the Academy of Educational Sciences (the A.P.N. as it is known, because of the Russian initials) may be seen in the accompanying diagram. It is linked on the one hand with the Academy of Sciences of the U.S.S.R. and on the other with the Ministry of Education of the Russian Federation of republics which has a population of some 160 millions. While, therefore, its institutes conduct research into all aspects of psychology and education it also advises the Ministry on educational issues. It was, for instance, integrally concerned in the planning of the

¹ There is an account of research into speech and thought undertaken by Georgian psychologists in *Recent Soviet Psychology*, pp. 304–26.

² *Psychology in the Soviet Union*, p. 42.



INTRODUCTION

school reform of 1958, the reorganisation of secondary education for all in such a way as to broaden its scope and link the schools more closely to life. The highest body of the academy—the presidium—brings together the leading psychologists and educationists in the R.S.F.S.R.; at the time of writing one of the two vice-presidents is an educationist, Professor Goncharov, and the other is Professor Leontiev, professor of psychology at Moscow university. Psychologists, therefore, are closely in touch with educational developments, indeed directly concerned in planning them.

Each of the specialised institutes of the A.P.N. has a staff of from forty to eighty full-time research workers. The main ones include a group of psychologists doing research in the specific field concerned in close relation with colleagues in the relevant departments of the Institute of Psychology. The academy also includes a new type of research institute known as ‘school laboratories’; these are themselves research centres, each with a staff of some ten to twelve research workers; one is an 11-year school (now experimenting with differentiated curricula in the final years), another a boarding school, another a rural school. Several main institutes have their own experimental schools; one such, attached to the institute of defectology, is a kindergarten for deaf mutes. There are also 150 ‘base’ schools attached to the A.P.N. which use experimental teaching materials and programmes under the supervision of research workers. There are, therefore, extensive possibilities for testing experimental findings as a step towards introducing new methods into general school practice.

There are two other institutes of psychology, at Kiev in the Ukrainian Republic and at Tbilisi (Tiflis) in the Georgian Republic where there are also separate educational institutes. In the Ukraine, with a population of some 40 millions, the institute of psychology—under the direction of Professor G.S.Kostiuk and with some fifty research workers—is attached to the Ministry of Education; so also is the institute of education, but it is hoped eventually to establish an academy of educational sciences. In Georgia the institute of education is also directly linked with the republic’s Ministry of Education but the institute of psychology named after D.N.Uznadze, of which Professor A.S.Prangishvilli is the director, is part of the Georgian Academy of Sciences. In Armenia, Turkestan and other smaller republics institutes, or departments, of psychology and education form part of the national Ministry of Education.

New institutes have recently been established as part of the A.P.N. One is the institute of pre-school education, set up a few years ago when responsibility for all institutions for children under the age of three was transferred from the Ministry of Health and local health

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boards to the education authorities; psychological research here is under the direction of Professor A.V.Zaporozhets.¹ Another recently organised institute is that concerned with shift schools which provide a full secondary education for all who have left school at fifteen; these schools are now rapidly expanding with the shortening of the working day. This institute is at Leningrad and psychological research, under the direction of Professor Iu.A.Samarin, is at present primarily concerned with questions of motivation and the development of the capacity for independent and creative intellectual work. Much of this research is conducted in experimental schools, in close co-operation with teachers, and is already resulting in the writing of textbooks embodying fresh psychological principles. Similar work is being done under Professor Bogoiavlenski at the Institute of Psychology in Moscow.

At the institute of the theory and history of education Professor L.V.Zankov heads a group of psychologists concerned with study of learning and development as well as general methodology. His own work has recently been concerned with combination of the verbal and visual in teaching, a subject with which his paper in the present collection deals.² But a main line of work of psychologists in this institute is a long term project, initiated in 1957, designed to make a qualitative assessment of the relation between learning and development; already a great deal of data has been assembled, covering the content of different subjects, methods of teaching, the whole organisation of the class concerned.

The institute of defectology includes medically qualified personnel and neurologists among research workers and has close connections with various children's homes and institutions as well as experimental special schools. It is concerned with all forms of defect—in sight, hearing, speech—and with the mentally backward child, being at present engaged in a long term study of a group of such children.³ It has made a primary contribution to methods of diagnosis and selection for special schools which finds a reflection in the detailed and careful procedure followed before any child is classified as mentally retarded and recommended for transfer,⁴ and is also concerned with working out educational methods relevant to particular forms of defect.

¹ Author of *The Development of Voluntary Movements* (Moscow, 1960).

² His book on the subject is entitled *The Combination of Verbal Exposition and Visual Aids in Teaching* (Moscow, 1958).

³ The most recent publications of the institute's work are *Studies in the Cognitive Activity of Pupils in Special Schools*, ed. G.M.Dulnev, *Izvestia APN.*, Vol. 114, 1961, and *Intellectual Development of Pupils in Special Schools*, ed. Zh.I.Shif (Moscow, 1961).

⁴ Described in *Principles Governing the Selection of Children for Special Schools*, ed. A.R.Luria & G.M.Dulnev (Moscow, 1956); the introductory chapter is translated in *SCR Psychology Bulletin*, Vol. 5, No. 1, 1958.

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There is a considerable literature on this subject, the contribution by Professor Luria in the following pages being a chapter from one of several recent books concerned with the mental characteristics and the teaching of oligophrenic children.¹ Similar work is carried out at the institutes of psychology at Kiev and Tbilisi.

Other centres of research besides specialised institutes are, of course, university departments of psychology and those in colleges providing a five-year education and training for intending teachers, which are of university status. At Moscow University, for instance, Professor A.N.Leontiev and his colleagues are concerned with research into the formation of functional cerebral systems, which has a close bearing on the development of abilities and so on education; Professor P.Ia.Galperin also conducts his research into the formation of mental actions in the psychology department here; Professor Luria, who has contributed much in the past to child and educational psychology, is now concentrating his attention on the general field of psychopathology, while Professor Sokolov's research is concerned with the physiology of higher nervous activity. At Leningrad University there has been important research into problems of sensation and perception, under the direction of Professor B.G.Ananiev, who is now chiefly concerned in his own work with aspects of the asymmetrical functioning of the brain.

A considerable amount of psychological research is carried on at the teachers' training colleges, or Pedagogical Institutes as they are called. One of the largest of these is the Herzen Institute at Leningrad with 15,000 students and a full-time staff of 500. This has two prorectors, one being responsible for the research work which is carried on in the various departments—covering general education, methods of teaching each main subject, defectology and so on. The head of the department of psychology here is Professor A.G.Kovalev, formerly of Leningrad University.² There are seventeen research workers at present engaged in projects relating to the psychology of personality and the department is also responsible for the teaching of psychology throughout the college. All the five-year training colleges have departments of psychology of a similar kind, if not on this scale.

The research undertaken in different institutions in the R.S.F.S.R. is co-ordinated by the Academy of Educational Sciences. The major research centres work out a seven-year programme in general terms,

¹ Much of this work, of course, has a close bearing on the psychology of the normal child. Mention might be made of the two comprehensive volumes of papers edited by A.R.Luria, *Higher Nervous Activity in the Normal and Abnormal Child* (Moscow, 1956, 1958).

² Where he was concerned with research into abilities, cf. A.G.Kovalev and V.N.Miasishchev, *The Psychological Characteristics of Man*, Vol. I, *Character*, Vol. II, *Abilities* (Leningrad, 1957, 1959).

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outlining long term projects and ensuring adequate exchange of information. More detailed plans cover a single year and the larger institutes produce printed programmes giving details of group research projects and the work of individuals. Co-ordination of research and interchange of experience also takes place through national and regional conferences of the Psychological Society of the U.S.S.R. and specialised conferences on particular topics; for instance, recent conferences in Leningrad have covered sensation, spatial perception, abilities, problems of personality. Some conferences, on such subjects as disturbances of speech or higher nervous activity in normal and pathological conditions, bring psychologists usefully into contact with the fields of medicine and neurophysiology; the latter subject being the particular concern, of course, of the Institute of Higher Nervous Activity of the Academy of Sciences of the U.S.S.R.

There is no journal specifically concerned with educational psychology; research findings are published in the general psychological journals. The chief of these is *Voprosy Psikhologii* published bi-monthly by the A.P.N. which also issues an *Izvestia* sometimes devoted to a single subject.¹ The institutes of psychology at Kiev and Tbilisi have their own transactions, while the larger pedagogical institutes, such as the Herzen Institute, also issue regular publications some of which are referred to in the accompanying papers.

Although Soviet psychologists themselves would like to see a closer link-up between research findings and the actual practice of teaching in the schools, research findings are, in fact, made widely known through such journals as *Sovetskaia Pedagogika* (Soviet Education), published monthly by the A.P.N., *Nachalnaia Shkola* addressed to primary teachers and similar journals covering other specific fields. They are also brought to practising teachers in the courses which are regularly organised in each region to enable the teacher to add to his qualifications. Mention may be made here of the 'educational readings' to which great importance is attached, though these bear more on methodology than psychology; these are first organised locally, the papers being read by local teachers, then a selection of the best papers is read at conferences in each republic and those which have aroused most interest are subsequently published. This serves to draw attention to the whole field of methodology in which very extensive research is also taking place, supplementing that in psychology. There is no space even to outline the scope of

¹ Journals such as the *Pavlov Journal of Higher Nervous Activity* and the *Sechenov Physiological Journal* also publish material bearing on psychology. Both these are available in English translation (published in the United States).

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this here but it must at least be called to mind to indicate the wide range of research bearing on education.

Most of the books that have been mentioned are publications of the A.P.N.¹ Besides monographs and symposia on particular aspects of fundamental research these include books which set out research findings in different regions of child and educational psychology in a systematic way in relation to school practice. Notable examples in one field are studies of different aspects of teaching Class I (7–8 years) in school, prepared by the Leningrad Educational Institute² and the symposium *Learning and Education in the Primary School* (1960) also edited by B.G.Ananiev. There are also many more popular booklets addressed mainly to parents. An example is the series by leading authorities, published by the All Union Society for the Diffusion of Scientific Knowledge in editions of 100,000, a recent title being N.D.Levitov, *The Psychology of the Adolescent and his Upbringing at Home* (1958).

II

Two of the departments of the Institute of Psychology of the A.P.N. are concerned respectively with child and educational psychology. The former is organised in three sections concerned with pre-school children (0–7), primary school children (7–11), secondary school children (12–18) covering the middle and upper schools. This form of organisation underlines the fundamental approach of Soviet psychology, namely that child development must be studied in close connection with the process of education. As a result, as will appear, there is a considerable overlap between research in child and educational psychology.

The pre-school section works closely with the new institute mentioned earlier and is concentrating at present on the development of sensation and perception. Research is mainly directed to analysing age-differences and to discovering methods of educating perception—for instance, differentiation of shapes and sounds. This last involves organising carefully planned forms of activity, with special apparatus, and assessing the course of formation of the requisite ability to differentiate. This work has a relation to more fundamental research relating to functional cerebral systems, to which brief reference is made in Leontiev's paper printed in this book; for instance, it tends to uphold the view that musical hearing can be formed in all children.

¹ A comprehensive *Bibliography of the Publications of the Academy of Educational Sciences, R.S.F.S.R., 1944–57*, covering also articles in periodicals under different subject headings, was published in 1958.

² Ed. B.G.Ananiev & A.I.Sorokin, *Izvestia APN* Vol. 70, 1955.

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At Tbilisi research is in progress on the formation of perception in infants while at the Kiev Institute work relating to the age group 3–7 years is mainly concentrated on the development of motor activity.

Leaving aside the primary school section for the moment, the secondary section of the A.P.N. department of child psychology is at present mainly concerned with aspects of the development of personality within a social context. This is the subject of considerable attention, the main line of approach being study of interrelationships within the ‘collective’—that is any group working together for similar ends, such as a class in school. Similar research into the formation of personality is carried on by Professor L.I.Bozhovich—in the section of the department of educational psychology concerned with general upbringing; here attention is focused on the formation of separate features of personality, for instance the development of a positive attitude to social responsibilities. At Kiev, research relating to this age range is concerned with emotional features of personality—the development of feelings of shyness and sympathy, of self-assurance and self-consciousness—as well as the child’s capacity for estimating his own progress in learning, his ability to check, regulate or control his own work.

Much attention has been paid, more particularly in the A.P.N. Institute, to evolving systematic methods of studying children in different types of school, notably the new boarding schools: one outcome is the publication of research findings in a book addressed to teachers in these schools. Practical documents are prepared for the Ministry of Education and to assist teachers in such matters as the compilation of school records and methods of assessing children’s progress in school. The psychology of moral education has been much studied of late, both at Moscow and at Kiev where work on the relation of the individual to the group and the part played by the school collective in forming personality has chiefly engaged attention. It is with such questions that Professor Kostiuik’s paper given here is concerned.

At Kiev research is also being undertaken into children’s thinking between the ages of 5 and 15, directed to discovering the most effective ways of developing the capacity for thought. This is closely related to the question of activising pupils’ work in school, and from this angle experimental work has been concerned with the teaching of language, mathematics and technology. The paper printed here on the transfer of different types of technical skill, by Dr. E.A.Milerian, has reference to this work, the author being in charge of a newly formed section of the institute concerned with the psychology of labour; this is at present concerned with the formation of skills, children’s interests in

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connection with work, and wider questions related to uniting learning with labour in the interests of promoting child development.

A similar section has been formed in the department of educational psychology of the A.P.N. and the importance accorded to this is shown by the fact that it is headed by Professor A.A.Smirtov, director of the Institute of Psychology as a whole. The school reform of 1958 incorporated the view that experience of productive work is an essential aspect of all education, not least moral education (a view, it is interesting to note, first propounded by Robert Owen) and research is now being directed to some of the basic aspects of labour—for instance, the process of planning work and self-regulation in performing it. While this is directed to helping pupils to work independently and thoughtfully, research is also carried on into specific work processes with the aim of finding methods whereby these can be taught in an educative way. Such research is also linked with questions of vocational guidance.

The work of the primary school section of the A.P.N. department of child psychology is at present devoted mainly to questions of learning and is of particular interest in that it throws light on the approach of Soviet psychology, as it is discussed from various aspects in this book, and on a key research method. Since it is held that development of the child's intellectual potentialities depends directly on the content of education and methods of teaching, research takes the form of investigating the formation of mental processes in the course of teaching and learning in school. This form of research was first advocated by L.S.Vygotski, who also formulated a general approach to the question of child development and learning; this is set out in his paper printed here and the subject is taken further in subsequent papers in Part I.

For the past three years research conducted by the primary school section has been directed to discovering the capacities of children aged 7 to 11; or, to put the matter negatively, to testing the hypothesis that the schools do not go the best way about developing capacities and in some cases actually hinder development because of the methods used. New syllabuses and methods of teaching have been worked out, applied and the results compared with those obtained when the usual syllabus is used. In general, preliminary findings suggest that the ground covered by present programmes could be covered in a much shorter period and that certain concepts, usually held to be beyond the capacity of primary children, can be formed at this age by the use of special methods.

During a visit to one of the 'base' schools used by the primary school section Professor D.B.Elkonin, who is directing the research project, summarised the theory informing it as follows:

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(1) The process of teaching should involve children not so much in the solution of practical problems as of what might be called study problems which put the emphasis on principles; at present the child is too often taught the mechanics of solving arithmetical problems, for instance, while remaining ignorant of the principles underlying the solution.

(2) Learning on the part of the child is an active material process, each mental action being formed in a series of specific stages as analysed and defined by the researches of Leontiev and Galperin.¹ Educational methods in the different subjects must ensure that the child is adequately taken through each stage before making the transition to the next, if he is fully to master the given mental action.

(3) The teaching programme should be so organised that it is always a little ahead of the children's development—that is, not based on an already completed stage of development but oriented towards what is to come, since learning prepares the way for development. (This is the essence of the approach advocated by Vygotski.)

A specific application of these principles is to be found in Elkonin's paper in the present volume concerned with the teaching of reading. By the methods there described the usual time spent in learning reading has been halved and the procedure of teaching children to distinguish the sounds of speech before teaching letters leads on naturally into later study of grammar. As a corollary very interesting work is being undertaken in the teaching of language; the methods used enable children of eight to do verbal analysis of the structure of language, and the relation between linguistic and semantic variations, with interest and success—matters not usually covered until the ages of 11 or 12.

Interesting research into the teaching of mathematics is also being undertaken at this experimental school. This takes into account that the concepts required by modern mathematics differ in principle from the concept of number the child acquires before he reaches school or in the kindergarten, as a name of a group of objects. After two years' experiment the work is now directed to investigating to what extent children aged 7 to 8 can assimilate generalised relations between quantities expressed in algebraic formulae, since all the principal arithmetical operations are based on algebraic foundations. From the outset, therefore, teaching is directed to clarifying the relations of equality and inequality and to grasping these relations in

¹ These are outlined in the paper published in *Psychology in the Soviet Union*, pp. 213–26; more experiment and much discussion since the theory of formation by stages was first advanced has led to some modification, but not in any major respect. This theory is of key importance in relation to practical problems of learning and teaching.

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algebraic form. The aim is to introduce the more generalised relations before the teaching of number, so that the relations between numbers will later be regarded as partial cases of generalised relations. Professor Elkonin is well aware that many psychologists, for example Piaget, hold that children of this age cannot master ideas of this order; it is precisely this point that he is submitting to experimental investigation.¹

The techniques used in this school are typical of the 'natural experiment' which is widely used in research. Six research workers are attached to the school and supervise teaching to a whole class, a parallel class acting as the control group, but the actual teaching is done by the class teacher. Since the work was, in September 1961, entering on its third year, it is now being conducted with Classes I, II and III.² Every lesson given to a class in the experimental subject is fully worked out and written out beforehand, after discussion between the psychologists and the teacher, so that the script of the lesson covers every question, action and statement on the part of the teacher, together with the response expected from the children. This is, of course, a final stage in collaboration between psychologist and teacher who have initially discussed the full programme of lessons, and each group of lessons, before coming down to an individual lesson in order to ensure a strictly controlled approach. The teacher then gives the lesson of which a complete record is made; everything that occurs is noted, in particular points of difficulty so that if necessary part of the lesson can be repeated. It might be thought that all this would restrict the teacher and deaden the pupils' initiative. But observation of lessons suggested that the technique had been very successfully developed and there was no sense of formality or strain; on the contrary there was considerable exchange between teacher and pupils, included in the record, and the pupils themselves were lively in both question and answer and use of the special apparatus.

The present experiment is scheduled to last another five years, taking the original group of children up to Class VIII, age 15, and meanwhile a number of papers are being published reporting findings. There is no need to underline that this research has both a theoretical and practical importance, that it throws light on specific features of the mastery of knowledge and children's capacities at different ages, so clarifying the psychological principles that must underlie the planning of programmes of teaching in the schools; the programmes and

¹ An important recent book bearing on the whole question of generalised thinking in school subjects is that by P.A. Shevarev, *Generalised Associations in School Work* (Moscow, 1959) which draws in the main on research into the mental processes involved in problem solving in arithmetic and algebra.

² The programmes and methods evolved are also being used in classes in two other schools: one in an industrial city, Tula, the other in a rural area, Kalinin.

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methods of teaching used and modified in the course of research may well influence the development of general school practice.

This leads on naturally to the work of the department of educational psychology which itself is divided into four sections. These cover the psychology of learning, abilities, labour (to which some reference has already been made) and general questions of upbringing—an example of the work of this section being that related to the formation of personality also referred to above. Since this book includes a long account of research into the psychology of learning there is no need to cover the ground here. But it should be emphasised that this work has assumed a wide scope, and that its fundamental aim, in the words of the paper printed here, is to ‘aid the teacher by working out scientific foundations for the rational organisation of the teaching process’. It has been concerned both with the psychology of learning separate subjects and with various aspects of learning—the formation of mental actions, concept formation, the role of association. Attention is given to analysing individual differences in learning, and developing an individual approach in teaching.¹ The key question of the application of knowledge in practice has also come particularly into prominence since polytechnical education has taken new forms and much attention is being given to overcoming formalism and verbalism in the schools.²

The section concerned with abilities is relatively new, though Dr. Krutetski who heads it has been working in this field for a number of years. The work now being undertaken brings squarely into the sphere of educational psychology a question which has hitherto chiefly been tackled on the borders of physiology and psychology. The researches of Professor Teplov, of the department of general psychology, have laid the groundwork for study of individual differences in the development of abilities and temperament by investigating the characteristics of different types of higher nervous activity. On the basis of his findings Teplov has advanced the view, now generally accepted among Soviet psychologists, that innate anatomo-physiological properties of the higher nervous system constitute only one of the conditions for the development of an ability in the psychological sense; these are an internal condition of the subject, *prerequisites* for the development of abilities. It is on their foundation

¹ A recent publication is L.S.Slavina's, *An Individual Approach to Unsuccessful and Undisciplined Pupils* (Moscow, 1958); extracts translated in *SCR Psychology Bulletin*, Vol. 6, No. 3, 1959.

² There is a recent symposium edited by N.A.Menchinskaia, *The Psychology of Applying Knowledge in School Work* (Moscow, 1958); for the introduction in translation, *SCR Psychology Bulletin*, Vol. 7, No. 1, 1960. The paper by E.A. Fleshner in the present volume is drawn from this.

that natural abilities develop, in the course of ontogenesis in dependence upon external conditions; such, for instance, is the ability to form conditioned connections which, though based on given physiological properties of the nervous system is yet influenced by the conditions of life, by training. Clearly distinguished from natural abilities are specifically human abilities such as speech, musical ability, ability to construct and so on. These are abilities in a psychological sense.¹

Leontiev's research has to do with the latter, specifically with the formation of musical hearing. Preliminary findings indicate that it is possible to form such an ability as discrimination of pitch by adjusting important motor components of the process; the conclusion is drawn that this ability is not inborn but depends on the formation of complex cerebral systems in the course of practice which can be developed and modified by relevant forms of training. Much light has also been thrown on the functioning of cerebral systems by work in the field of psychopathology; for instance, research into the characteristics of speech in cases when there is pathological disturbance of higher nervous processes. The papers given here by Leontiev and Luria refer to these questions.

It is on this foundation that a direct approach to the study of abilities is now being made in educational psychology. As several papers in this collection testify, the approach to this question by way of mental testing has been abandoned since 1936—it is not merely characterised as theoretically unsound but also, and as a consequence, practically misleading. As Leontiev puts it, test results at best only indicate the level of development attained; they cannot by their very nature throw any light on what specifically has contributed to produce this level of development, nor, therefore, offer practical guidance in relation to teaching methods, particularly in the case of the defective or backward child. The alternative approach adopted is to study specific abilities in the process of their formation with the aim of analysing their structure; since such abilities only come to light in the process of undertaking relevant activities this involves study of different aspects of mastering knowledge, skills and habits. Dr. Krutetski's section is now concerned with research into the formation and structure of mathematical ability, ability for construction and design, and literary ability. In studying mathematical ability on a wide scale and at various levels four groups of children have been

¹ This question is discussed in B.M.Teplov, 'Study of the Typological Properties of the Nervous System and their Psychological Expression', *Voprosy Psikhologii*, No. 5, 1957; translated in *SCR Psychology Bulletin*, Vol. 5, Nos. 2 and 3, 1958; another translation appears in O'Connor, *op cit*. See also A.N. Leontiev, 'The Formation of Abilities' in the English edition of *Voprosy Psikhologii*, No. 1, though the translation is inadequate.

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selected. The first consists of children who show early signs of exceptional mathematical ability—children chosen from all over the Soviet Union at the age of 3 1/2 to 4 years who are now aged 9 to 10 years; these are not brought together but data concerning their development is systematically collected. The second group comprises children who have shown special ability—for instance, in the normal unstreamed class (as all classes are in Soviet schools) there will be one such pupil, the third, children of average ability, and the fourth, children characterised by their teachers as incapable in mathematics. Particular interest centres on the latter since it is held that study of the nature of incapacity is a necessary complement, if not preliminary, to understanding the structure of ability; or, to put it another way, that there is no better way of finding out how an ability is formed and in what it consists than by actively substituting ability for inability. It is with one aspect of this question that Dr. Krutetski's paper, printed here, is concerned.

This research typifies the general outlook of Soviet psychology. That there should be growing interest in the question of abilities in a society moving towards the principle of social organisation 'from each according to his ability, to each according to his needs', is natural. But the question is approached in a functional and developmental context. The educational corollary is touched on by Teplov in the paper in the present volume—one written many years ago but still highly thought of—on artistic education. Here he justly remarks that if success in a particular field depended merely on the presence of corresponding abilities in individuals, if the work of the schools merely 'presupposed' the presence of these abilities and provided an arena for their manifestation, then its educational significance would not be very great. This is to make clear the fulcrum on which all the work published here turns. It is the conviction, in the light both of extensive research and of practice in the schools, that education can exercise a *formative* influence on the child's mental development. It can exercise this influence in a positive sense only if it rests on an understanding of the nature of the learning process on the one hand, and the ways in which teaching influences and controls this process on the other; it is the task of educational psychology to provide this understanding.

III

It is impossible, wrote Piaget, after visiting the U.S.S.R. in 1956, to do justice in a brief space to the scope of work in the field of the psychology of intelligence and thought, 'so rich and varied were the research projects that we were shown'.¹ So also the survey in the preceding pages is by no

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means comprehensive but rather in the nature of a progress report relating particularly to the papers printed here.

There has been no attempt to describe the philosophical background to Soviet psychology and the nature of the reflex theory associated with the names of Sechenov and Pavlov which constitutes its scientific foundation. These questions naturally arise in relation to this book but they were covered in some detail in the introduction to *Psychology in the Soviet Union*. As regards educational psychology, and the psychology of learning in particular, the essential point is that this took a new direction as an immediate outcome of rejecting the static, psychometric approach in the mid-1930's. It was this that led to concentration on learning as a process which in turn involved research into the development, the *formation* of mental processes. As several of the papers here make clear, it was only when the theories underlying mental testing—which in essence exclude the very concept of development—were subjected to detailed criticism, and there was a fundamental rethinking of certain basic categories, that a new perspective opened for advance in educational psychology, grounded on research into the actual formation of mental processes 'in changing conditions of activity'. There has since been widespread study of the psychology of learning different subjects and in the past decade attention has been turning more and more to the learning process in general with the result that Soviet psychologists feel that the general outlines of a learning theory are now beginning to emerge.

It is important to bear in mind here that the school system in the U.S.S.R. is very different from that in England: there is nothing equivalent to the 11+ examination, nor is there any streaming and selection within the school. Though there is some differentiation of education over the age of 15, even then there is not the same degree of specialisation as here. Consequently it is with the education of children in school that Soviet psychologists are concerned, the imparting of a socially-determined body of knowledge to all, the methods necessary to enable the younger generation to master this knowledge so that they may develop their capacities in an all-round way. This accounts for the scope of research into the learning process, for the constant emphasis on finding out in detail how children learn, analysing mistakes, discovering the cause of difficulties, and seeking improvements in the order of teaching and teaching methods in order to facilitate the learning process and the development of mental abilities.

¹ 'Some impressions of a visit to Soviet psychologists', *American Psychologist*, 1956, 11, 343-45.

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In this connection the main characteristics of the approach of Soviet psychology stand out clearly. First, the chief preoccupation is study of human learning, and, particularly, learning under the conditions of organised teaching in school, under planned educational influences. Second, and closely allied to this, much stress is laid on the role of speech in mental development and it is here that Pavlov's theory of the second signal system (the nervous apparatus corresponding to the effect of language as a tool and stimulus in human society) has been of such importance. Third, the emphasis is on developmental, or genetic, studies. Finally, as an outcome of all this, qualitative methods of research are used (standing out in sharp contrast to the mass, quantitative methods favoured by psychometry) which are well illustrated by papers in Part III of this volume. These methods are directed to discovering not only common characteristics in the process of learning but also individual differences in learning.

These trends are of particular interest to educationists and psychologists in Britain who find their attention being more and more drawn to the vital question of educating the ordinary child. This is only another way of saying that faith in psychometric techniques and findings is waning, the heavy emphasis on streaming and selection is increasingly questioned, and ways are being sought of furthering relevant experimental research into human abilities and learning. Some research into concept formation in relation to particular school subjects has already begun and a new interest is being shown in Piaget's experimental work but in general it is true to say that the field remains wide open. In cultivating it there is much of interest to be considered in the findings and procedures of Soviet psychologists, not least the 'natural' and 'teaching' experiment, the psychological analysis of the work of outstanding teachers, and other methods worked out in close touch with the educational situation—and, it should be emphasised, in the closest co-operation with the teaching profession. There is room and to spare for similar co-operation here between psychologists and educationists in tackling problems in the very complex, but infinitely rewarding, field of education.

Part One

LEARNING AND MENTAL DEVELOPMENT AT SCHOOL AGE

L.S.VYGOTSKI¹

ALL the main interpretations of the relation between development and learning in the child can be schematically reduced to three basic groups—these may be considered in turn so that the points are set out clearly and fully.

The first group of solutions advanced in the history of science has as its central proposition *the independence of the process of development from the process of learning*. In the light of these theories learning is considered as a purely external process which is in some way congruous with the course of child development but does not itself participate actively in that development, does not change anything in it, which utilises the achievements of development rather than advancing its course and changing its direction. The extremely complex and interesting conception of Piaget, who studies the development of the child's thinking entirely independently of the process of learning, is a typical example of this theory.

It is a surprising fact, hitherto overlooked, that researches into the development of thinking in the schoolchild take as their starting point the main tenet of this theory, that this process is independent of the child's actual school learning. The child's reasoning and understanding, his ideas about the world, explanations of physical causes, mastery of logical forms of thought and abstract logic, are consi-

¹ Printed in L.S.Vygotski, *Selected Psychological Works*, ed. A.N.Leontiev and A.R.Luria (Moscow, 1956), pp. 438–52. This article, written in 1934, the year of the author's death at the age of 38, was published posthumously. An active researcher in the period 1928–34, Vygotski is considered to have laid the foundations of a scientific psychology, particularly in relation to the development of speech and thought in the child. In his *Thinking and Speech* (1934) and other works he underlined the need to reject the behaviourist outlook and direct research to problems of the development of conscious mental processes. Other writings, previously unpublished, have appeared under the title *The Development of Higher Mental Functions* (Moscow, 1960).

dered by researchers as if these processes take place of themselves without being influenced in any way by the child's learning in school.

For Piaget this is a question of principle, not of technique; his method, when investigating the child's mental development, is to set tasks which are not only entirely foreign to school work but also exclude any sort of readiness on the child's part to give the necessary answer. A typical example, illustrating clearly the strong and weak aspects of this method, is Piaget's questions in his clinical dialogues with children. When a child of five is asked why the sun does not fall, the idea in mind is not merely that the child has no prepared answer but that he is in no position—even were he a genius—to give anything approaching a satisfactory answer. The object of posing such entirely inaccessible questions is completely to exclude the influence of previous experience, previous knowledge; to force the child's thought to work on what are known to be new and inaccessible problems so that tendencies in his thinking can be studied in a pure form, in absolute independence from his knowledge, experience and learning....

It is easy to see that this theory implies the complete independence of the process of development from the process of learning, that even a separation of these processes in time is postulated. Development must reach a certain stage, certain functions must mature, before the school can embark upon teaching certain knowledge and habits to the child. The course of development always precedes the course of learning. *Learning lags behind development*, development always goes before learning. This approach makes it impossible even to pose the problem of the role played in development by learning and by the maturing of those functions which are activated in the course of learning. The development and maturation of these is a prerequisite rather than a result of learning. Learning is a superstructure on development, nothing is exchanged in essence.

The second set of solutions of the problem—which may be understood as a reversal of focus, a directly opposite thesis—declares that *learning is development*. This compressed and precise formula expresses the essence of this set of theories though they arise on various foundations.

At first glance this standpoint may seem more progressive than the preceding one, which is fundamentally based on complete separation of the processes of learning and development, in that it gives to learning the central significance in child development. But a closer examination of this second set of solutions indicates that, for all the apparent contradictions, the two standpoints agree on basic points and are, in fact, very similar to each other. 'Education', says James, 'may best be defined as the organisation of acquired habits of behaviour and inclinations to action.'¹ Development is also in effect reduced to the

accumulation of reactions. Every acquired reaction, says James, is usually either a more complex form of the innate reaction which a given object initially tended to evoke, or a substitute for it. James affirms this proposition as a general principle which underlies all processes of acquisition, i.e. development, and directs all the teacher's activity. For him the individual is simply a living complex of habits.

It is difficult to clarify this concept except by saying that this set of theories regards laws of development as natural laws which teaching must take into account, just as technology must take account of the laws of physics; teaching can no more change these laws than technology can change anything in the general laws of nature.

Despite the resemblance between the two theories there are essential differences which can be distinguished if we turn to the connection in time of the processes of learning and development. As has been seen, supporters of the first theory affirm that the course of development precedes the course of learning. Maturation goes before learning. The educational process lags behind mental formation. The second theory sees both these processes as accomplished proportionally and in parallel, so that each stage in learning corresponds to a stage in development. Development follows on learning as a shadow follows on the object that casts it. Even this comparison is hardly bold enough for a theory which takes as its starting point the full union and identification of the processes of development and learning, which postulates an even closer interconnection by making no differentiation at all between them. According to this theory development and learning are superimposed upon one another at all points, like two equal geometrical figures laid upon each other. The further question as to which process precedes, which follows after, is, of course, pointless from the point of view of this theory—simultaneity, synchronisation, is the basic tenet of theories of this kind.

The third set of theories tries to reconcile the extremes of the first two points of view simply by way of their *conjunction*. On the one hand the process of development is conceived of as independent of learning; on the other, this same learning, in the course of which the child acquires a whole number of new forms of behaviour, is conceived of as identical with development. This implies a dualistic theory of development. A clear example is Koffka's theory, according to which two processes underly child mental development which, though connected, are different in nature and condition each other. On the one hand there is maturation, which depends directly on

¹ Retranslated from the Russian, as are all the quotations in this paper which lack references (Ed.).

the development of the nervous system, on the other hand, learning which—according to Koffka—is itself the process of development.

What is new in this theory may be summarised as three moments. First, as has been indicated, it brings together two contradictory points of view, formerly thrust apart. This very fact indicates that the two standpoints are not contradictory and mutually exclusive but, in reality, have not a little in common. Second, there is the concept of interdependence, that *the interaction of two basic processes* brings about development. True, the character of this interaction is hardly made clear in Koffka's published work in which there are only general observations about the existence of a connection between these processes. But these observations suggest that the process of maturation prepares for and makes possible a given process of learning; the process of learning as it were stimulates and to some extent advances the process of maturation.

Finally, the third and most essential new moment is that *the role of learning in the course of child development is extended*. This point must be examined more closely. It leads us directly to a longstanding pedagogical problem, which has recently become less actual, to what is usually called the problem of *formal discipline*. This concept, which finds its clearest expression in the Herbartian system, leads on, as is known, to another—to the idea that each subject taught has a given significance for the child's general mental development. From this point of view, different subjects have varying values.

In the light of this idea a school will choose subjects such as a classical language, ancient history, mathematics, on the grounds that they evoke a kind of discipline of great value to general mental development, quite independently of their actual value. As is well known, the theory of formal discipline has inspired a very conservative approach to the practice of education. It was as a reaction against this that the second group of theories we have examined arose, theories which attempted to restore to learning its independent significance, instead of considering it merely as a means to the child's development, in terms of the exercise and formal discipline necessary for the training of mental abilities.

The bankruptcy of the theory of formal discipline has been shown by a number of researches which indicate that learning in one particular region has very little influence on general development. Thus Woodworth and Thorndike have found that adults, after special practice, can successfully estimate the length of short lines but that this adds hardly at all to their skill in estimating longer lines; and that adult subjects who achieve success in estimating the area of a given figure produce less than one third of successes in estimating the area of a number of varying figures. Gilbert, Fracker and Martin have shown that

practice in rapid reaction to one kind of signal has little influence on rapid reaction to another kind of signal.

Quite a number of researches of a similar nature have been conducted with almost identical results, showing that special learning in a particular form of activity bears very little relation to other forms of activity even if these closely resemble the first. As Thorndike says, the extent to which a particular reaction performed daily by pupils develops their mental abilities as a whole is a question of the general educational significance of the subjects taught, or, in short, a question of formal discipline.

The usual answer given by the theoretical psychologist and educationist is that each particular acquirement, each special form of development, directly and uniformly improves general skill. The teacher has thought and acted on the basis of this theory, that the mind is a complex of abilities—powers of observation, attention, memory, thinking etc.—and that every improvement in one such ability is acquired for all abilities in general. In the light of this theory the concentration of powers of attention on Latin grammar means strengthening of ability to concentrate attention on other matters. It is the general opinion that the words accuracy, liveliness, reasoning, memory, observation, attention, concentration etc. signify real and basic abilities which change in dependence on the material with which they operate, that these basic abilities are changed to a significant extent through study of separate subjects, that these changes are preserved when they are transferred to other regions, that, therefore, if a man learns to do any one thing well then by virtue of some mysterious connection he can do other things well, which have no relation to the first matter. It is considered that intellectual abilities act independently of the material with which they operate. It is even considered that the development of one ability in itself leads to the development of others.

Thorndike has opposed this standpoint in the light of a number of researches which show it to be untenable. He has pointed out the dependence of different forms of activity on the specific material with which the activity operates. The development of one particular ability rarely signifies a similar development of others. Close investigation of the matter shows, he says, that the specialisation of abilities is even greater than it appears to simple observation. For instance, if from a hundred individuals ten are selected who master the ability to note mistakes in orthography or to estimate a length, these ten do not reveal better ability in estimating the weight of an object correctly. Even speed and accuracy in addition are not connected with the same kind of speed and accuracy in thinking out antonyms to given words.

These researches show that cognition is in no sense a complex of several general abilities—observation, attention, memory, judgment etc.—but the sum of many different abilities, each of which is at a certain stage independent of others and must be subjected independently to training. The task of teaching is not to develop the single ability of thinking, but to develop many special abilities of thinking about different kinds of subject, not to change our general ability to attend but to develop different abilities to concentrate attention on different subjects.

Methods which ensure the influence of specialised learning on general development act only through the agency of identical elements, identical material, the identical processes. Habit rules us. Hence the conclusion that to develop cognition is to develop many specific independent abilities, to form many specific habits, since the activity of each ability depends on the material with which this ability operates. An improvement in one function of cognition or one aspect of its activity influences the development of others only when there are elements common to both functions or activities.

The third set of theories to which we have referred stands opposed to this point of view. Theories based on the now dominant structural psychology—which affirms that the process of learning can never operate merely to form habits but comprises activity of an intellectual nature, allowing for transfer of structural principles implicit in the performance of one task to a whole number of others—advance the proposition that *the influence of learning is never specific*. In learning any particular operation the child acquires the ability to form a structure of a specified type, independently of the varying material with which he operates, independently of the separate elements which go to make up this structure.

This theory covers, therefore, an essential new moment, a new approach to the question of formal discipline, which comes directly into contradiction with its own primary proposition. It may be recalled that Koffka adopts the old formula which states that learning is development. At the same time he does not see learning as merely a process of acquiring skills and habits, does not regard learning and development as identical but postulates a more complex interrelationship. If, for Thorndike, learning and development are superimposed upon each other at all points, as two identical geometrical figures laid one upon another, then for Koffka development always covers a wider sphere than learning. The interrelation between the two processes might be schematically designated by two concentric circles, the smaller symbolising the process of learning, the larger the process of development extending beyond learning.

The child learns to perform an operation of some kind. At the same time he masters a structural principle whose sphere of application is

wider than that of the operation in which this principle was mastered. Consequently by taking one step in learning the child moves two steps in development, i.e. learning and development are not coincident.

Since the three sets of theories described interpret the relation between learning and development so variously, we may set them aside and contemplate a sounder solution of the problem. We may take as a starting point the fact that *the child's learning begins long before learning in school*. Schooling never begins in a vacuum. All the learning the child meets with in school has its pre-history. For instance, he begins to study arithmetic. But long before entering school he has gained some experience of quantities, he has already come across various operations of division and addition, complex and simple, so that the child has his own pre-school arithmetic which the psychologist would be blind to ignore.

Careful investigation indicates that this pre-school arithmetic is extremely complex, that the child has gone through an arithmetical development of his own for a long time before embarking on learning arithmetic in school. That there is this pre-history of school learning does not, however, imply a direct continuity between the two stages of the child's arithmetical development.

The course of the child's school learning is not a direct continuation of his pre-school development in any sphere; the course of pre-school learning can be deflected in certain ways and school learning may even take a contrary direction. But whether we have to do in school with a continuation of pre-school learning or its negation we cannot ignore the fact that school learning never begins in a vacuum but is always preceded by a definite stage of development attained by the child before entry to school.

The arguments of such researchers as Stumpf and Koffka, who attempt to obliterate the line between learning in school and learning at pre-school age, seem to us extremely convincing. It can easily be demonstrated that learning does not begin at school age. Koffka, trying to clarify for the teacher the laws of child learning and their relation to the child's mental development, centres all his attention on the more simple and primitive processes of learning which appear precisely at pre-school age. But, while seeing the resemblance between learning before school and at school, he fails to recognise the differences between them, to distinguish what is specifically new about the facts of school learning; he is inclined, following Stumpf, to consider that the only difference between the two is that the first is unsystematic, the second systematic learning on the child's part. It is not merely a matter of systematisation: school learning brings something altogether new into the course of child development. Nevertheless these authors are correct when they draw attention to the neglected fact that learning is

present before school age. Does not the child learn language from adults? Does he not, in questioning and receiving answers, acquire a whole range of knowledge, of information, from adults? Is it not through training by adults, accepting their direction of his actions, that the child himself forms a whole number of habits?

It goes without saying that this process of learning, as it takes place before entry to school, differs fundamentally from mastery of the elements of knowledge in the course of teaching in school. Nevertheless when, as a result of his early questioning, the child masters the names of objects in his environment he is already embarking on a specific stage of learning. Learning and development are not, therefore, first brought together at school age but are interconnected from the first days of the child's life.

The question confronting us has, therefore, a dual complexity. It resolves itself into two separate questions. First, we must understand *the relation between learning and development in general*, second, *the specific characteristics of this interrelation at school age*.

We may begin with the second question since it helps to clarify the first. In answering it we may take into account the results of some research which, in our view, is of first importance and has enabled the advancing of a new theory of key significance to the correct solution of the problems we have been considering: this relates to the zone of potential development.¹

It is an empirical finding, frequently verified and indisputable, that learning must be congruous with the level of child development. That only at a certain age can a start be made in teaching grammar, only at a certain age has the child the ability to study algebra—it is hardly necessary to offer evidence of this. We may, therefore, confidently take as a starting point the incontestable and basic fact that there is a relation between a given level of development and potentiality for learning.

Recently, however, attention has been drawn to the fact that when attempting to define the actual relation of the process of development to potentiality for learning we cannot confine ourselves to only one given level of development. We must determine at least *two levels of a child's development*, otherwise we fail to find the correct relation between the course of development and potentiality for learning in each specific case. The first of these we call the level of *the child's actual development*. We have in mind that level of development of the child's mental functions which has been attained as a result of a specific, already accomplished, course of development.

¹ *zona blizhaishero razvitiia.*

When we assess a child's mental age with the help of tests we are almost always concerned with the level of actual development. A simple check shows, however, that this level of actual development does not indicate with any completeness the present state of the child's development. Let us suppose that we have tested two children and found that both have a mental age of seven. When we set these children further tests, however, essential differences between them come to light. With the help of guiding questions, examples, demonstration, one child easily performs the tests, surpassing his level of actual development by two years; the other can only do tests which advance him by half a year. Here we meet directly with the central concept necessary for estimating the zone of potential development. This, in its turn, is connected with a reevaluation of the problem of imitation in contemporary psychology.

The traditional view takes it for granted that the only possible indication of a child's level of mental development is his independent activity, not imitation of any kind. All the contemporary systems of testing embody this outlook. The only tests considered to indicate mental development are those which the child does independently, without help from others, demonstration or guiding questions.

Research has shown that this standpoint is untenable. Experiments with animals have shown that an animal can imitate actions which lie in the zone of its actual potentiality. This means that an animal can only imitate actions which are accessible to it in one form or another, so that, as Köhler's researches have shown, the potentiality for imitation in animals hardly ever surpasses the boundaries of their own potentiality for action. If an animal is able to imitate an intellectual action this means that in its independent activity in certain conditions it displays ability to perform an analogous action. Therefore, imitation is closely connected with understanding, it is only possible in the sphere of actions which are accessible to the animal's understanding.

The essential difference in the case of the child is that he can imitate a number of actions which surpass the boundaries of his own potentiality, if not to a limitless extent. With the help of imitation in collective activity, under adult guidance, the child does much more than he can do with understanding, independently. The divergence between the level of performing tasks which are accessible under guidance with adult help, and the level of performing tasks accessible to independent activity, defines the zone of the child's potential development.

It is only necessary to recall the example already given. We have before us two children with a mental age of seven but one, with a little help, can do tests up to nine years, the other only those proper to seven and a half. Is the mental development of these two children equivalent?

Their independent activity is equivalent but from the point of view of future potentiality for development the children differ radically. That which a child is in a position to do with adult help we call the zone of his potential development. This means that, with the aid of this method, we can measure not only the process of development up to the present, the stage already accomplished, the processes of maturation that have taken place, but also those processes which are in the course of becoming established, which are only now maturing, developing.

What the child can do to-day with adult help he will be able to do independently to-morrow. The zone of potential development enables us, therefore, to determine the child's next steps, the dynamics of his development, to consider not only what development has brought about but what will come about in the process of maturation. The two children we have taken as an example exhibit an equivalent mental age in relation to the course of development already accomplished but the dynamics of their development are entirely different. The state of a child's mental development can, therefore, only be determined by finding out at least *two levels*—the level of actual development and the zone of potential development.

This fact, which in itself may seem of little significance, is in reality of decisive importance and brings into question all the theories about the relation between the processes of learning and development in the child. In particular, it alters the traditional view as to what should be the pedagogical approach when development has been diagnosed. Hitherto the matter has been presented as follows: we try, with the help of tests, to determine the level of the child's mental development and this the educator must regard as a limit which the child cannot transcend. This very way of presenting the question involves the idea that teaching must be oriented to the yesterday of the child's development, to the stage already accomplished.

That this standpoint is harmful has been recognised in practice before it was clearly understood in theory. This may be illustrated in relation to the teaching of mentally backward children. As is known, research has established that such children show little ability for abstract thinking. Teachers in special schools, therefore, adopting what seemed to be a correct approach, decided to base all their teaching on visual material. After long experience this approach has proved deeply disappointing. It has been demonstrated that a system of teaching based exclusively on the visual, excluding everything pertaining to abstract thinking, not only fails to help the child to overcome a natural disability but in fact reinforces this disability since stress on visual thinking smothers the small beginnings of abstract thinking in such children. The backward child, left to himself, never achieves any developed form of abstract thinking; precisely because of this it is the school's task to turn every

effort to moving the child in just this direction, to developing that which is lacking. In the present practice of special schools we can observe a beneficial turn from the former insistence on teaching by visual means. Emphasis on the visual is necessary and does no harm if it is used only as a stage in the development of abstract thinking, as a means but not as an end in itself.

Similar considerations apply to the development of the normal child. Teaching which is oriented to an already accomplished stage of development is ineffective from the point of view of the child's general development, it does not lead the process of development but lags behind this process. The theory of the zone of potential development allows for a formula which directly contradicts the traditional approach: *the only good teaching is that which outpaces development*.

We know from a whole number of researches—to which we can only refer here as there is no space to detail them—that the development of higher mental functions in the child, of those specifically human functions formed in the course of the history of mankind, is a unique process. We have formulated the basic law of development of these functions elsewhere as follows: *All higher mental functions make their appearance in the course of child development twice: first, in collective activity, social activity, i.e. as interpsychic functions, second in individual activity, as internal properties of the child's thinking, i.e. as intrapsychic functions.*

The development of speech serves as a paradigm of this whole problem. Speech originally arises as a means of communication between the child and people around him. Only at a later stage, transformed into internal speech, does it become an internal mental function providing the basic means to the child's own thinking. The researches of Bolduina, Piniano and Piaget have shown that the need to verify thought first arises when there is a dispute in a children's community, that only after this does there arise in the child thinking as an internal activity, the characteristic of which is that the child begins to know and verify the basis of his thought. 'We willingly believe the word', says Piaget, 'but only in the process of communication does the possibility arise of verifying and confirming thought'.

Just as internal speech and thinking arise from the child's interrelations with people around him, so also these interrelations are the source of the child's volition. In his latest work Piaget has shown that co-operation underlies the development of moral feelings in the child. Earlier researches have established that the child's ability to control his behaviour first arises in collective play and that only later does voluntary regulation of behaviour develop as an internal function.

What we have presented here as separate examples illustrate a general regularity in the development of higher mental functions in childhood which, in our view, applies to the process of child learning as a whole. After all that has been said there is no need to underline that the essential mark of learning is that it creates the zone of potential development, i.e. brings to life in the child, stimulates and sets in motion, a whole number of internal processes of development in the framework of interrelations with others, which are later taken into the internal course of development and become internal possessions of the child himself.

Looked at from this standpoint learning is not itself development but correct organisation of the child's learning leads to mental development, evokes a whole number of processes of development which could not take place without learning. Learning is, therefore, an internally necessary and universal moment in the process of development in the child not of natural but of historically formed human characteristics.

Just as the child of deaf mute parents, who does not hear speech around him, remains mute despite all the innate prerequisites for the development of speech and so does not develop those higher mental functions connected with speech, so also the whole process of learning is a source of development calling to life a number of processes which could not themselves develop without learning.

The role of learning as a source of development, constituting the zone of potential development, may be further illustrated by comparing the process of learning in the child and the adult. Little attention has been given recently to the differences between adult and child learning. Adults, as is known, command a high ability to learn. Recent experimental research contradicts the proposition advanced by James that adults cannot acquire new ideas after the age of twenty-five. But what it is that, in essence, differentiates adult learning from child learning has not hitherto been adequately explained.

In the light of the theories adopted by Thorndike, James and others, outlined earlier, which reduce the process of learning to the formation of habits, there cannot be any essential differences between adult and child learning. The very suggestion is frivolous. According to this view one and the same mechanism underlies the formation of habits whether in the adult or the child. One forms a habit with more, the other with less, ease and speed; that is all there is to it.

The question arises: what essentially differentiates the process of learning to use a typewriter, ride a bicycle, play tennis, in an adult from the process of learning written speech, arithmetic, natural science at school age? It seems to us that the essential difference lies in

the different relations of these processes to the process of development.

Learning to use a typewriter does, in fact, represent the establishment of a number of habits which in themselves do not change a man's mental traits at all. Learning of this kind makes use of an already elaborated and completed course of development and precisely because of this contributes very little to general development.

The process of learning written speech is quite a different matter. Special research has shown that this calls to life a wholly new, very complex, course of development of mental processes, and that the advent of these processes signifies an essential change in the child's general mental traits; just as the learning of speech marks an essential stage in the transition from babyhood to early childhood.

We may attempt now to summarise what has been said and give a general formulation of the relation between the processes of learning and development. Before doing this we may note that all the experimental researches into the psychological nature of the processes of learning arithmetic, writing, natural science and other subjects in the primary school show that the foundation for these, the axis around which they revolve, is a new formation at school age. All are inter-laced with the development of the central nervous system. The very direction of school learning stimulates internal processes of development. To trace the rise and fall of these internal lines of development, as this takes place in the course of school learning, is the immediate task of analysis of the educational process.

This hypothesis necessarily presupposes the proposition that *the process of development does not coincide with the process of learning, the process of development follows on the process of learning which creates the zone of potential development.*

The second essential moment of this hypothesis is the proposition that learning and child development, though directly connected, never take place symmetrically and in parallel with one another. The child's development never follows on school learning as a shadow follows the object that casts it. Tests of scholastic attainment cannot, therefore, reflect the real course of child development. There is an extremely complex, dynamic, interdependence between the process of development and the process of learning which cannot be covered by a single, *a priori*, speculative formula.

Every school subject has its own particular relation to the course of child development, a relation which changes with the child's transition from one stage to another. This implies reconsideration of the whole problem of formal discipline, i.e. the role and importance of each

separate subject in furthering the child's general mental development. Such a matter cannot be dealt with by a single formula of some kind but rather suggests how great is the scope for extensive and varied experimental research.

SOME ASPECTS OF THE INTERRELATION
BETWEEN EDUCATION AND THE
DEVELOPMENT OF PERSONALITY

G.S.KOSTIUK¹

[THIS paper opens by stressing the need to clarify the relations between education and the development of personality at a time of rapid educational advance. Soviet psychology has long recognised the decisive influence of education on mental development. But all the implications of this have not been fully worked out, as has been pointed out in the specialist and general press [17, 24, 40]. There has been little investigation of educational influence on the development of qualities of personality or of the most effective conditions for guiding the child's development. This is a very complex and extensive problem and this paper will be confined to drawing on the findings of recent experimental research with the aim of raising some of the issues involved and drawing attention to the need for further research.]

I

The child's mental development takes place in the process of his interaction with the natural and social environment. Educational guidance of development consists in organising this interaction, in directing the child's activity to cognising reality, to mastering with the aid of speech the knowledge and other cultural riches of mankind, developing social viewpoints, convictions and norms of moral behaviour. In this connection one of the most important questions is the interaction between learning, education and mental development.

It is well known that psychologists abroad have reached and still hold different views on this question. For some, development and

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learning are independent processes which have no internal connection; for others they are identical. An example of the former standpoint is the view of A.Gesell which lays down that the basic forms of the child's behaviour, their mutual connections and consequent changes, are determined by processes of maturation of the organism [41:524]. On the other hand, the identity of development and learning, passage from the first to the second by a process of forming habits, is the characteristic standpoint of the behaviourist school.

L.S.Vygotski opposed both these conceptions, attempting to point out the unity and the distinction between the child's learning and his mental development and to emphasise the leading role of education in this process [10]. S.L.Rubinstein [33] has advanced as a basic proposition in this respect that the child develops as he is educated and taught.

Though there have been very few experimental researches specially directed to clarifying the interrelations between learning and development, from the analysis and generalisation of numerous recent researches into the psychology of learning—the mastery of different aspects of knowledge, skills and habits—certain conclusions can be drawn concerning the internal interrelations and the specificity of the processes of learning and development. These data describe the characteristics of children's mastery of social experience, the essential part played in this process by educational guidance of the child's own activity, methods of elaborating new actions and the connections between the first and second signal systems which underlie these. All this makes possible a more specific explanation as to how the internal prerequisites for mental development are created in the process of learning and permits of a deeper understanding of their social conditioning. It helps us to understand how, in the course of the child's interaction with the environment, the objective—the social, becomes the subjective—the individual; how that which a child acquires in communication with adults and other children leads later to the organisation of his own activity, to the rise of new mental qualities.

In this connection data relating to the effect of mastering speech on mental development in early childhood has a particular interest. As research has shown speech processes, first mastered by the child in the form of immediate social acts directed to the satisfaction of needs of some kind, become later, in their external and internal form, significant factors in the development of his perception, of imagery, instruments of his thinking and of the entire organisation and regulation of his behaviour [18, 27, 28, 29].

The data of other researches throw light on how mental actions, formed in the child of pre-school age as 'inter-individual' acts of cognitive activity arising in speech communication with adults

(question and answer, the grouping of objects and establishing the quantitative similarity of groups, their composition, enumeration, etc.) become later 'internal-individual' acts which the child also accomplishes outside the specific teaching situation [9, 22].

Whereas at pre-school age there is involuntary assimilation of knowledge, school age children engage in various forms of purposeful educational activity. Research has shown that when reading, writing, the vocabulary of the native language, grammar, arithmetic, geometry, physics, are mastered the results are not comprehended under the fact of acquisition. They produce some measure of improvement in the pupils' cognitive activity and ability to assimilate knowledge [2, 5, 11, 30].

The mastery of a new vocabulary and other aspects of language improves children's speech, gives rise to new demands on speech processes and new attitudes to these. When the content of texts is mastered pupils also master the ability to use forms of analysis and synthesis (bringing out the important ideas, bringing these together, the plan of composition, etc.). Methods of working on verbal material, notably written texts, which are developed under the teacher's guidance, are later, with the transition to a new stage of scholastic activity, generalised and become a means to the pupil's thinking, voluntary memory and reproduction [15, 20, 25]. The mastery of more complex concepts enables development of the requisite abstraction and generalisation, leads to the formation and improvement of logical operations, the arousal of curiosity, to initiative and independence in the assimilation of knowledge.

This is no place for detailed analysis of the data of the relevant researches: it can only be emphasised that, taken as a whole, they clearly reveal the dependence of mental development upon teaching and give a new content to the concept that teaching plays an active role in development. When teaching sets new cognitive tasks to the pupils it does not merely organise the activity directed to performance of these tasks; it arms pupils with the requisite methods, mastery of which gives rise to new mental actions and qualities, to the development of mental potentialities.

From the physiological point of view, as Pavlov noted, 'all learning consists in the formation of temporary connections' [32:580]. It is with the forming of these connections that development takes place. Without the formation of temporary nervous connections nothing new can or does arise in the child's behaviour, his actions, his relations to surrounding reality—consequently there cannot be development. As has been noted by A.N.Leontiev [26] connections formed in the process of learning are links in the complex physiological mechanisms which underly the formation of mental qualities in the child. Research data

bearing on the improvement in mental processes that takes place in the process of learning help us definitely to establish that it is not the differentiation of complex forms of mental activity innate in the child that constitutes mental development, by underlining that these forms of activity are elaborated in the process of mastering social experience. In the absence of this mastery there could not be that individual human 'history of the development of sensation, imagery, thought, feeling, etc.' the study of which Sechenov regarded as the key task of psychology [37:208].

These findings also indicate that the transition from mastery to development is not a simple but a complex process. First, the process whereby children actually master specific knowledge, skills or habits, does not take place immediately; it proceeds—as innumerable facts have indicated—through a series of stages, the character of which depends on the complexity of the content to be mastered and the readiness of the pupil. Second, mastery of specific material does not always and immediately lead to improvement in the pupil's mental development, to the rise of qualitative characteristics, i.e. to real development. This depends on what is mastered and how it is mastered. Here the pupil's individual characteristics play a role, the characteristics of higher nervous activity. Third, the transition from mastery to development takes place in different ways in relation to different aspects of the developmental process. It must be borne in mind that there are different, though connected, aspects of development: the development of knowledge, of cognitive activity, and the development of mental qualities (simple and complex, partial and general) included in this process, and of the functional properties of the brain which underlie them.

Research findings illustrate, for instance, that when the young child masters certain words from adult speech this does not lead immediately to changes in activity nor establish a new ability to organise his own actions. The child acquires this function gradually, through a series of micro-intervals, the sum of which gives rise to more notable qualitative change. Research has shown that when a pre-school or primary school child masters a new word, from a literary or scientific text, this is not at once brought into his active vocabulary. The pupil often leaves it aside in his own spoken and written speech and uses other, previously known, more 'familiar' words with a more general meaning [12, 38].

It has also been established, in connection with mastery of various aspects of work with texts, that pupils who have developed the capacity to draw up a plan do not in fact use this in organising their own exposition—they draw up a plan only after doing the work (set by the teacher), instead of using this capacity when writing their composition

they prefer to draw up a plan after writing. Research has shown [39, 20] that a considerable time is necessary, an adequate level of mastery of methods of analysis and synthesis and generalisation of these, before pupils develop the capacity to improve their understanding of the content of a text, voluntary memorisation and reproduction. The same applies to the role of mastering new concepts in different subjects, changes in the quality of pupils' thinking in explaining different phenomena of reality, the solution of practical tasks requiring application of these concepts.

Teaching in our schools is not confined merely to transmitting certain knowledge to the pupil, to forming a certain minimum of skills and habits. The task is to develop the pupils' thought, their abilities to analyse and generalise the phenomena of reality, to reason correctly—in a word, to develop their minds as a whole. If this aim is to be achieved there must be successful solution of the immediate problems of teaching. One of the most active factors in success in school is the development of logical thinking [21]. But this does not mean that all teaching contributes to ensuring the pupils' development. As P.N.Gruzdov has noted: 'Teaching often proceeds at a level which, far from furthering the development of mental abilities, in fact smothers them' [13:11]. This is the case when there are faulty methods of teaching, when dogmatism or formalism prevail.

General sedative formulae about the educational character of teaching are, therefore, inadequate: we must study the conditions in which teaching acquires this character and help teachers to provide these conditions in practice. This points to the need to clarify how teaching influences mental development, the development of mental qualities, to find ways of estimating the effectiveness of different methods of teaching in relation to their influence on the development of thinking, memory and other mental processes.

There have been few researches of this kind. The research undertaken has been confined to analysis of pupils' mastery of particular knowledge, skills and habits. At best elementary improvements in cognitive activity come to light but the further dynamics of these, which arise as a result of mastery of the given knowledge, are not followed up. The fact is that the process of development only begins with the mastery of scholastic material. As Vygotski correctly pointed out [10], and others have done since, the processes of learning and development are differentiated in all their various connections. This raises the problem of the interrelations between learning, mastery and development.

The indices of these processes are different. Such, in relation to development, are qualitative changes in pupils' mental activity which take a new form with the transition from a lower to a higher stage of

thinking, from less developed to more finished methods of thought. Of course, in guiding the mastery of educational material and securing a full value result we are at the same time guiding the development of the pupils' thinking. But this is not all there is to the guidance of development. It must have in view specific aims and ways of achieving them. If the teacher forgets about this and only directs attention to what the children assimilate he fails to ensure that they master knowledge.

Study of the specific interrelations between learning and development at different stages of school work in different subjects is needed if fundamental methods of effectively guiding mental development are to be found. The data of recent research into the psychology of teaching show its important role in this process, not only in respect of the content but also the use of methods ensuring that mastery of knowledge has an active character and that the requisite mental actions are formed.

A necessary condition for the transition from mastery to development is an order of teaching [2, 8], systematisation of the knowledge to be mastered, which provides the foundation for the formation of systems of temporary connections. Teaching leads to real mental development when it guides the formation of such systems. The systematisation of connections is fundamental not only to profound and durable mastery of knowledge but also to the development of cognitive activity, the formation of new logical operations, new mental qualities. As Piaget has correctly noted, a generalised logical operation only exists and functions as part of a system of operations [42:46]. The role of systematisation in the formation of mental qualities has been indicated [16] and experimental investigations undertaken in Leningrad show that systems of connections formed in the process of learning various school subjects have great significance in clarifying the internal interconnection between learning and development [3, 8, 35].

It is necessary in connection with such research to formulate a psychological concept of systematisation which, of course, can only be successfully achieved on the basis of generalising the results of research. Sometimes when this concept is used to clarify the interconnection between learning and development, systematisation is understood only in the sense of the stereotype. The latter has undoubtedly great importance in mental development since formation of the new always proceeds on the basis of the old, the already completed and reinforced. But the stereotype alone is not an adequate concept to cover the rise of those new formations which are characteristic of real development.

In order to understand, for example, the rise of new methods of abstract and generalised thought in the process of learning, it is

necessary to study the changes that take place in already complex systems as new systems are formed, how they are reorganised, included in a new wider whole, their grouping, generalisation, co-ordination, the establishment of a specific hierarchy, the dynamics of organisation. It is also necessary to study those motive forces under the influence of which the transition from lower to higher levels of organisation of activity is accomplished. This raises major questions, the experimental study of which is only beginning.

II

In order to clarify the problem of the interrelations of education and development it is also necessary to investigate how the motivational aspect of mental activity is formed. The development of intellectual qualities in pupils cannot be adequately discussed in isolation from the development of other qualities (emotional, volitional, characterological), in isolation from the formation of the psychological structure of the developing personality as a whole. The development of personality is a unified process, not simply the sum of partial changes evoked by separate educational actions. Among other qualities it is necessary particularly to refer to attitudes to the environment recently successfully studied by V.N.Miasishchev [31] which characterise a personality's individual elective position, the internal conditions of actions. Other researches have shown the important part played in the assimilation of knowledge by motives, the subjective relations of the pupil to school work [6].

Some of these attitudes are formed in the process of learning itself. Such, for instance, are the cognitive, scholastic interests of pupils, their love of knowledge, etc. The results of a number of researches go to show that these attitudes are the result of active cognitive activity on the part of pupils, organised in a specific way, which enables them independently to solve problems accessible to them and leads to cognition and realisation of the results achieved. Other subjective attitudes are the outcome not so much of methods as of 'roundabout' educational actions which lead to changes in the objective relations between a personality and the social environment, changes in practical behaviour, ways of life [7].

Learning and education, of course, have much in common. On the one hand in teaching children, imparting knowledge to them, we are to a considerable degree educating them. On the other hand in all education there is always mastery by the educand of certain elements of social experience (viewpoints, value judgments, norms, correct moral behaviour, etc.). Nevertheless, for all that they have in common, these processes have also specific peculiarities which must be borne in mind

when dealing with the interconnection between education (in its different forms) and mental development.

Recent research in educational psychology indicates how children's attitudes to surrounding reality develop in the process of education, how new attitudes are formed under the influence of the tasks set, the methods of educational activity most effective in this connection and the contrary. Some of these attitudes take shape at pre-school age under the influence of particular forms of education. Thus the pre-school child begins to develop general motives of behaviour in an elementary form (for instance, a striving to do something positive for people around him, a positive attitude to work, etc.). In the formation of such motives it is not only the child's consciousness of the significance of the instructions he fulfils that plays an important role but also the organisation of joint activity directed to satisfying the needs of the collective and collective discussion of its results. Research has shown that the formation of positive attitudes to school work proceeds through a series of stages. It takes place initially under the influence of the teacher's instructions and the demands of the child collective. Later, with the accumulation of experience, the child begins to fulfil his tasks without help. There has been formed a positive internal attitude to work which is initially manifested within very narrow limits but gradually acquires a generalised character [19].

The data of other researches characterise the conditions and methods for forming various qualities in the schoolchild—love of work, disciplined behaviour, responsibility and so on. As Miasishchev has noted [31] these data indicate that moral norms regulating behaviour are formed under the determining influence of accepted and mastered external social demands which are transmuted into internal demands made by the pupil on himself. The child's consciousness of these demands does not immediately constitute a regulator of his own behaviour but this function is gradually acquired. The regulating norm begins to be formed in direct work in co-operation with adults and other children and functions with continuous support from their side. Later it is converted into an internal regulator of behaviour which acts without direct stimulation and reinforcement on the part of others, without their aid, as the initiative of the pupil himself.

Research has shown [4, 14, 34, 36] that this process takes place differently with different individuals. It depends on the motives of activity, the subjective situation, the characteristics of the pupil's attitude to those around him developed at an earlier stage, above all on his attitudes to the teacher, to school and school work and to his family. When there is a favourable subjective soil the demands made upon him immediately and readily take root and rapidly have an active outcome. If they come into conflict with already formed and more or less stabilised

subjective attitudes to other people they are cognised formally, do not 'take root' internally and do not, therefore, acquire a regulatory function. It often happens that a pupil who is conscious of these demands in relation to others does not apply them to his own behaviour.

The facts indicate that the demands made upon the pupil's behaviour and understood by him do not produce the desired effect if they come into conflict with the actual motives of his activity, if the schoolchild sees them as an encroachment on his efforts towards independence, self-assertion, satisfaction of his interests, as a threat to his esteem (which is often mistakenly felt) or his position in the collective and so on. Where such subjective conditions obtain educational influences cannot evoke the necessary response from the child, the tasks set do not represent an actual necessity for him. The pupil overtly or covertly indicates his resistance. Often endless persuasion fails to produce a specific and stable result, fails to evoke in the child proper attitudes to the matter in hand, to change his real behaviour.

What has been said is relevant to discovering the conditions for effective educational guidance in the development of qualities of personality, in particular, motives of behaviour, attitudes to other people and to obligations. The effectiveness of guidance depends on whether the methods of education correspond to its tasks, on the identity and constancy of different educational demands (by the school, the home), on unity of word and deed in education, on how, in fact, the life and activity of each educand is organised and guided.

Education influences a personality's motives of behaviour and its internal regulation differently (at a different tempo and with varying success) to the extent that it takes account of, uses and changes in the necessary direction, the subjective attitudes formed in the course of earlier development, the actually operative motives of behaviour.

Education achieves its immediate (simple) and ultimate (general) aims when it brings into action the powers of the pupils themselves and correspondingly guides their use. Here an important role is played by the interaction of different aspects of education (intellectual, moral, aesthetic, practical and physical), ensuring the child's participation in the various activities necessary for all-sided development of his potentialities.

All education determines the development of the child's personality in one way or another, leaving its imprint on him. However not all education actively guides development towards specified aims. There are cases (and to our knowledge sufficiently frequent) when it produces results quite contrary to what is desired. It is impossible, therefore, to be satisfied with soothing declarations about the leading role of education in the development of personality; rather it is necessary to find those conditions in which education really does fulfil this role and thereby to

give practical assistance in foreseeing negative phenomena in the development of moral and other qualities of the adolescent personality which justly concern our society.

Education which separates words from deeds is bankrupt; verbal pedagogical instruction which the child does not use fails to bring about any real change in his life, in his position in the collective. Education fails if it does not take into consideration all the child's various interconnections with the environment, if it is divorced from his real life, from the subjective conditions (through which alone it can act), from the previous history of development of each educand, his age and individual characteristics, his abilities, interests, demands and other attitudes to reality. If education regards the child 'only as an object and not as a living being' (Makarenko), ignores his self-activity, jolts his independence, then it does not realise its power (however many and weighty the external educational 'measures') so that, in fact, the work is barren.

III

All that has been said leads to the conclusion that there is a genuinely complex interrelation between education and development. On the one hand the development of personality depends on education, which provides the necessary conditions for it, is determined by education. The process of education, by setting before the pupil new aims and tasks—by setting ever new requirements (in the performance of which he is involved) and providing the necessary means—guides development. On the other hand education itself depends on the development of the child, his age and individual characteristics. In the absence of demands from society there cannot be development of personality, but these demands only become real when potentialities for fulfilling them are created in the child in the course of development.

Development takes place by means of what the child masters in the process of learning and education, but its results extend further in some respects than what is directly mastered. In the course of the child's life and activity, organised by education, there arise not only new knowledge, reflecting objective reality, but also new needs, demands, interests, strivings (in particular the striving towards self-improvement), general means to intellectual and practical actions, new systems of operations, forms of thought, feelings, traits of character, new abilities. These qualities are not established immediately but are formed in the course of the child's activity (at school, at work, etc.) under the guidance of education. Their formation is connected with the development of his life as a whole in which maturation of the organism

plays a role. As a result of development there arise new potentialities, new reserves for education.

At present the interrelation of these processes is often simplified and explained one-sidedly. Statements on this question often stress only that development depends on education. The child's mental development is described as a simple succession of different educational influences, as though his own qualities exercised no influence on the process of education. Interpretations of this kind arise from a confusion of learning, education and development.

These processes, though closely interconnected, are in reality different. From what has been said earlier it follows that the differences between them are not absolute but relative. Nevertheless they exist. Recognition of these differences, study of the specific characteristics of learning, of education and of development is of great importance to further clarification of the interconnection between these processes, to the provision of a sound psychological basis for successful educational guidance of the development of personality; to take a negative attitude to this question, to make no attempt to study it scientifically, is to oversimplify the task of guiding the child's development. Such a simplification has a harmful effect on practice. By emphasising exclusively the limitless potentiality of education it in fact limits it because it narrows and so disarms pedagogics.

The history of the child's mental development, the formation of consciousness and self-consciousness, is accomplished in the process of learning and education. It has, however, its own characteristics, its own laws, connected with the laws governing learning and education but not identical with them; it has, also, its own specific motive force.

The map of mental development is not a simple replica of the educational influences to which the child is subjected, a simple, stratified, quantitative accumulation of that which he acquires in separate acts of scholastic and other activity. There is selection, internal transformation, reorganisation, amalgamation, interaction, as a consequence of which one quality disappears, another is born and develops. This process is determined by the course of the child's whole life in social conditions, under the influence of which one system of connections is inhibited, extinguished, another is reinforced, consolidated and so on, with the result that laws governing the transition from a lower to a higher stage of development come into action. In their general form the laws governing development reflect the connections and relations underlying the constitution of the conscious personality, the formation of various qualities, the transition from lower to higher forms of reflection of reality, from lower to

higher forms of regulating interaction with the environment, to higher forms of self-regulation.

As Lenin emphasised ‘the condition for a knowledge of all processes of the world in their “self-movement”, in their spontaneous development, in their real life, is the knowledge of them as a unity of opposites’ [1:327], of the contradictory tendencies within them. This applies also to the psychology of child development. The motive force of this development must be seen primarily in the internal contradictions between new demands made upon the child and the undertaking of these, his questions, strivings, actual aims and the level of development he has achieved, between new tasks and already stereotyped thinking and behaviour, between potentialities formed internally, subjectively, and objective relations with the environment. It is our task to disclose these contradictions and the conditions in which they arise, to find out how they take form at different age levels and methods of resolving them, to come to an understanding of the development of personality as ‘spontaneous, internally-necessary movement’ [1:116].

It is sometimes thought that acceptance of the spontaneous character of mental development is inconsistent with the principle of determinism, the principle that development is socially conditioned and that education plays a determining role. This view rests, on the one hand on idealist interpretations of the spontaneity of development, on the other on a simplified, mechanistic, understanding of how development is conditioned. There are to be heard here repercussions of the original ‘epigenetic’ standpoint which envisaged the child’s mental development as a passive outcome of education, lacking any ‘self-movement’, any specific laws of its own. The significance of these laws for educational practice is overlooked when this standpoint is adopted. This is evidenced in the inadequate attention paid to study of age and individual characteristics in mental development and to the application of research results in practical educational work in school.

The dialectical-materialist approach, which in fact proceeds from determinism, sees the ‘spontaneous’ character of development as inherent in self-movement. The development of any being, the child included, his ‘own movement’, his ‘own life’, is conditioned by ‘the entire totality of the manifold relations’ to surrounding reality [1:192]. As has been noted elsewhere [23] an understanding of development as ‘self-movement’ rather than excluding the task of pedagogical guidance points the way to undertaking it with success. It is the key to understanding how the new arises in the child’s life, how he becomes independent, develops initiative, creative activity, the ability consciously to regulate his behaviour, and so also to discovering the directions in which educational methods can be improved. Only

skilful education leads to development of the child's personality and education is only skilled when it takes into consideration the laws and characteristics of the process of development. The more education is guided by these laws, the more conscious it is, the more is it in a position successfully to guide the development of personality in accordance with educational aims. To recognise the specific nature of mental development is to ensure that psychologists devote close attention to study of this process, to arm pedagogy with a knowledge of its characteristics, and so to provide the psychological foundation for active methods of guiding the education of the rising generation in ways that ensure the all round development of personality.

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THE RELATION BETWEEN LEARNING AND
MENTAL DEVELOPMENT IN SCHOOL
CHILDREN

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[THIS is Chapter IV of a book entitled *Psychology of the Mastery of Knowledge in School* The opening paragraphs note that preceding chapters have analysed research into scholastic activity. Attention has been concentrated on characterising the processes which constitute the fundamental psychological content of the assimilation of knowledge and the conditions which favour their development. The present and succeeding chapters will consider different aspects of the mastery of knowledge. In Chapter V an attempt will be made to pass from analysis of the assimilation of knowledge as a process to characterisation of the interdependence between mastery of knowledge and the individual characteristics of pupils. But before making this transition it is necessary to deal with a number of theoretical points which bear on the general question of the interrelation between learning and mental development in the schoolchild. The present chapter deals with these questions.]

Contemporary Soviet psychology, in considering the process of mental development, is sharply critical of the idealist “two factor theory” which prevails generally abroad and came to the fore here during the period when psychometry flourished. According to this theory the child’s development is inevitably predetermined by two factors: age, understood purely biologically, and the environment, i.e. those external stimuli to which the child is subjected in the process of education. Soviet psychologists cannot accept the passive role assigned to the child in this interpretation of development. In fact,

¹ Of the Institute of Psychology, Academy of Educational Sciences of the R.S.F.S.R. From *Psychology of the Mastery of Knowledge in School* (Moscow, 1959), pp. 155–77, a book addressed to those concerned with methods of teaching, teachers, and students in higher educational institutions training as teachers.

the child is not only the object but also the *subject* of development. Education and environment do not automatically influence mental development, these factors act differently in dependence upon the level of development the child has attained, on his relations to the environment, the aims of his activity and so on. These ideas have been developed by various psychologists [18, 16, 38].

The most precise formulation has been advanced by S.L. Rubinstein, who states that 'external causes act through internal conditions' [31]. Developing this concept further he writes elsewhere, 'These internal conditions are themselves formed as a result of external action' [32], implying by this not only the history of each individual but also of the species to which it belongs.

We are in agreement with these propositions, the laws of development of the child mind are both 'external' and 'internal'. We cannot discover the contradictions between 'external' and 'internal' conditions which are the motive force of development if we do not simultaneously consider the demands made upon the child in the process of teaching and those individual characteristics of his mind, his personality as a whole, which have already been formed.

However, in our view, the concept of 'internal' (or, as it is sometimes expressed, 'spontaneous') development should be further examined, since it is widely prevalent in psychological literature abroad where it is understood in the idealist sense—as self-development of the mind in isolation from all material conditions. For important ideas bearing on this problem we may turn to the works of I.M. Sechenov and I.P. Pavlov. In particular, attention may be drawn to the way in which Sechenov deals with the question of external action on the 'nervous organisation' of the child.

When speaking about 'innate nervous organisation', Sechenov adds to this term the essential epithet 'developing', thereby emphasising that, as a result of the action of the external world, the 'innate nervous organisation' is changed not only in its reactions but also in its structure, i.e. the structure of the nervous system. Characterising the process of the child's mental development Sechenov notes that 'at the higher stages of child development the external world continues to act in its former way, that is, through the sense organs'; consequently psychological actions '*are as formerly excited by stimuli from without*' (these words he underlines) but the 'influences', he adds, 'now fall on a different soil' [33:220]. With changes in the process of development, therefore, the individual reacts *differently* to external stimuli.

We may also turn to Sechenov for an elaboration of what constitutes previous experience, the modification of the individual's reactions to external stimuli. Sechenov distinguishes personal from mastered 'other

experience'. This 'other' (i.e. social-historical) experience is transmitted to the child with the aid of oral and written speech. 'The most important determinants of mental development', wrote Sechenov taking his ideas further, 'are those mental revolutions which take place in the pupil's head when he learns the skills of speaking, reading and writing' [33:176-7].¹

Sechenov's ideas about 'developing nervous organisation' and the important role played by the word were elaborated in Pavlov's theory into a scientific system of concepts relating to the second signal system, which develops as orienting 'verbal signals' achieve significance for the living being. The specific physiological forms of development of the second signal system still remain to be studied. It is still not clear whether they are consolidated by morphological changes or bear a functional character; but the data of Pavlovian physiology have established beyond doubt that these changes are the physiological substratum both of phylogenetic and ontogenetic development.

Pavlov's concept of the second signal system, as a nervous organisation which specifically reflects the social action of the environment by means of the word, brought to light the unscientific nature of the approach which postulates the isolated influence of two factors on mental development. In this connection, Pavlov's comments published in *Clinical Wednesdays* are particularly relevant.

In one of the conversations, A.G.Ivanov-Smolenski raised the question of Pavlov's attitude to three concepts advanced in the contemporary theory of constitution: (1) the genotype—an innate property, (2) the paratype—an acquired quality and (3) the phenotype—the first and second together. Pavlov replied, 'I do not know how these can be separated in man. He is indubitably educated by environmental conditions. How is it possible to distinguish?' And when his questioner, insisting on the content of these concepts, repeated that 'the phenotype is the conjunction of the innate and acquired but the paratype is only the acquired', Pavlov exclaimed, 'Ah, separately? Then this is a fiction because what man acquires in life is never successfully explained', and expressed his meaning still more pointedly by adding, 'The concept of the paratype is a fabricated abstraction but the reality is the phenotype, this is both what

¹ In the 1870's when Sechenov wrote these lines psychology was still far from embarking on study of the 'mental revolutions' which take place in the pupil's head under the influence of learning basic skills. At this time the child's mental processes were studied *in isolation from* education and learning and the data of general psychology was simply *applied* to the facts of educational practice. Sechenov in fact formulated the problems with which much Soviet research in educational psychology is concerned today.

has been inherited and what is produced by man himself as an outcome of his individual life' [29:615–6]. Pavlov expressed the same ideas in his article 'Conditioned Reflexes' when he indicated that the 'definitive' nervous activity of the animal is 'a fusion of the features of a type and the changes conditioned by the external environment' [28].

These comments relate to the problem of development with which we are concerned and the idea of the 'soil' expressed by Sechenov is a scientifically based physiological concept; the 'soil' is a fusion of the specific innate qualities of the nervous system and those changes induced in it by the experience of life. 'Previous' experience is represented by systems of temporary connections imprinted on the cerebral cortex, which arise under the influence of external stimuli, i.e. under the influence of teaching and education. In the accumulation of this experience great importance attaches to the word by which not only 'personal' but also 'other' experience is mastered.

Therefore a materialist understanding of 'internal development' covers psychological changes which arise under the influence of external stimuli, 'assimilating' the existing conditions of the nervous system, those 'traces' which are preserved in it under the influence of previous experience. In this connection, the early acquisition of knowledge and formation of methods of thought is of particular importance to moral development.

Such an understanding of internal development removes the coating of idealism from the concept and dialectically resolves the apparent contradiction between biological and social influences.

1. Mental development and age

It is in the light of these theoretical considerations concerning the unity of the external and the internal, the biological and the social, that the interrelation between learning and the age and mental development of the child must be considered.

It is necessary to insist particularly on the concepts of 'age' and 'age characteristics'. It must be established from the start that there are clear cut differences between age changes in the physiological processes of the organism and age changes in mental, notably cognitive, processes. If the former appear more or less specifically and immediately in dependence upon age, the latter are characterised by multiple and extensive variance.

Thus growth and the addition of weight, the appearance of milk teeth and later of permanent teeth, sexual maturation—these are organic processes which are steadily accomplished at specific age periods with insignificant fluctuations in time. But age changes in the mind and

qualities of personality do not take place in so specific and simultaneous a form, or, more precisely, they take place differently in dependence upon the child's form of life and activity, the educational conditions.

Children of six or seven learning in school (in the preparatory or first class) differ widely in mentality, in particular in the characteristics of their thinking activity, from those of the same age remaining in the kindergarten. We also know from the practice of teaching that children of the same age, taught by different teachers, manifest different qualities of mind and behaviour. One teacher may not be able to organise the attention of seven-year old children while children of the same age under another teacher are not easily distracted, though this trait is usually in evidence at this age. Adolescents of Classes V–VI (11–13) may in one case be characterised by very irresponsible, undisciplined behaviour while other pupils of this age are distinguished by responsible, disciplined behaviour. Taken together such facts show that it is impossible to gauge the dependence of mental development upon age without relation to the conditions of life in which the child finds himself.

Age indications of mental development are extremely unstable, variable, and may fluctuate within considerable limits. This variance is not identical at different age periods. The age of early childhood, when speech is mastered by the child, shows little variance. After speech has been mastered, when the child begins to master the social-historical experience of mankind, his potentialities for mental development are greatly extended and the appearance of age characteristics becomes particularly labile. It is well known that these potentialities may not coincide with the age of the pupil. This lack of coincidence is observed above all in the development of cognitive processes and qualities of personality.

The principle of 'conforming to nature' advanced by Comenius, which is closely connected with the idea of age characteristics [21] has a different significance for organic processes than for forms of mental activity. If in the former case it is necessary to speak of 'maturation' in the direct sense of the term, in the latter this term is inapplicable. Comenius, formulating his view about the powers of education, wrote, 'nature brings nothing to light other than that which, maturing within, itself strives to emerge' [14]. This proposition has a bearing on the simplest somatic indices (for instance, the appearance of teeth), though in this case reservations must be made concerning the need for corresponding conditions of nourishment. Applied to the child's cognitive processes the principle of 'conforming to nature' loses its force. Education and teaching do not 'await' the maturation of mental functions but stimulate, condition, their development.

Vygotski correctly underlined that learning has its own place in development and does not lag behind it [36].¹ In research in educational psychology directed to discovering the laws governing the assimilation of knowledge, age characteristics are not in practice separated from particular stages of learning. This sets another problem for child psychology. In this case the object of study must be characteristics which belong to the same stage of learning but to different age groups.

The wide variance of indices of mental development at different age periods aggravates the difficulty of establishing a principle for the psychological periodisation of age, which at present in fact coincides with educational periods (pre-school, primary school, etc.). In the past, various attempts have been made to characterise different age periods on the basis of the particular psychological function that predominates—as may be done by means of physical indices ('the growing period', 'the period of filling out', 'the age of milk teeth', 'the age of permanent teeth', 'the period of sexual maturation' etc.). Diesterweg, for instance, established three age stages: (1) the stage of supremacy of the sensory, (2) the stage of memory, (3) the stage of reasoning [6]. However, none of these characterisations has found corroboration in actual data on the mental development of children.

In more recent works, in particular those of Vygotski, a tendency may also be noted to attach the predominant development of different mental functions to different age levels. (Vygotski attached particular importance to the transition to thinking in concepts at the adolescent stage.) Whenever there was a question of an intermingling of the development of separate functions, Vygotski saw the formation of interfunctional connections as a separate problem.

In reality, in the process of thinking, analysis and synthesis develop as a unified activity. Each act of analytic-synthetic activity exercises and brings together all the mental functions necessary for the performance of the given cognitive task; the specific content of the task alone determines how functions are 'mobilised' and to what extent. Thus to arrive at a psychological characterisation of an age period it is necessary to see, not the predominance of any mental process² but the processes and qualities of thinking activity formed in the sum of learning taken together. At each age period there may be observed a co-existence of different stages. There are still traces of an earlier stage of development, but new phenomena are also arising

¹ This concept is developed in a book dealing with the younger schoolchild [19].

² Only in early childhood is it possible to establish the successive rise of different mental functions.

which may be sufficiently typical and are developed in the succeeding age period. In addition, it is necessary to bear in mind that age changes are 'masked' by individual differences which generally come to light in the process of mastering knowledge.

It follows from all that has been said that it is wrong directly to connect individual differences in mastering knowledge with age (as is often done in pedagogics). Both biological and social factors influence mental development, not directly but through those changes which take place in the 'nervous organisation' as a result of external stimuli—as a result of morphological and functional changes in the developing brain.

It is in this sense, in our view, that we must understand the united influence of the biological and social about which so much has been written. If the age of the child sometimes limits his potentialities for cognitive activity the accumulation of experience may expand them. The child's real potentialities are best discovered therefore by studying the level of analytic-synthetic activity which is developed under the influence of both biological and social factors. The true indicator of the child's potentialities is his mental development.

2. Mental development and the assimilation of knowledge

In practice, psychologists rarely deny that the mastery of knowledge, the broadening of 'experience', is closely connected with mental development despite the prevalence of idealist theories which negate this standpoint. In reality, we know that in the process of teaching constant changes take place in the pupil's experience; his knowledge is widened, the content of concepts is enriched and they acquire a more differentiated, generalised character, which allows of their general use for orientation in new situations, in performing new tasks, in mastering new difficulties. The utilisation of acquired knowledge assists towards a more complete and precise reflection of the essential aspects of phenomena studied. Together with a growing fund of acquired knowledge goes an increased potentiality for thought, for incorporating new knowledge in those systems of knowledge acquired earlier which constitute 'previous experience'. It may be said that Ushinski's thesis, that the mind is actually developed only by real knowledge, has a great progressive significance and is still altogether relevant.

But mental development, though closely connected with the mastery of knowledge, does not bring this about. The process of learning changes not only what is reflected in consciousness but also the ways in which reflection takes place, i.e. the mental processes involved. Different aspects of mental development must be distinguished. Sechenov has some precise formulations on this question. Dealing in *Elements of Thought* with active forms of

thinking he wrote: 'Half man's mental development takes place as he perceives and masters elements of his own and other experience. But is it not well known that man, in learning to think, must not only master the elements of experience but also utilise its evidence—apply it to the matter in hand? As a thinker he must observe and analyse facts, compare them and reach a conclusion, generalise the results of analysis and comparison and, finally, determine the cause of phenomena. Insofar as in all these cases man is the active agent the whole complex phenomenon is called 'active thinking' [33:386–7).

These propositions of Ushinski and Sechenov opened up an approach to the problem of learning and development which was more fully explored in later psychological research.

Vygotski, analysing associationist and behaviourist views which attribute the process of mental development to learning, noted that this very standpoint excludes the concept of development because learning, seen in this light, does not open any new perspectives for the child except in relation to the reproduction of knowledge. In his view the most harmful aspect of the mistaken theory of associationism and reflexology, which attributes all mental processes to the formation of associations or connections between stimulus and reaction, is that it prevents the distinguishing of qualitative characteristics of development.

Vygotski's criticism of theories which identify learning and development is correct. But while he rightly indicates the bankruptcy of the theory of empirical associationism and reflexology in this respect, it would be wrong to think that the reflex theory of Sechenov and Pavlov, in which the formation of conditioned connections or associations assumes great importance, has nothing relevant to say on the relation between learning and development. It should be noted that Vygotski ignored the contribution of Sechenov and Pavlov towards solving the problem of development, and in criticising classical associationism, also brushed aside the concept of connections in the Pavlovian sense (as did most other psychologists in the 1930's).

Pavlovian reflex theory by disclosing the physiological mechanisms of complex mental actions—that is, the laws governing analysis and synthesis in the actions of the cortex—throws light on the material basis of mental development. The process of assimilating knowledge involves not only a quantitative accumulation of systems of associations reflecting the action of the external world, but also the development of forms of analytic-synthetic activity which arise as the central link of a reflex in response to external or internal stimuli. Such changes in 'nervous organisation' take place mainly in the second signal system, in the nervous apparatus of verbal thinking. Though physiological

research has yet to discover the character of these changes it can be accepted that it is precisely these changes that evoke the psychological phenomena characterising mental development.

The characteristic feature of mental development, therefore, is the accumulation not merely of a fund of knowledge but also a related fund of intellectual methods, actions, well 'worked out' and firmly reinforced, which belong among mental skills. Owing to the formation of mental actions man has the potentiality voluntarily to use these in the performance of new cognitive tasks. This, of course, justifies the definition of voluntariness first formulated by Sechenov in relation to physical movements—namely, that all voluntary movement is 'learned' movement. The term 'learned' applied in this case, must be understood in the widest sense as 'worked out', formed, in the totality of exercise.

The data of numerous researches carried out in recent years show that the potentiality adequately to use mental actions arises as a result of more or less prolonged exercise. The mastery of mental actions takes place in the process of thinking activity and consists in this, that mental actions become habits which are carried out with great freedom and ease [3, 25, 24, 9, 35].

It must be noted that the two aspects of mental activity (the process of acquiring knowledge and the process of forming mental actions) have been the object of many researches in educational psychology, though the second aspect has had less attention than the first. It is characteristic of recent research that the mastery of knowledge has been studied in the two above aspects, inasmuch as the processes of mastering knowledge have been treated as mental actions of analysis and synthesis. It is also characteristic of this research that the processes of abstraction and generalisation are treated as actions deriving from analytic-synthetic actions.

It is well known from school practice that not all knowledge has a developmental character. The acquisition of knowledge does not always mean an advance in the child's mental development. To discover *what* in the mastery of knowledge serves mental development it is necessary to know *how* scholastic material is mastered—what kind of thinking operations are used. It is important to find out the *level of mastery* of knowledge various pupils command in their study of *different stages* of the programme.

The term 'level of mastery' should be made precise. By this we understand the means to, or operations of, thought used by the pupil in mastering knowledge. In establishing the level of mastery account must be taken not only of direct manifestations of these qualities but also the indirect—the product of learning, its result; whether these results are stable and are manifested in the mastery of *different* school disciplines.

A certain constancy in the level of mastery found in a pupil may serve, therefore, as one of the indices of his mental development.

It is known, for instance, that pupils vary in their mastery of an exposition of new material by the teacher. Some immediately master what has been said (after using previous experience establish new connections) but others are not in a position to do this and often single out and master inessential aspects of the material. One pupil transfers formed methods of thought from one sphere of activity to another, while a second—even in relation to one subject and the same year of study—always begins to use thinking operations at the lowest level. Similar facts have come to light showing how different levels of mastery of knowledge depend on individual characteristics. Other researches have shown the presence of different levels of mastery internal to one age period and stage of teaching. Parallel with these are the presence of a similar level of mastery in pupils of different ages in different classes. Similar facts relate to differences in material [1, 5, 8, 11, 13, 15, 17, 30, 34, 37].

In these researches into the basic characteristics of the level of mastery different principles are applied insofar as we are dealing with mastery of different kinds of material, but from the facts obtained one conclusion can be drawn: the level of mastery is not determined by the simple sum of the knowledge accumulated, it also depends on the pupil's 'readiness' for mastery at the moment of studying the particular material. And this 'readiness' is in turn conditioned by the measure to which the pupil has mastered certain intellectual methods.

This means that account must be taken of an established fact which emerges from many researches; there is found among pupils who have reached a certain level of mastery of knowledge, in relation to the complexity of the educational material, a temporary displacement to a lower level, a return to the use of former methods of thinking. This has a universal application since the same phenomenon is observed in adults as well as in children. In illustration we may cite some of the data obtained in various researches.

Pupils of Classes IV (10–11) and V (11–12), when making the transition to study of fractions need once more a sensory support, i.e. a support for perception and later for imagery, though in operating with whole numbers they can easily use abstract methods of thought which exclude the need for visualisation [23, 22].

With the study of geometry in Class VI (12–13) there comes to light the very strong influence of perception of diagrams which in many cases is closely connected with the action of the word. Some pupils when mastering geometric concepts on the basis of generalisation use features which they have perceived in the figure and not the essential

features which contribute to solution [40]. This peculiarity of thought, whereby the action of the sense impression is stronger than that of the word, does not extend to other aspects of activity in the case of pupils of Class VI, but is very characteristic for younger pupils (of pre-school and primary age). In analysing the conditions of geometric problems some pupils of Class VII (13–14) pick on inessential features in writing down the conditions in the same way as do children of Class I when solving arithmetical problems. Thus, some seventh class pupils do not note the geometric data if they are not given in letter designations (DAS etc.) but written in words ('an angle formed by bisecting the base'). The analogy in Class I is failure to note arithmetical data designated verbally and not in the form of figures to which the children are accustomed.

Pupils of Class VI studying functional dependencies in geometrical material show characteristics similar to those observed in pupils of Class IV in the study of arithmetic: first the qualitative aspects of changes are mastered and only afterwards are changes in the dependence of magnitudes expressed quantitatively [37].

In the study of grammar in Class V, VI and VII a 'naive semanticism' is often found: pupils, when construing, leave aside grammatical criteria proper and are guided only by the everyday meaning of word and sentence. A precisely similar 'naive semanticism' has been brought to light in a number of researches [2, 4, 7, 26, 39] and is a characteristic feature of the early mastery of grammatical concepts by younger pupils.

In the performance of certain technical tasks (assembling and planning models of the simplest mechanisms) some pupils of Class VII (who have not mastered technical habits) are seen to make too rapid a transition to action with parts of the mechanism without a close preliminary study of the text of the task and the relevant drawings [12]. This characteristic of behaviour, shown in specific conditions in adolescence, strongly recalls the behaviour of the four-year old children described by Liublinskaia [20]. When they were set the task of mending a broken toy they at once embarked on action without preliminary consideration of the task and only came upon the necessary solution after a series of probing actions.

What conclusions can be drawn from these many facts? The level of mental development and the connected level of mastery of knowledge depend on many variables; the sum of knowledge, the presence of elaborated methods of thought, the degree of complexity of tasks. The latter must be taken into account when attention is directed to pupils' mental development. It is impossible to evaluate characteristics of the child's thinking activity without

reference to the content of the material which constitutes the object of thought.

3. The mastery of knowledge and the content of scholastic material

The content of scholastic material exercises an important influence on the character of the process of mastery, since the objective characteristics of this content predetermine to a considerable degree the cognitive processes, the methods of thought, necessary for adequate mastery of the knowledge.

This does not, of course, mean that to know the characteristics of the material studied is to foresee the whole course of the process of mastery since this depends not only on the content of knowledge but also on the 'soil'—previous experience and the level of development attained—in which this knowledge takes root. Some degree of logical analysis of the content of the material to be mastered is of great importance. Preliminary analysis of the concepts the pupil must master and the objective relations between them, and of logical peculiarities in the structure of the task the pupil must perform—all this enables the teacher to note the forms of analysis and synthesis through which it is proposed to lead the pupil on the way to mastery of knowledge; this, in turn, helps the teacher to keep in view not only the end aim but also the partial, intermediate, aims which must be borne in mind at each stage of teaching.

It is correct and reasonable that there should be a particular methodology for the teaching of different school disciplines which interprets general didactics in various ways; this is accounted for by the differing content of these disciplines and the resulting differences in the specific processes of mastering them. But these empirically established facts about the influence of content on its mastery have not hitherto been subjected to special psychological analysis.

Much work has been devoted to study of the specific characteristics of mastering particular school disciplines. We have referred above to data from researches relating to arithmetic, the Russian language, mathematics, geography, physics, chemistry, foreign languages and so on. What we are primarily interested in here is the discovery of general laws governing the assimilation of knowledge. But all these researches throw light on the specific, what specifically is mastered in different disciplines. In this connection it would be desirable, using comparative methods, to work out a classification of types of mastery of knowledge in dependence on its scientific content.

We do not pretend to solve this problem here since the necessary material has not been collected. Nonetheless we think it worth while to raise the question, if only in terms of suggesting the direction that this work might take.

It seems to us that psychological differences in the mastery of separate school disciplines are evoked primarily by the relations between the sensory and abstract elements of knowledge. From a psychological point of view, particular importance attaches to the character of the initial data as a support for further generalisation. It is possible to distinguish knowledge which rests initially on visual material and knowledge based on verbal material which is only indirectly connected with real facts and phenomena.

Though this is a very general division, it is not without psychological significance, since, in the first case, the process of mastery of initial facts and phenomena proceeds mainly in the form of practice, and, in the second, it proceeds in the form of intellectual analysis and synthesis. Obviously the first kind of mastery of knowledge corresponds most closely to the course of analytic-synthetic activity since it proceeds from the visual to the abstract, and this means it is easy for the pupil; the second kind of mastery of knowledge, on the other hand, requires an effort on the part of the pupils if it is to be concretised.

The clearest example of a school discipline of the first kind is nature study because in this case the object of study is concrete facts and phenomena of nature and the teacher can so organise teaching that it rests either on the pupils' direct perception or on their practical experience. In addition, in the content of many of the concepts of natural science (such as the concepts of species and families in botany and zoology) the visual component of knowledge corresponds to their essential aspects. It was not without good cause that Ushinski considered study of natural phenomena to correspond most closely to the characteristics of the child's thought and brought up his pupil (*The Child World*) mainly on this material.

At the opposite pole mathematical concepts (in the field of algebra and higher mathematics) comprise knowledge in which the separation of thought from reality is most clearcut, since the initial material for these branches of mathematics is confined to abstract concepts. At each higher stage of abstraction, however, the mastery of mathematical science rests on the concrete knowledge mastered at the previous stage of learning. Thus in higher mathematics such initial data are algebraic and geometric knowledge, in algebra the concepts and rules of arithmetic. And arithmetic itself is based on analysis of real facts, it is the generalisation of these that provides the foundation of arithmetical concepts—number. Though, therefore, mathematical science rests exclusively on abstractions, these abstractions are a reflection of actual reality, however far removed from it. But the process of mastering a mathematical science such as algebra cannot, by contrast with the mastery of natural science, rest on the sensory elements of experience.

The sensory basis of knowledge does not always rest on perception. There are a number of sciences in which such supports are confined to propositions about things and objects which are often reconstructed in imagination. Such concepts are to be found, in particular, in history. Occurrences and phenomena relating to earlier societies cannot, naturally, be the object of direct observation. Nevertheless, as has been shown by various researches [10, 15, 30], mastery of historical concepts requires correctly formed images. Such images are formed as a result of the activity of imagination, which reconstructs historical pictures and representations from the elements of available experience.

The poorer the experience of the child the greater the distortion of historical reality observed in the formation of these images (most frequently to be observed in such cases as modernisation of historical forms). Whereas in natural science the initial visual material subject to analysis and generalisation is presented in a finished form, in the case of history this material must be reconstituted in the pupil's imagination and this calls for special methodological procedures (clear colourful description, historical pictures, films etc.).

In physical geography, as in natural science, the basis of a whole number of concepts is the data of direct perception (rivers and lakes, mountains and ravines, forests and deserts etc.). The process of reading a geographical map is, however, a distinct psychological process. Here also the initial data are received through direct perception. But what the pupils see on the map is only conditioned knowledge of external reality, i.e. special visual symbols. If these are to provide a sensory support for thinking they must be correlated with reality and this calls for special preparation of the pupils.

In the study of grammar and orthography the character of sensory-visual elements and their interrelation with abstract concepts is unusual. The formation of grammatical concepts and mastery of correct orthography is based on a morphological analysis of the word and a syntactical analysis of the relations between words making up sentences. The object of study in this case is the word in which the linguist distinguishes a number of structural linguistic elements (prefix, root, suffix and inflexion) each of which has a certain function in language, has a certain linguistic significance (the root signifies the material meaning or general idea of the word; the prefix and suffix individualise and concretise the meaning of the root; the inflexion signifies a series of grammatical categories and simultaneously serves as an expression of the relation between words). In addition the word as a whole has a particular meaning (lexical) which synthesises the meaning of all the morphological parts.

The visual-sensory elements of the word are primarily the sound or letter composition of the word forming its morphemes. However the

differentiation of separate sound or letter combinations in a word cannot alone lead to correct grammatical analysis. Grammatical abstractions do not distinguish any combination of sounds or letters in a word but only the morpheme, i.e. a combination having a specific linguistic significance. Analysis of formal aspects of a word, without taking account of semantics, leads, as research has shown, to mistakes of a formal character. In short, the visual-sensory elements in grammatical categories serve as supports for correct grammatical analysis only if their linguistic functions, which are of an abstract nature, are understood.

In study of the mastery of grammar researchers have also noted other aspects of visual representation—the visual images evoked in pupils by a given word. Thus, for instance, when, at the initial stage of learning grammar, children group words according to parts of speech and begin to evaluate a word, they conform only to a single image of this word, or to that visual association which it brings to mind. Such specific representations hinder the recognition of grammatical abstractions and it is often observed that pupils assign the same word to different parts of speech in dependence upon the specific image it has evoked. For instance, the word ‘spinning-top’ is assigned as a verb if it is pictured in movement and as a noun if it is motion-less [39]. In such cases, visual representation does not assist grammatical abstraction but hinders it. While such facts about the negative role of representation are found at the early stages of learning, the difficulties evoked by the contradiction between the lexical meaning and grammar of a word are characteristic of various stages of learning. Since the lexical meaning of a word is not a simple but a generalised image or concept, mastery of lexical meaning calls for abstraction and generalisation of the facts of actual reality. Understanding of the meaning of a word is a necessary prerequisite for recognition of a grammatical abstraction but the latter does not follow on understanding the lexis of a word. Meanwhile it is precisely transmission of the lexical meaning of words and sentences that is the basic function of speech as a means of communication, that aspect of speech which is reinforced in all living practice. Therefore, if the lexic does not correspond to the grammatic or is in contradiction with it, then insufficient elaboration of methods of grammatical analysis leads pupils to adjudge linguistic facts according to their lexical semantics. In this case, the pupils reason excellently in this way: ‘*To be lazy*—this is not a verb since no action has taken place; *clock (chasy)* and *sentry (chasovoi)*, these are not related words because a clock is an object and a sentry is a man; *somebody knocked at the window*—this is an indirect

personal sentence because it is not known who knocked, somebody knocked at the window, we don't know who.'

Similar examples of 'anti-grammatical hypnosis' have been found by researchers at different stages of learning from Class I to VII [3, 7, 27, 39]. They all demonstrate that pupils' judgments, though correct from the point of view of understanding real facts and events, hinder the grasping of grammatical abstractions. On the other hand, without an understanding of the lexics of a word grammatical qualification of linguistic material is altogether impossible.

There are, therefore, two parameters in the study of grammar which characterise linguistic phenomena objectively—form and semantic, lexic and grammatic—and which at the same time determine, at least in its general features, the subjective, psychological aspect, marking out the processes necessary for mastery by comparison with other school subjects.

As we have seen, differences in the sensory-visual elements of scholastic material, different interrelations between these elements and abstract concepts, differences in the 'remoteness' of concepts from actual reality—all this is essentially reflected in the process of mastery.

Do these characteristics of scholastic material cover every aspect of the interdependence between the nature of the content of knowledge and ways of mastering it? We do not think so. Abstraction and generalisation may be a basic characteristic of the mastery of theoretical knowledge. But no less significant as a stage in cognitive activity is the transition from theoretical thinking to practical activity. This process cannot be neutral in relation to the end product of learning—to the different forms of practical activity and different types of interrelation between theoretical knowledge and practical action characteristic of different spheres of knowledge. The polytechnical school brings this aspect of study of pupils' cognitive activity into prominence but we have not yet assembled material allowing for a differentiated study in relation to particular school disciplines. Here we have only pointed to some problems and, wherever possible, noted ways of approaching and studying them.

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PRINCIPLES OF MENTAL DEVELOPMENT
AND THE PROBLEM OF INTELLECTUAL
BACKWARDNESS

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MANY thousands of children in different countries of the world are retarded in their intellectual development, although in all other respects they do not differ essentially from their contemporaries. These are children who show inability to learn adequately, at an adequate rate, in conditions which are called 'normal'. When such children are placed in conditions suitable for them and special methods of teaching are used then, as experience has shown, many of them make significant advances and some even overcome their backwardness.

The latter cases are particularly noteworthy. Each such case forces us to think about those who remain in the category of inadequate intellectual development, about those who find themselves 'beyond the threshold'. Are these children really set apart or is their fate determined by the action of conditions and circumstances—conditions which could be changed, circumstances which could be removed to allow for their development?

Here there arises another question; of what value are investigations of the problem of intellectual backwardness by psychologists and doctors—to what end result to their diagnoses, prognoses, methods of selection, lead? Do they result in diminishing the number of children classed as intellectually underdeveloped, or do they, perhaps, sometimes lead to the opposite result?

This question may exaggerate a danger and be in no way justified. Nevertheless there is a basis for posing it. I have in mind facts which

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indicate that the wide use in many countries of psychological tests to select intellectually gifted children bars from a full education not only those who really cannot learn because of organic defects but also those who although they have not surmounted elementary difficulties *could* do this. But it would be wrong to ascribe everything to technically imperfect methods of diagnosis and selection. The cause underlying the facts with which we are concerned lies deeper. It consists in an unsatisfactory understanding of the nature of 'sub-normality', which in turn depends on theoretical views about the process of mental development in the child.

The point at issue is interpretations of intellectual backwardness which rest on the proposition that the child's mental development is determined by the action of two factors; on the one hand endogenous, biological, factors, and on the other hand exogenous, environmental, factors.

This view of development is widely disseminated and it seems that it simply states an obvious fact. Therefore discussion is nearly always confined to the relative role of endogenous and exogenous factors, the role played in the child's mental development by biological characteristics and by the social environment. One author gives a leading importance to biological factors, another to social factors, a third stresses the convergence or coincidence of these factors. The different conceptions advanced within the confines of this general proposition are sufficiently well known and I need not insist on them.

Though these conceptions differ in theoretical approach, they deal in essentially the same way with the basis of intellectual backwardness. This is so because if the criterion of intellectual backwardness referred to is used and the child shows a retardation in development by comparison with the level achieved by children of the same age *in similar external conditions*, and with this the 'two factor' theory of development is taken as a point of departure, then reference to the role of the environmental factor is impossible. If the child of retarded intellectual development does not have any clear pathological characteristics, as is often the case, then an assumption is made about the influence of internal factors such as general intelligence. Hence the practice of applying tests to measure the 'intelligence quotient'.

At best, the results of measurements undertaken with tests only give a superficial orientation to the level of development. Tests never, of course, disclose the nature of intellectual backwardness and cannot in any way interpret it. They only give the illusion of explaining why the given child is retarded in his intellectual development. They cannot,

therefore, provide any basis for deciding what methods should be used with different children or groups of children to overcome their intellectual inadequacies. On the contrary, the claim that tests study stable factors, and that these have a decisive prognostic significance, means that testing spreads ideas about the inevitability of intellectual backwardness and so hinders the development of scientifically based and differentiated methods of educational work with backward children.

Of particular concern is the fact that a child's future is sometimes decided in dependence upon a given 'intelligence quotient'. This is the case notwithstanding the fact that changes in this quotient have been found not only in practice but also by special research which has been undertaken, in particular, with twins.

I think that many traditional views need rethinking and above all that it is necessary to consider the child's mental development in another sense. The aim of this lecture is to formulate some principles of development which, in my view, eliminate a number of the difficulties encountered by those who work with intellectually backward children. I will confine myself to outlining three of the more important of these principles.

1. The child's mental development as a process of mastering the experience of mankind

The mental development of the child is qualitatively different from the ontogenetic development of animal behaviour. This difference is primarily determined by the fact that what is most important to the child's development, and absent in the animal world, is the process of mastery or 'appropriation' of the experience which has been accumulated by mankind in the course of social history.

In the case of animals we meet with experience of two kinds; experience formed in phylogenesis, reinforced by heredity, and individual experience acquired in the course of life. To these there correspond behaviour mechanisms of two kinds. On the one hand, there are the mechanisms of heredity which either come fully into action at birth or gradually mature in the process of ontogenetic development: the formation of these mechanisms proceeds according to the general laws of biological evolution and is a slow process, answering to slow changes in the environment; in animals these mechanisms have a *fundamental* adaptive significance.

On the other hand, there are the mechanisms of acquiring individual experience. The most important characteristic of these is that, through heredity, they embody only the potentiality of forming that behaviour which is realised in individual adaptation—the behaviour itself is fixed through the mechanisms of hereditary experience. Although the

mechanisms of acquiring individual experience allow animals to adapt themselves to rapidly changing conditions in the environment, the actual evolution of these mechanisms, as also of the mechanisms of hereditary behaviour, proceeds slowly.

It should be particularly underlined that the two different forms of animal experience and the corresponding two mechanisms of behaviour, are interconnected both genetically and functionally. It may be considered as an established fact that manifestations of hereditary behaviour do not appear independently of individual experience; on the other hand, individual behaviour is always formed on the basis of the hereditary behaviour of the species. The individual behaviour of animals, therefore, always depends on the experience of the species, instinctive behaviour, fixed in the mechanisms of unconditioned reflex activity, and on individual experience which takes place in ontogenesis by means of the mechanism of conditioned reflexes. The basic function which the mechanisms of forming individual experience perform for animals is the adaptation of species behaviour to changeable elements in the environment. The ontogenetic development of animals can be represented as the accumulation of individual experience, perfecting of the operations which realise their instinctive activity in complex and dynamic external conditions.

The case of man is entirely different. By contrast with animals man has experience of yet another kind. This is the social-historical experience that he masters. It does not coincide either with species experience, inherited biologically, or with individual experience though often incorrectly confused with this.

What, then, is this experience that is exclusive to man alone?

In the course of history, men, governed by the action of social laws, have developed higher characteristics of mind. Thousands of years of social history have produced more, in this connection, than millions of years of biological evolution. The achievements of mental development have been accumulated gradually, transmitted from generation to generation. This is the way they have been consolidated. Could they have been consolidated in the form of biological, hereditarily transmitted, changes? No; because the historical progress is extremely rapid, always accelerating, and consequently the demands upon man's abilities made by the conditions of his life in society, change rapidly quite out of relation to the much slower tempo of biological fixation of experience.

The achievements of men's historical development are consolidated and transmitted from generation to generation in a particular form, namely, in an exoteric, external form. This new form of accumulating phylogenetic (or, more precisely, social-historical) experience has

arisen because man's specific form of activity is productive activity. This is the basic activity of people, their work.

The first all-sided, scientific, analysis of this activity was made by Karl Marx. The human activity (both mental and material), which takes place in the process of production, is crystallised in the product of activity; that which at one pole is manifested in action, in movement, at the pole of the product is transmuted into a fixed property. This transmutation itself is a process in which there takes place an objectivisation of human abilities—the achievements of the social-historical development of the species. Every object created by man—from the simple tool up to the contemporary electronic computing machine—embodies the historical experience of mankind and together with this the intellectual abilities formed in this experience. The same may be seen still more clearly in language, in science, in works of art.

Thus, by contrast with the phylogenetic development of animals, whose achievements are consolidated in the form of changes in their biological organisation, in the development of their brains, the achievements of men's historical development are consolidated in the material objects, in the ideal phenomena (language, science), created by men. The point hardly needs to be argued.

What is more complex and much more important for us is the other process, the process of mastery, or appropriation, by different individuals of the achievements of the spiritual development of preceding human generations, embodied in the actual objects and phenomena they have created.

From birth the child is surrounded by an objective world created by men—that is, food, clothes, simple tools, and language, the propositions, concepts, ideas, reflected in language. The child meets even with natural phenomena in conditions created by people; clothes protect him from the cold and artificial light disperses the darkness of night. It can be said that the child begins his mental development in a humanised world.

Does not the child's development take place, nevertheless, as a process of adaptation to this world? No, despite this widely held view, the concept of adaptation does not reflect the essentials of his mental development. The child is not adapted to the world of human objects and phenomena surrounding him, but takes it to himself, i.e. *appropriates it*.

The difference between the process of adaptation, in the sense the term is used in relation to animals, and the process of appropriation is as follows. Biological adaptation is a process of *changing* the qualities of a species, both the abilities of the subject and its natural behaviour, which

is evoked by the requirements of the environment. It is otherwise with the process of appropriation. This is a process which has as its result reproduction in the individual of the historical formation of human qualities, abilities and characteristics of behaviour. In other words, it is a process whereby there takes place in the child that which is achieved in animals by the action of heredity; the transmission to the *individual* of the achievements of the development of the *species*.

A simple example may be given. In the world surrounding him the child meets with the fact of the existence of language, which is itself the objective product of the activity of preceding generations of men. In the process of his development the child makes language his own. This means that there are formed in the child such specifically human abilities and functions as ability to understand speech, ability to speak, such functions as the hearing of speech and articulation.

These abilities and functions are not, of course, inborn but arise in ontogenesis. What calls them to life? Primarily the fact of the existence in the child's environment of *language*. As for the child's inherited, biological characteristics these constitute only the necessary conditions making possible the formation of these abilities and functions.

For instance, in order that the child should develop hearing of speech, it is necessary for him to possess organs of hearing and the organs participating in pronunciation. But it is only the objective existence of speech sounds in the child's environment that can explain why hearing of speech develops. Even the quality of hearing he possesses—whether it is predominantly of timbre or tone—and the different phonemes accessible to him depend on the phonetic characteristics of the language the child masters.

What makes up the actual process of appropriation by different individuals of the experience accumulated by men in the course of the history of human society and embodied in the objective products of their collective activity—a process which is simultaneously a process of formation of human abilities and functions in men?

It is necessary to emphasise, above all, that this is always an *active* process. In order to master objects or phenomena it is necessary actively to undertake activity adequate to that which is embodied in the given object or phenomenon. When, for instance, we say that the child masters some tool this means that he begins to use it correctly, that he forms the relevant motor and mental actions, operations.

Can these actions, these operations, be formed by the child under the influence of the object itself? Obviously not. Objectively these actions and operations are embodied, *given*, in the object, but for the child subjectively they are only *tasks*.

In this case what leads the child to form the necessary actions, or operations, and the abilities and functions necessary for their accomplishment? The fact that his relations with the world surrounding him are mediated by his relations with people, that he comes into practical and speech *communication* with them.

Let us consider how a small child masters a simple thing such as, for instance, a spoon. We may begin with an imaginary case. A child has never seen a spoon and one is now put in his hand. What does he do with it? He may manipulate it—move it from one place to another, make a noise with it, try to carry it to his mouth, etc. In other words it is not the developed social skill of using it, which is embodied in its peculiarities of form, that is manifest to him but its unspecific ‘natural’, physical, properties.

We may turn now to an actual case. The mother or nurse feeds the child with a spoon; after a little time she puts the spoon in his hand and he makes an attempt to eat independently. As observation has shown, at first his movements are subordinated to the natural ability ‘to carry what is held in the hand to the mouth’. The spoon in his hand does not keep the necessary horizontal position and as a result the food falls on the bib. But of course the mother does not remain indifferent, she helps the child, taking part in his actions; there arise therefore *combined* actions with the child and the habit is formed of using a spoon. The child now masters the spoon as a *human* object.

I have used this example in order to pose another question. May it be assumed that the habit of using a spoon can be formed by a child apart from society, apart from combined actions with adults, i.e. as habits are formed in animals? Theoretically, of course, this can be assumed. More than this, it is possible to place the child in practice in such conditions that this is the only possible way. But this is an entirely abstract assumption. A child cannot, in fact, live and develop without practical and verbal intercourse with adults.

It can be admitted that a child may need independently to develop various skills, various habits, because the methods adults use to help him, to teach him, are inadequate. He may achieve success, but how much time this requires and how much he is retarded in these habits by comparison with his more fortunate contemporary ‘whose hand has been guided by reason’.

In order not to complicate the issue I have given an example relating to the formation of a motor operation. But how much more obvious is all that has been said in analysis of the mastery of *mental* actions such as reading, writing, counting. It is particularly clear that the formation of such actions is itself a process of mastering operations formed in the experience of preceding generations and that they only arise under the influence of teaching which directs the child’s activity in a specific way,

which *organises* his actions. But we may return later to the process of formation of these operations.

It remains for me to touch on a final question—that of the role in the child's development of individual experience in a specific sense. I have tried to show that the process of appropriation by the child of the experience of preceding generations of men is a specific process, which differs both according to the conditions in which it takes place and in its mechanisms from the process of forming individual experience, the process of adaptation, in animals. At the same time mechanisms of acquiring individual experience also participate in the child's development. But these mechanisms are used, as we have seen, only in the role of participating mechanisms in realising the process of appropriation. This is one aspect. The other is that they are used for the functions I have already indicated; they realise the adaptation of phylogenetic experience to changes in external conditions. But only in the case of man does this take the form of historical experience which is mastered in the course of life.

What has been said can, therefore, be summarised in the following proposition: the most important processes which characterise the mental development of the child are the specific processes whereby he masters, or appropriates, the achievements of the development of previous generations of men, which, by contrast with the achievements of phylogenetic development in animals, are not fixed morphologically and are not handed on by way of heredity.

This process takes place in the child's activity in relation to objects and phenomena of the surrounding world in which are embodied the achievements of mankind. Such activity, however, cannot be developed by the child himself, it develops in practical and verbal intercourse with people surrounding him, in combined activity with them; when the aim of such activity is specifically to transmit to the child certain knowledge, skills and habits then we say that the child learns, the adult teaches.

Sometimes it seems that in this process the child is only brought into action by his own natural abilities and mental functions, that success depends on these. But this is not so. His *human* abilities are formed in this actual process. This proposition constitutes the content of the second principle characterising the child's intellectual development to which we may now turn.

2. The development of abilities as a process of formation of functional cerebral systems

The proposition that the mental abilities and functions formed in the process of social-historical development are reproduced in individual men

not by the action of biological inheritance but by acquisition in the course of life, poses the very complex question of the anatomical-physiological basis of these abilities and functions.

From a scientific, materialist, point of view it is impossible, of course, to postulate the existence of abilities and functions which do not have their specialised organs. Therefore attempts have long been made to localise higher mental processes in specific, morphologically reinforced structures of the brain. The presence in man of various abilities or functions depends on the presence of corresponding inborn cerebral structures, that is of special organs of these functions. This proposition has also been extended to abilities which are evoked in man only in the process of social development; in other words, their direct dependence on heredity is assumed.

If, however, it is necessary to accept the first proposition, i.e. that *all* abilities or functions represent the functioning of specific organs, it is impossible unreservedly to accept the second proposition just indicated. It contradicts many well established facts. How can we reconcile the view that the higher mental functions of men have their own morpho-physiological basis with the assertion that these functions are not fixed morphologically but are only transmitted by way of *social* 'inheritance'?

One approach to the solution of this problem was the successful development of the physiology of higher nervous activity. I have primarily in mind the classic work of I.M.Sechenov, I.P.Pavlov and his colleagues, particularly P.K.Anokhin, and also the work of A.A.Ukhtomski. This is from one point of view.

From another angle light has been thrown upon the problem by many psychological investigations into the formation and structure of complex mental functions in human beings, among which I would mention the work of L.S.Vygotski and his colleagues. The suggested solution of the problem is that simultaneously with the formation in the child of higher, specifically human, mental processes there are also formed the cerebral organs essential to their functioning—that is, stable reflex formations, or systems, used to perform specific acts.

The potentiality of forming such functional cerebral systems in life is found in higher animals. But only in man do these systems bring about really *new formations*¹ in mental development the formation of which is an important principle of the ontogenetic process.

The results of researches we have undertaken permit a more detailed characterisation of these functional organs that arise in the course of life.

¹ *novoobrazovania*.

The first of their characteristics is that, once formed, they function as a single organ. Therefore the mental processes they realise can acquire the character of direct acts, expressing particular abilities, such as the ability directly to perceive spatial, quantitative or logical relations.

Another characteristic is their durability. The functional systems in question are formed by way of the formation of conditioned connections but are not extinguished as conditioned reflexes are extinguished. For instance, the ability to visualise forms perceived by touch is formed in the course of life and therefore altogether lacking in children who are blind from birth; nevertheless those who lose their sight after this ability has been formed retain the ability for decades, though reinforcement of tactile-optic connections is, of course, impossible.

The third characteristic is that these systems can persist for so long that their separate components can be replaced by others, so stabilising the given functional system as a whole. In other words they display the highest capacity for compensation.

In order to indicate the structure of these functional organs it is necessary first to describe their formation. They are formed by the common mechanism of forming conditioned connections, but not in the same way as the usual chains of conditioned reflexes, or dynamic stereotypes, are formed. These connections are not formed simply by external stimulation but by the unification in a single system of relatively independent reflex acts with their different motor effects and afferent reversals; so that unification takes place by way of unification of their motor effects.

In the process of formation of such a new 'structure' the actions of the motor effects of these acts are interconnected. Such actions, representing a functional motor system, at first always have a maximally differentiated external form. With the further separation of the external motor components the formed actions are gradually reduced and their connections become only internal cerebral, intracentral connections. The action as a whole is stabilised, abbreviated¹ and begins to become automatised.

Obviously, when formerly independent separate reflex acts enter into the constitution of a new action, they lose by consequent reduction their external motor links with their adaptive significance. Therefore reinforcement or non-reinforcement may now belong only to the end effect of the action as a whole. This creates the specific dynamic of such functional systems. As experimental data have shown, they are characterised by the fact that reinforcement of the

¹ *svertyvatsia*, i.e. roll up, curtail.

end link of the system leads to inhibition of the majority of its links and to its further compression; lack of reinforcement gives rise, on the contrary, to disinhibition of these links. This, it may be suggested, is to be explained by the fact that inhibition of the last, end, link of the system evokes, by the law of induction, excitation of the links that were inhibited.

The outward manifestation of this particular dynamic is that when such actions, representing functional systems, meet with a difficulty they have a tendency to become extended.¹ When they lead to the required end effect, they are always further abbreviated—up to a point when they cease to produce the required effect; the links which were inhibited are subsequently released and the system becomes anew effective.

In our laboratory in Moscow University we have traced in detail in experiments the formation of certain sensory functional systems, particularly systems of tonal hearing. In these experiments we were able actively to reorganise the hearing of subjects, bringing into action and adjusting an important motor component (tuning up perception of sound and its basic pitch by singing aloud). In subsequent, as yet unpublished, experiments we attempted to substitute for this component another—that is, adequate tonic strength of the muscles of the hand which was specially formed to this end. The preliminary data of these experiments indicates the possibility of such a substitution.

These investigations, as also others with normal subjects and the researches of A.R.Luria and his colleagues with intellectually backward children, make it possible to advance the following proposition summarising what has been said.

The child is not born with organs ready to accomplish functions which represent the product, of the historical development of man; these are formed in the child in the course of life—are of the order of appropriation by him of historical experience. The organs of these functions are functional cerebral systems ('mobile physiological organs of the brain' according to Ukhtomski) formed in the actual process of appropriation referred to above.

The results of research show that the formation of these systems does not proceed similarly in all children; depending upon how the process of development takes place, and in what conditions, they can sometimes be inadequately formed or even not formed at all (in which case we meet, for example, with the phenomenon of 'deafness' to different sounds according to basic pitch). In this case, on the basis of close analysis of the structure of the corresponding

¹ *razvertyvatsia*, i.e. unroll, unfold.

processes, it is possible actively to reorganise or to form anew the underlying functional systems, functional organs. What has been said applies not only to motor and sensory systems but also to the systems regulating speech (A.R.Luria) and to speech itself.

Of a much more complex nature is the process of formation in the child of internal thinking operations; it calls therefore for special attention.

3. The child's mental development as a process of formation of mental actions

We have already seen that the child's mental development takes place in the process of communication, primarily in practice. But the child very early enters into speech communication with those around him. He meets with words, begins to understand their meaning and actively incorporates them in his speech. Mastery of speech is the most important condition of his mental development, because the content of the historical experience of man, the experience of social-historical practice, is not, of course, only reinforced in the form of material things; it is generalised and reflected in verbal form, through speech. It is precisely in this form that the child meets with the rich accumulation of human knowledge, of concepts, about the world surrounding him.

The child faces the task of mastering this knowledge, these concepts. But in order to do this he must develop cognitive processes which are adequate to (but of course not identical with) the processes whose product is the given concept. How are these cognitive, intellectual, processes formed?

Two possible propositions must, at the very outset, be set aside as untenable. First, the unjustifiable assumption that the child possesses mental functions and cognitive operations at birth and that the action of external phenomena only brings these to life. Second, the simple assumption that thinking operations are formed under the influence of the child's personal, individual, experience, that in the process of learning the child undergoes stimulation, the repetition and reinforcement of which results in the formation of new conditioned connections, or associations, and that his thinking activity represents not anything new but the simple reproduction of these connections or associations.

These propositions come into contradiction with the facts. The formation of thinking processes in this way would require very extensive experience over a very prolonged period. In reality the formation of thinking processes in the child rests on a relatively short individual experience and proceeds relatively fast. This is explained by the fact that the child masters experience in an already generalised form. However, generalisation cannot give the child this experience in,

as it were, a finished form. It can, of course, form such associations as three plus four equals seven, or five minus two equals three, etc., but this alone does not mean that the child masters the corresponding arithmetical operations and concepts of number. The teaching of arithmetic does not, therefore, begin with this but with active formation in the child of actions with external objects; and the corresponding moving and counting over of these. Later these external actions are gradually transformed into speech ('counting aloud'), are abbreviated and finally acquire the character of internal actions ('counting in the mind'), which become automatised in the form of simple associative acts. Behind these, however, are now concealed the extended actions with objects which we first organised in the child. Therefore these acts may always unfold anew and become exteriorised.

Thus in order to master concepts, generalisation, knowledge, the child must form adequate mental actions. This implies that such actions must be actively organised. These initially take the form of external actions, which adults form in the child, and are only later transformed into internal mental actions.

This process has been studied in detail in the researches of P.Ia. Galperin and his colleagues. They began with preliminary orientation of the child to a task, by showing the child the action and its product. This constitutes the 'orienting basis' of the first actions children learn to perform. It may be said that they are realised in the form of external actions with external things with the direct aid of adults. Already at this stage a transformation begins; the child begins to perform the actions independently; they acquire a more generalised character and become abbreviated.

At the succeeding stage the actions are transferred to the plane of speech, become verbalised. The child begins to count aloud without depending on external objects. At this stage the action acquires the character of a *theoretical* action; now it proceeds as an action with words, with verbal concepts. At this stage there takes place a further transformation of the action in the direction already indicated and its gradual automatisation. Only at the following stage is the action transferred as a whole to the mental plane where it undergoes further changes until it finally acquires all those characteristics which belong to an internal thinking operation. At this stage it can, of course, be corrected and controlled by adults, which necessitates making it once more external, for instance moving it to the plane of spoken speech.

This is only a general schema of the process of formation of thinking operations. Since it cannot be enlarged upon here I will confine myself to certain comments. First, the process does not always

pass through all the stages indicated but may begin directly with formation on the plane of speech depending on the preceding stage of the child's mental development. Second, there are different types of this process as a whole. From the point of view of problems of retardation I want to note only the following. If the teacher's primary aim is to provide the child with certain knowledge and little attention is paid to the ways in which the child himself goes about this, what operations he uses to solve problems set to him so that the further transformation of these is not controlled, then development may be disturbed.

To make clear what I have in mind I may cite some experiments I once undertook in a school for intellectually backward children.

My attention was drawn to the fact that the pupils, when doing mental arithmetic, secretly counted on their fingers. So I asked for some plates, gave two to each pupil and asked them to lift them above the table at the moment when they were replying. It turned out that in these conditions the operation of adding numbers entirely disintegrated in the majority. Closer analysis showed that when adding these pupils in fact remained at the stage of the external operation of 'counting in ones' and had not made the transition to the succeeding stage. Therefore they could not, without special help, advance in learning arithmetic beyond action with numbers up to ten. In order to advance it was necessary, not to take them further but, on the contrary, to return to the initial stage of extended external operations, correctly 'to condense' these operations, to transfer them to the plane of speech, words, and then to organise anew the ability 'to count in the mind'.¹

Research has shown that such a reorganisation can really succeed even in the case of children with severe intellectual retardation. It is particularly important to note that in cases where there is less retardation the effect is fully to eliminate this.

Of course such interference in the process of formation of mental operations must be at the proper time, because otherwise the stage of formation of the given process may not develop or may develop incorrectly and fail to take its normal course, so that the impression is created that the given child is intellectually inferior.

What has been said above also suggests criteria for deciding how to study the child's mental development. Tests of intelligence which establish only which tasks are performed and which are not performed by the child, but do not throw light on the characteristics of mental processes themselves, must be regarded as entirely

¹ Some research bearing on this by L.S.Slavina was translated in *Psychology in the Soviet Union*, pp. 205-12 (Ed.).

unsuitable for evaluating the child's intellectual potentialities, particularly when it is a question of slight retardation.

It remains for me to make some concluding remarks. The principles of child mental development to which I have drawn attention do not of course cover all the complexities of this process. I have had to leave aside many important questions which bear on the problem of intellectual backwardness. To avoid any misunderstanding I will name the most important of these problems. First there is the question of the influence of the social conditions in which the child develops, on which depends the availability of active educational guidance and, when this is necessary, special educational assistance. There is, further, the question of the role of biological prerequisites and individual characteristics, in particular the characteristics of different types of higher nervous activity which cannot, of course, be ignored. Finally there are important questions relating to characteristics in the emotional and motivational spheres of the child's personality.

Leaving all these questions aside I have tried to emphasise what is most important: that investigation of the process of mental development has led to the discovery of corrective-educational measures which are widely (though regrettably not universally) used and that hurried—in essence unsupported—diagnoses and prognoses are unacceptable.

I may be reproached for showing psychological and pedagogical optimism. But I am not ashamed of this, since my optimism is based on objective scientific data and fully upheld by advanced educational practice.

THE ROLE OF SPEECH IN THE FORMATION
OF TEMPORARY CONNECTIONS AND THE
REGULATION OF BEHAVIOUR IN THE
NORMAL AND OLIGOPHRENIC CHILD

A.R.LURIA¹

[THIS is a chapter from a short book intended for teachers in special schools and others concerned with the diagnosis, care and education of the oligophrenic child. In the opening chapter use of the term 'intellectually backward' is defined (p. 8):

[‘In school not only do abilities which have already developed come to light, but also children’s abilities are formed, further developed; all normal children, in acquiring methods and habits of learning in school, develop skills, compensate for deficiencies and realise their potentialities for mental development. The school, like life itself, is a powerful formative factor; it is the greatest mistake to underestimate this formative influence, to consider that ‘innate ability’ inevitably determines the child’s future and so to assign difficulties in learning to a low level of innate ability. Nevertheless, among children who find difficulty in learning there are some who experience insurmountable difficulties in mastering the curriculum who, despite the teacher’s persistent efforts, are unable to make progress in acquiring the necessary knowledge and habits. Such children usually stand out among their contemporaries from the outset; they cannot master the curriculum, grasp the relevant knowledge, understand the teacher’s explanations. This backwardness becomes particularly marked when the children concerned begin to embark on mastery of abstract material....

[‘These are intellectually backward children, who are sharply distinguished from other unsuccessful children. A psychological study

¹ Professor of Psychology, Moscow University. Printed in *The Intellectually Backward Child: a short study of the characteristics of higher nervous activity in oligophrenic children* (Moscow, 1960), Chapter VI, pp. 152–69.

of such children shows that their mental processes have *abnormal features*, and a close study of the history of their development usually indicates that, in the pre-natal period or early in life, they have suffered from serious disease of the brain, making their mental development as a whole abnormal.... All their deficiencies of behaviour are the outcome of early damage which has given rise to malformation of the brain and so to serious defects in mental activity. Psychologists have investigated in detail the mental characteristics of these children, the range of their imagery, the features distinguishing their intellectual operations, the peculiarities of their behaviour; all this sharply differentiates the intellectually backward child from his normal contemporaries'.

[The following studies are here referred to: L.V.Zankov, *The Intellectually Backward Child* (Moscow, 1936), L.V.Zankov and I.I.Daniushevski (ed.), *Aspects of the Psychology of the Oligophrenic and Intellectually Backward Child* (Moscow, 1940); I.M.Soloviev (ed.), *Characteristics of the Cognitive Activity of Pupils in Special Schools* (Moscow, 1953). And, as the fullest studies from abroad: C.Burt, *The Backward Child* (4th ed. London, 1958), A.M. and A.B.D.Clarke (ed.) *Mental Deficiency* (London, 1958).

[Succeeding chapters cover diagnosis and the characteristics of intellectual backwardness as follows: (ii) Clinical characterisation, (iii) Electrical Activity of the Brain, (iv) Orienting Reflexes, (v) Higher nervous activity, after which there follows the present chapter concerning speech.]

1. The basic function of speech

In describing characteristics of the higher nervous processes which arise with the development of speech and the changes that supervene in the organisation of human behaviour, we may briefly compare the development of this behaviour with the processes of development of new experience in animals.

Biological science recognises two main factors underlying the development of animal behaviour. In part the animal receives readymade forms of behaviour, inherits these from its ancestors. The bee does not learn to build cells, the spider does not learn to spin a web—these 'skills' are passed on by heredity from previous generations, more precisely, they are passed on in the form of wings or structure of the eye. These inherited forms of behaviour are one of the constituent parts of animal behaviour and take a more prominent place the lower we descend on the biological ladder. The second aspect of behaviour is that which the animal acquires in the course of life. Charles Darwin discovered the origin of instincts, I.P.Pavlov, studying the mechanisms of formation of conditioned reflexes, discovered the origin

of new forms of behaviour which arise in the individual. The higher the animal on the biological ladder, the greater the role played in its life by the acquisition through personal experience of forms of behaviour.

The behaviour of man covers both these forms. But man also possesses a means of acquiring new experience which is absent in animals. No animal can acquire new knowledge and skills otherwise than through direct interaction with the conditions of life; no animal can hear from its elders how to produce actions, nor is there any animal to which the experience of previous generations can be handed down by any means except direct heredity or immediate imitation.

In the case of man it is another matter. Man masters verbal speech and with the help of this can master the experience accumulated by mankind through thousands of years of history. When the child says to the mother: 'What's that?' and the mother answers: 'It is an engine' and explains how it works—the child masters what has been achieved by the work of many generations. When in school the child learns reading, writing, counting and the fundamentals of science, he masters social-human experience, of which he could not master a millionth part were his whole development determined only by the experience he gains in direct interaction with the environment. It is through verbal generalisation that the child acquires a new factor in development—the mastery of social-human experience—and this quickly becomes the basic factor in the formation of his mind.

The development of the mind through the acquisition of social-human experience by means of language is the third type of development which does not exist in animals and which is the greatest achievement of human society. For animals there is only evolution, with man there begins history and developing forms of behaviour which must be considered not as a biological product but as the product of this social history.

The function of generalisation is the main function of human speech, without which mastery of the experience of preceding generations would be impossible. But it would be wrong to think that this is the only basic function of speech. Language is not only a means of generalisation; it is at the same time the source of thought.

When the child masters language he gains the potentiality to organise anew his perception, his memory; he masters more complex forms of reflection of objects in the external world; he gains the capacity to draw conclusions from his observations, to make deductions, the potentiality of thinking.

When the child names something, pronouncing, for example, 'that is a steam engine', he is at the same time analysing with the aid of means developed through many generations.... Saying the word 'steam

engine' (*paravoz*) he begins to understand that in the movement of the machine named steam (*par*) plays a role and that it moves other objects. In mastering words and using them the child analyses and synthesises the phenomena of the external world, using not only his personal experience but the experience of mankind. He classifies objects, he begins to perceive them differently and with this to remember them differently.

But the speech mastered by the child does not consist of single words; it consists of complex grammatical combinations, of whole expressions. These expressions allow not only for the analysis and synthesis of perception, but also the connection of things with actions, and still more the posing of things in certain relations with each other. Acquiring forms of developed, connected, speech the child acquires the potentiality not only to form concepts but also to draw conclusions from accepted assumptions, to master logical connections, to cognise laws, far surpassing the boundaries of direct, personal, experience; in sum, he masters science, gains the potentiality to foresee and foretell phenomena, which he could not do by merely witnessing them.

What has been said up to now does not fully cover the role of language, the role of speech, in the formation of man's mental processes. Speech activity besides being a means of generalising and the source of thought is also a means of *regulating behaviour*.

When the mother says to her child: 'This is a cup', the child turns his head and looks at the object named; when the mother says to him: 'Clap your hands', he lifts his hands and claps them together. This treatment by the mother regulates the child's behaviour.

But the possibility of regulating the behaviour of another by means of speech is only one aspect of this important function of speech. The child, at first subordinated to the spoken instructions of adults, later masters this means of organising actions; he himself begins to form images of his future actions. Speech, reflecting the connections and relations of reality and formulating the methods of future actions, speech addressed as a command to oneself, very rapidly becomes as the child develops one of the most important means of regulating his own behaviour. When a man carries out a voluntary act, this seems to have no cause and so to transgress the general law of nature according to which every phenomenon must have its cause; but at the root of such actions there is always open or concealed (internal) speech, which reanimates the traces of previous experience, a signal which is as real as any other but incomparably more generalised and mobile. The fact that man governs his own behaviour with the aid of such signals is, in essence, what differentiates his mental activity from the behaviour of animals.

The question now arises as to the participation of speech in the acquisition of new experience by normal and intellectually backward children. This question, which has in part been covered in a preceding chapter, is a very important one and merits particular attention.

2. The role of speech in the formation of new connections in the normal and intellectually backward child

We may briefly outline how the three functions of speech referred to are formed in the child, how they participate in the most complex phenomenon—that is the regulation of the child's voluntary behaviour.

At a very early age the child begins to master speech addressed to him; at first the general tone of this, then separate words and finally the content of complex combinations, the information which the adult addresses to him. At early stages of development information is perceived only in cases when the adult's speech is included in a situation witnessed by the child. If any child of up to a year old is addressed in an unusual tone, in an unusual situation, or if there are no concrete actions accompanying speech, then the content of speech remains beyond the child's understanding. Only in the third year does the child begin to perceive relatively complex sentence constructions.

The child's ability to use the verbal instructions of adults develops in a similar way. By the end of the first year the child is in a position to fulfil simple commands; but he only fulfils them if the command is given in a reasonable (and adequately feeling) tone and in a causal situation. A command given in an unusual tone, or addressed to the child in an unusual situation, is not fulfilled. If, for instance, a child who has just reached the age of two is asked to take a doll, at a moment when he is on his way to pick up another toy, he is unable to fulfil the adult's verbal instructions and, reaching out towards the doll, picks up the other toy in his way. If a child of this age who is putting rings on a stick is asked to *take off* a ring, the adult's verbal instructions, coming up against an already prepared action, are not sufficiently strong to overcome it, and the child, hearing this command, continues intensively to carry out the action begun.

Speech, which expresses some content or command, is perceived by the child, but at an early age the action of the verbal command is easily disseminated if the content comes into conflict with the situation directly acting on the child. Only considerably later, at the age of three to three and a half years, does perception of adult speech and performance of the tasks formulated verbally reach a stage of development at which speech in fact determines the child's further activity independently of the conditions in which it is addressed.

Does this mean that at this age the general functions of speech are to a considerable extent formed? Does it mean that the child who has reached this stage of development can use speech independently to regulate his behaviour? We attempt to find the answer to these questions by special investigations.

We conduct with children of 2 to 2 1/2 years experiments such as those described in a preceding chapter. We give to a child any signal (for instance, the flash of a red lamp) accompanying each signal with the verbal instructions: 'Press the button'; we give another signal (for instance, the flash of a green lamp) accompanying each signal with the instructions: 'Don't press!'

Does the child of 2 1/2 to 3 years master the simple rule formulated in the instructions? Can he generalise the simple general rule: 'It is necessary to press the button every time the red lamp flashes and to refrain from pressing the button when the green lamp flashes?' Can he form the conditioned motor reaction stably when it is mediated by formulation of the rule in speech?

In conducting such experiments it can be observed that children of this age are sharply differentiated from older children. At first the child presses the button only in response to a simple verbal command; initially no conditioned motor reaction to the red light is formed. It is necessary to repeat the combination of the red light with the instruction 'press' many times before the child once presses the button. At first this conditioned reflex has a very undifferentiated character and any light produced—yellow, blue and green—evokes such a reaction from the child; but it is only necessary to accompany showing of the green light with the instructions 'Don't press' on one occasion for the child to stop pressing the button in response to all other signals, including the red signal. It is necessary to work for a very long time with children before the conditioned reaction gradually takes on a more clearcut and differentiated form; only gradually does production of the red light begin to evoke in the child a rapid motor reaction, and production of the green light, after evoking a slow and weak movement, altogether cease to evoke a motor response. But even so the child's differentiated conditioned reaction cannot be considered to be stably formed; the experimenter must, each time the child has made a movement (or refrained from a response), say 'good' for the child to continue to give the necessary reaction. If he does not receive this approval for his actions, the child once more either begins to press at all signals in the order, or altogether ceases to press. This effect may be produced if there is a short interval between experiments or a sudden increase in outside stimulations.

This gradually formed conditioned reaction in the small child has yet another important characteristic. If we ask the child to say how he

reacts to the stimulus presented to him we at once note a number of peculiarities, which basically differentiate his behaviour from that of the older child, the schoolchild or adult. It appears that even after the small child has formed the motor habit—pressing the button when the red light appears and not pressing for the green—he is not in a position verbally to formulate the rule which in fact he follows. To the experimenter's question, what did he see, the child may answer 'mama'; to the question: 'what did you do?' he may answer: 'I walked'. Even when the question directly covers those connections that have just been formed, and the child at rest is asked: 'When did you press?'—he is confused and either cannot give an answer or answers: 'Now'.

This behaviour of the small child differs in essence from that of the schoolchild; in the latter case there is analysis of the conditions of the experiment, rules of behaviour are formulated and only after this does the necessary movement begin to be accomplished; in the former, when a motor habit has been formed, it is never possible to speak about it.

The formation of conditioned motor reactions (motor habits) in the child of three years does not always take place with a full-value participation of his speech; his speech does not stand out here as a means of orientation in the circumstances of the experiment, as a means of formulating a rule and organising the corresponding behaviour. The ability to use speech as a means of communication with others is as yet inadequately developed, and the child still uses it insufficiently as a means of orientation in situations and of regulating his own behaviour.

Only some time later, with the child of 3 1/2 to 4 years, does the picture essentially change. Now, when the child, after the showing of the red light, is given the command: 'press', he does not wait for a further instruction and as soon as the lamp lights up the next time at once turns to the experimenter with the question: 'Must I press now?' Given the negative instruction: 'Don't press', he does not cease to press at all the later signals but asks the experimenter anew: 'Must I now?', which testifies to a lack of mastery of the value of the signal significance of the flashing lamp, so that he turns to the adult to find out the rule which must determine his further reaction. The child of this age engages in speech as a means of generalisation in order by this means to extend his information and to formulate the necessary rules of behaviour.

This stage is not, of course, the last and if the child of 3 1/2 to 4 does not get a ready answer from the adult he makes some probes and formulates a rule for himself: 'When there's a red light I must press', he says. From a means of generalisation his speech is converted into the

source of generalisation, finding out a rule, and this finding out of a rule by the child himself quickly changes into a whole process of further formation of the habit. Formulating the rule, the child mediates all his further behaviour with this. 'Now I must', he says as soon as the red light appears; 'And now I mustn't', he says when the green lamp flashes, and the elective reaction necessary under the conditions of the experiment begins to be formed quickly, sometimes at once, at a bound. Such rapid, immediately formed motor reactions are the first indication that the child's movements have ceased to be mechanical and are becoming conscious as a result of the mediation of speech.

The transition to conscious formation of habits marks an important stage in the child's behaviour. Not only do habits now begin to be formed relatively quickly but also they at once acquire considerably greater stability. Now the formulation of a system of reactions is not extinguished when the experimenter ceases to reinforce the child's reactions with the word 'good', this is already unnecessary to the child since the process of formation of the habit on the basis of formulating the rule is a process of self-regulation, which is reinforced by the coincidence of his reaction with the rule.

If at an earlier stage every rule of action for the child is upheld by the approval of an adult, now the coincidence of the child's reaction with the rule which he has formulated verbally acts as a reinforcement of his reaction and it is precisely on the strength of this ruling that the method of reacting becomes stable. Now a short pause or external stimulus does not lead to the disintegration of the system formed; the child recalls the rule and firmly retains the methods of behaviour he has acquired. Now, in answer to our questions as to what he does and when exactly he presses the button the child answers: 'When it's red, I press, when it's green, I don't' and this answer about his actions indicates that we have here conscious and specifically human behaviour.

* * * *

Having outlined very briefly the formation of conscious behaviour by the child during the early stages of development we may now turn to the question of the intellectually backward child. Experiments conducted with intellectually backward children show that in this case the participation of speech in the formation of new connections is very different from the process in the normal child which has just been analysed.

It has been noted, earlier in this book, that only in very simple cases—when, for instance, the red light is accompanied with the

command 'press' and the green light with the command 'do not press'¹—does the intellectually backward child grasp what it is necessary to do and formulate the necessary rule. But for the child of eight to nine (sometimes ten to twelve) this task is too simple and it is impossible in the light of this example to say anything sufficiently differentiated about the role played by speech in orientating the child in reality and organising his behaviour. It is necessary, therefore, somewhat to complicate the task in order that the actual situation stands out with greater clarity.

We may present the intellectually backward child with a task, the performance of which requires some preliminary analysis of joint stimuli. We may, for instance (as has already been suggested earlier) combine each *long* signal of a blue light with the command 'press', and each *short* signal of this light with the command 'do not press'. In this case, in order to perform the task correctly, the child must first analyse the signals, not paying attention to their single colour but distinguishing the feature that differs—length, and on the basis of abstraction formulate a general rule.

The experiments undertaken allow us to isolate the traits which characterise the intellectually backward child.

The severely retarded child always performs this task without any kind of rule. He usually presses the button at every blue signal, failing to note the differences between them or to connect the different reinforcements ('press' or 'do not press') with the length of the signal. Sometimes he generalises an instruction and ceases to press at every signal after one of the signals has been accompanied by the command 'do not press', or begins anew to press at every signal when another is accompanied by the instruction 'press'. Only after many trials does he begin to turn to the experimenter with the question 'Must I now?', but from the answer he gets he does not draw any conclusions and with the appearance of subsequent signals once more says in a stereotyped way: 'Must I now?' The meaning of these questions is not that he needs the data to form a rule independently, but that he should be able to evade thinking about this rule, save himself from all effort and act always according to instructions. For the normal child a question to an adult is only a step towards independent conclusions, but for the severely retarded child such a question is a means of saving himself from a task, from the need to think anything out.

The characteristics of the less severely retarded child in making use of speech are similar. The debilitated child also addresses to the experimenter the question: 'Must I press now?' but once more this question does not lead to independent thinking, the answer is not

¹ "Nazhmi" (press), "ne nado nazhimat" (do not press).

used independently to formulate the necessary rule. The basic difference here, from what has been said above, is that on the basis of questions put to an adult and his answer these children try to draw the necessary conclusions. However their conclusions are inadequately differentiated and, correctly reacting to the subsequent signal, the child proceeds to ask: 'Was it right to press?' and even having received approval for the correctness of his action does not cease questioning further and does not formulate a general rule which would make these questions superfluous. Inability to use knowledge, gained in the process of speech communication, lack of potentiality to perceive spoken instructions in a generalised way and to formulate them as a rule of action, inability to use speech as a means to independent thinking—these are characteristic of the intellectually retarded debilitated child and, of course, this trait is one of their basic characteristics.

Incapacity to move over to independent verbal analysis of the task set, to formulate independently a rule of action implies that the participation of speech in the formation of new connections is considerably limited in the oligophrenic child. The oligophrenic child can easily state verbally those features which he perceives visually, but he finds himself unable to distinguish relatively minor features with the help of speech and to fix their signal significance; in other words, to do any complex work of analysis and synthesis, leading to the formation of a stable rule of action. Therefore in complex conditions such children frequently react by pressing the button only in response to the direct instructions of the experimenter, and only gradually, after many presentations of the instructions in conjunction with the signal, do they begin to form temporary connections.

It is precisely because of this that the formation of temporary connections in the oligophrenic child differs essentially in kind from their formation in the normal child. The latter begin to cognise the rule to which their actions must be subordinated, connections are formed quickly and at once become stable; but in the case of the former connections are formed mechanically, gradually, long remain unstable, and, most important, are not formulated in speech by the child himself, not cognised by him. Sometimes a small outside interruption in the experiment is enough to disintegrate the connections formed. It is sufficient for the experimenter to cease saying each time to the child 'good' and to leave him to himself, for the system of reactions which has been formed in causal conditions to disintegrate and the child to begin anew to react by chance.

During the first stages such mechanically formed habits remain unstable, but after long and intensive training, during which each signal is continuously accompanied by the commands 'press!' or 'do not

press', the habit becomes sufficiently stable. At the same time, however, it becomes very inert and immobile, and if we attempt to turn this habit into reverse (for instance, accompany each short signal with the command 'press' and each long one with the command 'do not press') we find that the child, despite the verbal command, reacts in the same way as before, persistently reproducing the learned system of reactions; or, if commands not conjoined with the formed habits are continued, he entirely loses any kind of system and begins to react only according to the instructions of the experimenter. The experienced teacher will easily recognise a regularity in these facts—how difficult it is to form any habits in such children and how inert habits are when it is necessary to change them.

The fact that it is so difficult and so slow a matter to reinforce new connections in the case of relatively complex tasks, and the inertness of the habit formed—these are two traits which characterise the formation of complex connections in the intellectually backward child and underlie the familiar pedagogical problems which arise for the teacher.

3. Verbal regulation of actions in the normal and intellectually backward child

In order to make clear in what conditions speech can exercise its regulatory role we have described how the regulatory functions of speech operate in the normal child at early stages of development.

We have said that the child of 1 or 1 1/2 years can successfully fulfil the verbal commands of an adult and that the speech he perceives begins here to play a regulatory role. But we know that this regulatory function of adult instructions is not retained later in all conditions. This picture may be observed in the child of 2 to 2 1/2 years if very simple experiments are undertaken with him of the kind which have been described.

We put in the child's hand a rubber pear and ask him to press it when a red lamp is lighted in front of him. It seems that the child can easily perform this task. The child is able to master this instruction and even to repeat it. However, when a rubber pear is placed in his hand he begins to press it, not waiting for the signal; when the red lamp lights he begins to consider it, temporarily forgetting about the action he should perform. Coincident speech and action is difficult for him, perception of the verbal instructions does not lead to performance of the necessary action. The child is able either to listen to instructions and follow them, or directly to react to an object he sees. In these conditions the verbal instructions of adults cannot, naturally, play the necessary regulatory role.

In other cases the child masters the verbal instructions as a synthetic whole and in simple cases begins to follow them. In answer to the lighting of the red lamp the child can, following the instructions given, press the rubber pear; however his pressing does not cease when the lamp goes out; the processes of excitation, aroused by the signal, are so diffused that the child continues further to press the pear, is not in a position to inhibit this movement. Adult speech is not enough to stop an already begun excitation; even if we say to the child: 'When the light is not there, don't press' he is not in a position to meet the instruction; sometimes our instruction: 'Don't press any more' gives rise to an opposite effect and only strengthens pressure on the rubber pear. In this case adult speech acts on the child in an unspecific way, it only sets in motion the course of his action but cannot inhibit it.

All these conditions—the difficulty of synthesising verbal instructions and actions, the diffuseness of the child's nervous processes, the unstable specific action of speech—constitute a considerable hindrance to the establishment of the regulatory role of adult verbal instructions.

A weakness in the regulatory role of speech of this kind may be observed also in the child of 3 to 3 1/2 years. If, with a child of this age, we light the red and then the green light, asking him to press the pear in response to the red and not to press in response to the green, we find that even though he masters the instructions well he cannot in practice perform the task. The process of excitation, which underlies his movements, is still at this age so diffused, and the process of inhibition so weak, that, beginning to press the pear in response to the appearance of the red light, the child impulsively presses it also when the green light appears, although he distinctly remembers the instructions. The regulatory role of speech is here too weak to overcome the diffuseness of the processes of excitation and the connection of instructions with movements is so inadequate that the child often does not even notice his mistake and believes that he is performing the task set precisely.

Is it possible in these cases to strengthen the regulatory role of verbal instructions and to obtain a correct response to them from the child? Experiments have shown that a means can be found. The simplest way is by many repetitions of the instructions brought closer to the showing of the signal. If each signal is accompanied by a verbal command—after the red light: 'press' and after the green: 'do not press'—the concentration of the nervous processes is reinforced and the child, retaining the instructions given to him, is now able successfully to follow them.

But there is another, more rational, way of overcoming the early diffuseness of nervous processes and reinforcing the regulatory

role of verbal instructions. This is to draw the child himself into speech, which at this age has already reached a level at which he is beginning to master some of the qualities necessary to regulate his behaviour.

We introduced some changes in our experiment. We asked the child of 3 to 3 1/2 years not to produce pressure when the red signal appeared but only to respond to it by the word 'I must' (*nado*) and in answer to the green signal by the other word 'I must not' (*ne nado*). The results showed that the child who could not yet successfully respond to both signals with different *movements*, could successfully respond with different *words*, without mistake, saying in one case 'I must' and in the other case 'I must not'. His speech responses showed *greater mobility and greater control* than his motor reactions. Thus when we cannot master the child's movements, we can master his speech.

Can we use this characteristic of the child's already formed speech to give him a means of controlling his movements? Can we, each time we give the corresponding instruction, ask the child himself to give it to us and so to include his own speech in the regulation of motor acts?

Experiments show that this is altogether possible; if we ask the child himself to say when each red signal appears: 'I must', simultaneously pressing the rubber pear, we find that his own speech strengthens the influence of the instructions and successfully regulates his motor reactions. But this is possible only if the child remains *silent* at the time of the appearance of the green signal. If we ask him to pronounce aloud either 'I must', or 'I must not', pressing in one case and refraining from pressing in the other, it turns out that this task is too difficult for him. Excitation arising through pronunciation aloud of 'I must not' is so great that it overcomes the inhibitive action of the meaning of the words—and, saying aloud 'I must not', the child simultaneously strongly presses the pear, only afterwards noting that he has ignored the instruction.

Only at the age of 4 1/2 to 5 years does this direct (or as it is sometimes called 'impulsive') influence of a spoken response weaken; it is subordinated to the stronger influence of thought connections attached to the word and the child's speech begins successfully to regulate his motor reactions. Later the child's own speech becomes such a strong regulatory factor that he begins to perform tasks without any external pronouncements.

What is the position in relation to the regulatory function of speech in the case of the intellectually backward child? In the experiments referred to earlier, we noted that, as a result of long exercise, there can be achieved a recall of the order of the motor reactions required from

him and that the intellectually backward child can formulate a necessary rule. But despite this, his motor reactions remain uncontrolled and mastery of the rule does not regulate their course in the necessary way.

What underlies this disturbance of the regulatory role of speech in the oligophrenic child in such cases? As has been seen in the preceding chapter, the dynamics of his nervous processes are quickly disturbed; the tonus of the basic nervous processes (particularly of inhibition) are weak, nervous processes are concentrated with difficulty, any outside influence easily inhibits an already begun reaction. This means that creation of the system of excitation which is necessary in order that each motor act should be mediated by speech is very difficult. Because of this efforts directed to using the child's speech for the regulation of his motor processes are often unsuccessful; the child begins to dictate to himself the necessary actions, but this act is so difficult for him that it takes all his attention and inhibits any other motor act; he begins to press on the rubber pear, but then the influence of his speech command inhibits and this system disintegrates.

Research has shown that the difficulty created by the speech motor dynamic system constitutes an important physiological factor hindering the performance of complex actions by the intellectually backward child.

Yet another factor underlies the intellectually backward child's difficulty in regulating his own actions by speech. As we have already said, the child's own speech can regulate his motor processes only if the nervous processes underlying it are themselves more concentrated and more mobile than the nervous processes underlying motor reactions. But the speech connections of the oligophrenic child are not more, but even less, mobile than his motor reactions and are easily converted into a stereotyped form.

We may give two examples illustrating this. The oligophrenic child is asked to react to a red signal by pressing with his hand, and to a green signal by refraining from pressing. For some time he follows these instructions quite well. Later the conditions of the experiment are changed, the child is asked to respond with the word 'I must' when the red signal appears and with the word 'I must not' on the appearance of the green signal. In performing this task the child often very quickly loses the correct order of reactions, monotonously alternating the answers: 'I must'—'I must not', independently of the signals. Sometimes he sticks to one of these answers and repeats all the time: 'I must not'—'I must not', or reproduces a single speech stereotype without any signal.

In all these cases the nervous processes underlying speech are so inert that the speech reactions themselves very easily become thoughtless and lose their correct character. The speech processes of the

oligophrenic child are very easily converted into an inert stereotype and this is one of the essential reasons why they cannot perform their necessary role in regulating actions.

In conclusion we may briefly summarise what differentiates the higher nervous processes of the intellectually backward child from the course of higher nervous activity in his normal contemporary.

Complex forms of higher nervous activity in the normal child are formed in the process of communication with adults; in this process speech is mastered and this, from a means of generalisation very quickly becomes established as a tool of thinking and a means of regulating behaviour. It may be said that not a single act of behaviour is formed by the normal child without the participation of speech which systematises his previous experience and directs his active behaviour.

The matter is entirely otherwise in the case of the intellectually backward child. In the process of his development he also masters speech, but the nervous processes which underlie speech show pathological changes and are inadequate to allow for the rise of the complex and mobile systems of connections necessary for the normal functioning of speech. The speech connections of the intellectually backward child cannot, therefore, play the necessary active role in the formation of his intellectual activity and the regulation of his behaviour.

Disturbance of the participation of speech in the formation of complex mental processes and defects in its generalising and regulatory function are the traits which differentiate the intellectually backward child.

Part Two

THE PSYCHOLOGY OF LEARNING 1900–1960

D.N.BOGOIAVLENSKI AND N.A.MENCHINSKAIA¹

[THIS account appears in the second of the two recent volumes, referred to in the introduction, in which leading psychologists summarise research in different fields over the last half century. A number of these contributions bear closely on education, those on the formation of mental actions, on individual differences, on attitudes, on 'set' and personality, on the development of speech, memory and thinking. Within this framework the present paper is directly concerned with research into the learning process. It is in two parts: a general outline of the progress of educational psychology and a more detailed consideration of research projects. The opening sections of the first part relating to the period before 1930 may be briefly summarised.

[At the turn of the century much attention was being given to educational psychology in Russia, as elsewhere; five national conferences on the subject were held between 1906 and 1916. Efforts to relate psychology to life were much in evidence but there was also a tendency to counterpose theoretical to applied psychology and to substitute the latter for pedagogics. An example is the work of A.P.Nechaev who denigrated pedagogics and held that all problems concerning learning in school must be approached by way of experimental psychology. At this period N.E.Rumiantsev advocated the absorption of pedagogics in psychology maintaining that the school must not take established programmes and methods as a starting point but instead concentrate on the pupil's needs. This tendency towards 'child-centred' education was directly connected with the theory of free education which dominated pedagogics at this time.

[Researches published in Russia at this period attempted to make a systematic approach to psychology and to aid teachers in organis-

¹ Of the Institute of Psychology, Academy of Educational Sciences of the R.S.F.S.R., printed in *Psychological Science in the U.S.S.R.*, vol. ii (Moscow, 1960), pp. 286–336.

ing the educational process [96, 141, 174]. Despite divergences of view on essential questions, these had one common characteristic: they applied data derived from research in general psychology to the facts of school life simply by way of deduction. The results did not, therefore, in any way match up to the pretensions of psychologists to provide the groundwork for the educational process.

[In the first decades of this century research was undertaken, by Nechaev and others, into the mental processes which make up the internal conditions of learning and teaching; that is, into perception, imagery, memory. Attempts were made to divide pupils into groups according to the specific characteristics of their mental processes. Nechaev and his colleagues also attempted to study changes in mental processes and qualities of personality in relation to age and studied children's interests. During this period some psychologists felt the need to reorientate educational psychology, to turn to study of the child's mental processes in the actual conditions of his activity, a tendency clearly marked in the writings of M.M.Rubinstein [174].

[In the 1920's, following the socialist revolution, serious discussion was initiated on the aims of educational psychology and its place in educational science. P.P.Blonski affirmed that educational psychology should take from theoretical psychology important points of interest for education and, on the other hand, discuss the educational needs of society from the angle of their correspondence to the laws governing mental life. This viewpoint was opposed by L.S.Vygotski who stressed the futility of taking over sections of general psychology and, in relation to the second point, maintained that educational needs could not be distinguished without some scientific guidance, that this was the task of theoretical pedagogics. In affirming the need for an independent science of educational psychology Vygotski did not envisage that this should be absorbed in pedagogics. He was concerned to argue that there should be an experimental approach to educational psychology which should develop as an independent branch of psychology.

[In addition, many psychological concepts were reconsidered and revised after the socialist revolution. The campaign against verbalism in the schools, attempts to develop the teaching of practical subjects, all this found its reflection in educational psychology. Changes were introduced in courses of educational psychology in 1918 by Rumiantsev [178] under the influence of progressive ideas about conscious learning advanced by the Russian revolutionary democrats, Herzen and Dobroliubov, and elaborated by K.D.Ushinski. The new demands made upon educational psychology widened perspectives for research. Vygotski's *Educational Psychology* (1926) had a decisive significance in determining future developments, but owing to the lack of research

data he had often to bridge large gaps between the propositions of general psychology and teaching practice. At this period there was, therefore, too facile an interpretation of the psychological bases of individual differences and sometimes also contradictory educational propositions. General theories about thinking as problem solving and the role of difficulties in evoking thought were advanced as a psychological justification for various forms of project method, including the Dalton plan. The method of using 'whole' words in teaching reading was easily accepted as fundamental by psychologists who accepted propositions about the 'whole' character of perception in children.

[Different psychologists upheld contradictory pedagogical approaches. Some leading educational psychologists stressed use of the visual in teaching as corresponding to the concreteness of child thought, while others stressed the harm of this, holding that thought is evoked by difficulties and that visual methods eliminate these for the children. This arbitrary discussion of the psychological foundations of different educational methods was inevitable at this stage when research into the child's mental processes in the course of activity, in the process of teaching and learning, was still lacking.

[In the 1930's, however, Blonski, Vygotski and their colleagues began to conduct research into the child's mental processes in the course of activity, and this posed new theoretical problems relevant to educational practice. A characteristic tendency of this research was study of mental functions not in isolation but in their interrelations, an example being Blonski's *Memory and Thought* published in 1935 [13]. This led to a widening of the concept of mental functions and raised the question of the process of transition from one function to another. In particular, Blonski stressed those 'moments of transition' in which it is difficult to discern the function involved, so raising a point which had considerable influence on the content of the concepts developed in educational psychology. He had already laid great emphasis on the concept of 'mastery' which afterwards took a central place. He noted that mastery must not be confused with memory since it is concerned not only with this but also with the capacity for checking and correction. Studying the process of mastery by pupils of school subjects, he established a series of stages in this process.

[Blonski was also concerned with the interrelation between knowledge and thinking. He postulated that knowledge is a necessary condition of thinking but that rational thinking is not merely the reproduction of knowledge; it develops only at a higher stage of development of memory—the greater the knowledge, the greater the ability to reason. But he also distinguished memory and thinking,

suggesting that subjects begin to think when habit or previous knowledge is found to be inadequate. Developing these ideas further, Blonski often returned to the point that ability to think depends on the degree of habituation to a task and the degree of difficulty—a proposition upheld in many researches. The data obtained established that differences in ability for problem solving may be found not only in different subjects according to age and intellectual development, but also in the same subject according to the degree of difficulty of problems. This proposition, though not central to Blonski's own work, later acquired great importance in the psychology of learning.

[Vygotski, in *Thinking and Speech*, published in 1934 [35] posed the question of studying thinking in the process of learning and placed the question of the formation of concepts on a new footing. He and his colleagues studied the formation of actual concepts introduced in the process of teaching, so initiating study of the mastery of concepts. An early investigation on these lines was that of Zh.I.Shif [229]. The first question raised was the interrelation between mastery of scientific concepts and of so-called 'everyday' concepts acquired apart from systematic teaching—a question accorded a key place by Vygotski in the wider problem of the interrelation of systems of concepts. He emphasised the importance of research into the formation of concepts in school learning (as opposed to artificial experiment) since here all the new stages in the development of generalisation rest on generalisation at preceding stages. In a number of researches Vygotski traced the reorganisation of the relation of concept to object and the generalised relations between concepts. He particularly stressed the importance of the formation of systems of concepts in the process of teaching, a question which was later to be widely studied.

[In addition, Vygotski made an experimental and theoretical analysis of the more general question of the interrelations between learning and development, advancing in a paper published in 1934 propositions which still retain their force to-day.¹ The view that mental development in the process of learning marks a change to qualitatively new levels of thought opened up new perspectives for research into the learning process.

[In characterising stages of mental development, however, Vygotski made the error of distinguishing these in the light of the 'theory of cultural development'. Taking as a point of departure the proposition that the child's mental processes are reorganised by mastery of culture (the sum of the historical development of knowledge) he postu

¹ The paper published first in this volume outlining Vygotski's theory of the complex dynamic interdependence of learning and development and the concept of the 'zone of potential development'. (Ed.)

lated that it is essential for this reorganisation to make a transition from direct, 'natural', forms of behaviour to the 'indirect' (i.e. using symbols, 'cultural' acts). Counterposing organic and functional development, he held that in the first case the nervous apparatus is perfected, in the second modes of behaviour. According to the theory of cultural development, mastery of knowledge or of operations takes place in several stages: the first is natural reactions without use of symbols (i.e. in arithmetic, direct perception of quantity without counting), at the next stage external symbols are used (e.g. counting with the fingers), later the symbol is internal (e.g. counting in the mind), external methods being as it were rotated into inner methods constituting internal reactions.

[To counterpose organic and functional development is to schematise the process of development and to assess incorrectly the transition from lower to higher stages in the mastery of knowledge. In fact this transition does not mean that an action loses the character of an external action with objects and becomes assimilated in speech. Mastery of speech changes the character of action with objects; there takes place not a simple 'rotation' of an external into an internal action but a *reorganisation* of the child's actions with objects *with the aid of speech*. Leaving aside this aspect, Vygotski's thesis leads to the proposition that the pupil does not immediately grasp abstract knowledge (or operations) but proceeds towards mastery through actions with objects. This does not, however, mean that action with objects is proper only to the early period of mastering knowledge. As subsequent research has shown there is a dynamic interrelation between action with objects and thinking and a return to the former is always possible at a higher stage of formation of thought. This question of the transition from thinking to action with objects is of key importance to polytechnical education. In this connection Blonski pointed out that there are different relations between thinking and action in the solution of any problem; usually there is a transition from action to thought or conversely, but sometimes only actions are present and sometimes these are replaced by thought. This interrelation, Blonski emphasised, is determined not only by age and intellectual development but also depends to a considerable degree on the difficulty of tasks, so that it differs in the same subject in relation to different problems.]

General outline of the progress of educational psychology from 1930

Important steps were made towards a scientific elucidation of problems of educational psychology at the start of the 1930's. But advance was extremely slow because the development of psychological science was

arrested at this period by uncritical borrowing of theories from bourgeois psychologists—by the wide dissemination of psychometry. In published works it was not always possible to separate genuine psychological research from pseudo-scientific, psychometric, reasoning and facts. Many psychologists directed their efforts to constructing tests designed to determine the level of intelligence of school-children and to ‘measure’ their attainments in school.

The Central Educational Laboratory, established during these years in Moscow, attempting to analyse the causes of pupils’ failure, was led to initiate wide ranging ‘research’, the essence of which was to seek coefficients of correlation between success in school and other factors such as the amount of living space available to children and the amount of meat they consumed. Such ‘research’ took the place of genuine scientific study of children. Psychometrists dominated in the schools but their activities were carried on in isolation from the teachers and school work. Nor did psychologists develop other methods, based on a scientific understanding of children, with which to oppose the harmful practice of testing. This position was radically changed after the resolution of the Communist Party of July 4, 1936, ‘On the distortions in the system of public education promoted by psychometry’ [160]. This resolution, in condemning the theory and practice of psychometry, pointed to its harmful influence on the development of a scientific psychology and, above all, the development of that branch connected with the schools, i.e. educational psychology. Subsequently psychologists embarked on a radical rethinking of the main foundations of their science and began to direct efforts to eliminating unmarxist, pseudo-scientific propositions deeply embedded in psychology.

Particular attention was directed to a critique of the main ‘law’ of psychometry—that the child’s development is fatally determined by two factors, heredity and an unchanging environment. This necessitated study of changes in the child mind under the influence of changes in the educational process; the tracing, in particular, of how methods of teaching and the content of the knowledge studied are reflected in the psychological characteristics of the mastery of scholastic material, and the significance of the activity of the pupils themselves in the process of mastery. The need for a critical rethinking of the concept of age was sharply posed—of the rigid, unchanging, age standards which are an essential accompaniment of the principles of psychometry, the use of which effectively eliminates the very concept of development. Age characteristics of the child mind were established in close connection with the nature of education and teaching, specific stages of learning, those experiences which the child acquires in the process of life.

The proposition that mental processes are not merely manifested but formed in activity (advanced by S.L. Rubinstein in 1934 and later developed in his *Fundamentals of Psychology* [170]) took a central place in psychological theory. It acted as a stimulus to the progress of research into the development and formation of mental processes in changing conditions of activity. Research of this kind had the effect of distinguishing the specific objects and tasks of the psychology of learning more clearly from general psychology. It was established that the object of study is how pupils' activity is determined by education, and the aim to reveal the psychological laws governing this process.

This understanding of the aims of research led to study of mental activity, not as a manifestation of abstract mental functions, but as the activity of human beings—of active men, living in specific social-historical conditions and directed by socially conditioned aims and intentions; activity in connection with these was seen as a single dynamic process.

Study of activity as a process took a key place and psychologists advanced the view that genetic methods of research are of great importance since they allow for study of this process in normal conditions of learning. The transition from study of separate functions to study of actual activity opened up wide perspectives for educational psychology, for the use of research results *in practice in the schools*.

At this time the important question of the interrelations of educational psychology and pedagogics was raised (e.g. the paper by A.N. Leontiev published in 1937 [112]). An essential corrective was introduced to the former view that psychology is the groundwork of pedagogics and it was emphasised that educational psychology for its part *rests on pedagogics* since it studies the mental development of children in conditions of upbringing and teaching. It was established that the task is not to take the teacher's place in guiding the educational process in school but to aid him by working out scientific foundations for the rational organisation of this process.

For a considerable period the practical work of psychologists in the schools had been discontinued, so that it was necessary to find new foundations on which to base methods of studying children. Setting aside the method of testing, psychologists began widely to develop methods of observation, discussion and experiment, paying particular attention to improving the natural experiment.¹ The 'principle of cross sections' was widely used in the form used in genetic psychology (comparison of data relating to children of dif-

¹ i.e. experiment which is carried through in school in the normal conditions of teaching and learning, see p. 13 (Ed.).

ferent ages). Psychologists conducting research into the learning process also began to study mental processes in the same children at different stages of learning thus providing a sound basis for discerning those changes that take place in the child's mind as a result of teaching. With this aim a new form of natural experiment was worked out—the 'teaching experiment'—whereby psychologists themselves form the necessary knowledge, skills or habits, combining study and action in their experiments [cf. 123, 172, 173].

In 1936–7 research into the psychology of learning attained a wide sweep. At its centre was the process of acquiring knowledge in all its aspects; investigations were made into the process of understanding differing scholastic material, into the mastery of concepts and thinking operations in the process of studying basic subjects; research was carried on into problem solving and the formation of habits and skills; pupils' mistakes were investigated with the aim of discovering their psychological nature and the psychological prerequisites for more effective mastery; there was study of motivation, of the role of praise in the process of mastering knowledge, etc.

Research into such questions became more widespread after the establishment of the Academy of Educational Sciences in 1944. The bringing together of academic psychologists on the one hand and of those concerned with methodology and didactics on the other facilitated mutual discussion and the choice of research projects of the most importance to the schools. In the process of this collaboration psychologists mastered the techniques of studying specific characteristics of learning (and this was not acquired at once), they began to analyse the experience of teachers from a psychological point of view and at the same time to approach the solution of problems formulated by the resolution of the Communist Party on the primary and middle school of September 5, 1931—'To concentrate the work of the relevant research institutes mainly on study and generalisation of the experience accumulated in the course of practical work in schools' [160].

In research into the psychology of learning there is a marked tendency to subordinate research to logic and consequently to seek regularities in the characteristics of *different* mental processes or, more precisely, different aspects of pupils' cognitive activity in *one specific* sphere of knowledge. Thus the psychology of learning can be divided into a number of branches—'the psychology of learning to read', 'the psychology of learning arithmetic', etc.—each of which is based on research, generalised in some cases in monographs.

Attention was mainly directed, therefore, not to the general laws governing mastery of scholastic material by pupils of different ages and at different stages of learning, but to partial laws specific for the mastery

of material of a specific content. In this connection psychologists laid emphasis at this stage on the advantages of a particular method of teaching a school discipline but not on general theories of teaching, on didactics.

It is reasonable to say that in the period 1936 to 1950 there was a marked development of particular aspects of research into the psychology of learning. In this lay the strength and weakness of this stage. The positive aspect was that psychologists studying special aspects of scholastic activity made a notable contribution to providing a scientific basis for the teaching of the relevant subjects. The negative aspect was a setting aside of the question of the general laws governing the child's thinking in the process of acquiring knowledge, insufficient attention to general learning theory. Thus, for a long period there was little work providing general guidance for educational psychology and the psychology of learning in particular (whereas in the pre-revolutionary period there had been a considerable amount of guidance of this kind). But, undoubtedly, a great deal of research provided the basis for new and deeper generalisation.

An important influence on the progress of the psychology of learning was exercised by the scientific session concerned with Pavlov's physiological theories, held in 1950. The assimilation of Pavlovian theory, attempts to utilise in research Pavlov's ideas (about associations, systematisation, the interrelations of the first and second signal system, etc.) brought major problems into prominence. On the basis of a variety of materials, general laws of learning gradually came to light and the general outline of a learning theory began to emerge. The general features of the contemporary psychology of learning may be characterised by singling out some essential aspects.

Application of the genetic principle, that is the study of phenomena in development, is fundamental to all research into the psychology of learning. How the transition takes place from non-knowledge to knowledge, through what successive stages or steps the pupil passes in mastering aspects of knowledge, skills or habits, how ability to perform school work changes—these questions interest all researchers.

Knowledge and habits have been studied both in their developed form (in adults) and in the process of their formation in children. Comparative study of pupils in different classes was undertaken by N.A. Rybnikov as early as 1936 when he studied habits of reading [182]. Various monographs, generalising a number of researches, are concerned with the question of mastery of one or another branch of knowledge or aspect of school activity: e.g. mastery of habits of reading [222, 59], the development of habits of writing [46, 48, 213], the

psychology of learning arithmetic [123] and of learning spelling [15, 17].

In researches into the psychology of learning the age of pupils is not distinguished from the stage of learning, i.e. data is compared relating to pupils of different classes and consequently of different ages but no attention is paid to insignificant variations internal to one or another age period among pupils of the same class.

It is characteristic of all research into the psychology of learning that attention is directed to *qualitatively new* stages in the mastery of knowledge and habits. This principle, as it applies to habits, has been formulated by L.M.Shvarts as follows: 'the development of a habit is nothing else but the way in which one method gives place to another, more efficient one as a result of which the habit is *qualitatively* changed' [222:95]. As he emphasises, the method formerly elaborated does not disappear but is transformed. Each new stage in the development of a habit is characterised by certain methods which are predominant. But it is not always the dominant methods that evoke methods of a higher quality. 'On the contrary', as Shvarts notes, 'at every stage of development of a habit it is usually possible to find the first gleams of more finished methods. But these have yet to become firmly established, to develop on the base of the old, and become the usual, dominant, methods only when they reach a certain level of development and push the formerly predominant methods into the background'.

This proposition applies in the same degree (if not more) to the process of mastery of knowledge. All researches concerned with this question have brought to light specific forms of interrelation between old knowledge (or methods of applying it) and new, a transition from a lower to a higher stage of mastery, the appearance of 'shoots of the new' and their subsequent development. Stages or levels¹ in the mastery of knowledge and habits have been found to depend not only on age and on the level of scholastic attainment and development, but also on stages in the perfection of methods of learning and on the content of the scholastic material cognised.

This question is examined in papers by A.N.Leontiev published in 1937 and 1945 [112, 113] and also in those by S.L.Rubinstein [172] and G.T.Ovsepien [148] published in 1939 and later there was experimental as well as theoretical solution of the problem.

It can be said without exaggeration that all research into the psychology of learning for the past 40–50 years has contributed to the point of view outlined above on the course of the pupil's mental development in the process of learning.

¹ The terms '*etap*', '*stupen*' (stage), '*uroven*' (level) are usually used as synonyms, but different authors show a preference for one or other of them.

According to the genetic principles used in the psychology of learning (as distinct from child psychology) changes have been observed in *two* directions: firstly, the *complication* of knowledge and habits in the transition to higher stages of learning, to new material in the school programme, and secondly, *simplification* of methods of operating with knowledge and habits by pupils performing exercises with the same material.

Concern with the appearance of qualitatively different methods of mastering and operating with scholastic material is directly connected with the fact that researches into learning are, in fact, researches into the psychology of *conscious* learning; they are sharply opposed to that trend of research which has for long been dominant in this field in other countries and is based on the connectionism of Thorndike (a variety of behaviourism). As is known, in the research of this school the process of learning is reduced to the simple quantitative accumulation of connections between stimulus and reaction and accordingly exercise is treated as mechanical training. In studying the basic laws of conscious learning Soviet psychologists have subjected behaviourist views to criticism.¹

Another characteristic feature of research into the psychology of learning is that it is directed not only to discovering the common characteristics in the process of learning, to be found in pupils of a given class or age, but also to discovering individual differences in this process. Here it should be noted that the latter is an essential aspect of almost all researches.

There are in each class pupils whose abilities for learning differ. Some advance from less full to full knowledge very quickly, while for others this process extends over a period of time and is divided into a series of stages. It is essential that the researcher, attempting to discover the psychological nature of the process of learning, should bring within his sphere of investigation both these ways of learning even if he is not specially concerned with study of individual differences. With this aim in view the psychologist is interested in the difficulties pupils meet with in the process of learning and the mistakes they make in mastering and applying knowledge or forming and using habits. Study of the character of mistakes, the degree of their constancy, or, on the contrary, the rapidity with which they are overcome, makes possible the discovery of the characteristics of children's thinking in the process of learning. There has also been research into difficulties as a special problem [cf. 5, 57, 67, 105, 122, 130, 158, 181, 224].

¹ These criticisms were particularly relevant insofar as in the 1930's a number of Thorndike's works on questions of learning were translated into Russian. For critical analysis of the work of this school cf. 223, 129.

Finally an important feature of research is the attempt to study not any one mental function but cognitive activity brought about by the participation of a whole series of mental functions (memory, thinking, attention, etc.) and taking the form of integral analytic-synthetic activity.

In some researches, however, attention has been concentrated on different mental processes and their role in the process of learning [cf. 52, 207, 219]. This is not the usual approach in research into the psychology of learning but it is undeniably a correct one.

The fact that many researches in general psychology, concerned with different mental processes and in particular with memory, have a direct significance for the psychology of learning must not be overlooked. Among the latter are works in which memory is treated as a particular aspect of man's activity so that three approaches are united—that of general, child and educational psychology. (See the work of P.I.Zinchenko [71], L.V.Zankov [68, 69], A.A.Smirnov [200].)

Review of Research

We may now turn to a review of the results of research into various problems. This will be limited to work characterising the different aspects of cognitive activity in pupils which is the main trend in the psychology of learning. Aspects which have received the most attention are: understanding, the formation of images and concepts, problem solving and the formation of skills and habits. (The question of mental actions performed in the process of mastery and problem solving is included under these headings.) Note will be taken of the conditions for effective mastery, in particular, the question of motivation. Mention will also be made of individual differences which appear in the process of learning.¹

Understanding

Understanding is a constituent part of the process of learning but is at the same time an independent problem which has been the subject of many researches. Some of the data of these may be reviewed. There have been different approaches to this problem in relation to different material—studies of understanding of the principles and laws of different sciences (mathematics, natural science, history, etc.), understanding of spoken and written speech, understanding of texts in the native and foreign languages, etc.

¹ Work on the psychology of learning does not cover only these problems but it is these that have been the subject of most research and have been of central interest to many researchers.

Though specific characteristics of understanding are found in different kinds of activity, a number of general propositions as to the psychological nature of understanding have been established.

Understanding acquires a different character (as has long been established in psychology) according to the level of difficulty of the cognitive task to be performed. For instance, 'direct' understanding (which takes place at once in the process of perception) can be differentiated from 'indirect' understanding which develops in the process of time and requires for its establishment a series of thinking operations. Researchers have been concerned mainly with the second aspect. The changes in this process have been traced from two angles: changes in understanding of the same scholastic material in dependence on stages of learning, i.e. in pupils of different classes, and, parallel with this, the changes that take place in the process of understanding in the same pupil as a result of work on certain material. In both cases certain stages in understanding have been established.

Much data derived from research testify to the fact that at the initial stage understanding has an undifferentiated, general character, that later separate specific features of the object studied are distinguished and, finally, there takes place the formation of understanding of the whole.

A.N.Sokolov, studying understanding of a foreign text of considerable difficulty by adults [203], noted that in connection with the specific meaning of the first words read there first arises a vague conjecture about the general content of the text, then there is differentiation and specification of the meaning of words, and, finally, at a third and higher stage there takes place conjointly a differentiation of the meaning of words and a precise establishment of the general meaning of phrases or paragraphs.

Analogous changes in the process of understanding have been found in relation to other material of a very different kind. We have in mind the process of understanding mechanisms which was investigated by S.A.Zhekulin [60] in pupils of Class X (16–17) and in adults. Experiments have shown that subjects, after preliminary familiarisation with an object (when they have established that this object is intended for some technical aim—that it is a 'tool'), enter a period of analysis and partial synthesis of the object. At this point they single out and recognise different parts of the instrument (as having a certain use). The parts singled out are then put into relation with each other. At this stage there arise propositions relating to principles of action. As a result of a series of trials the subjects arrive at a single system of interaction between parts of the mechanism and reach the concluding stage of 'general synthesis'—in the words of the author of this research. In the same

sense changes have been found in understanding of principles and functional dependencies in mathematics by pupils of different classes [109, 31] in the study of history [14] and so on.

The fact that the same basic stages of understanding are found in relation to different material indicates that we are here concerned with general regularities which have as their physiological foundation the laws of generalisation and differentiation established by Pavlov.

What processes make possible complete understanding? This question has attracted the attention of many researchers.

L.I.Kaplan, analysing understanding of a scientific text by pupils of the higher classes and adults [97], has shown that when reading through a text and attempting to reach an understanding of it the subjects do not reproduce the text in the way it is written but reconstruct its verbal aspect. In place of the words of the text, the author notes, there are evoked in the reader's mind other words close to these in meaning. In the process of understanding, therefore, there takes place an actualisation of connections or associations formed earlier, the inclusion of new connections in the systems formed before, as a result of which it becomes possible to reach understanding. Pavlov held that understanding is the 'use' of connections acquired earlier and this definition indicates sufficiently precisely the essence of the process described.

Research has shown that understanding is difficult in cases when it involves the dissociation of two associative wholes: the one being subordinated to the author's intention, the other resting only on the basis of the preceding experience of the pupil reading the text. This problem arises particularly in relation to the arts. The process whereby children understand allegory or metaphor has particularly engaged researchers since in this case we have to do with double meaning—direct and transferred, in which the first is given at a glance in the external situation while the second is the product of generalisation. Study of the process of understanding transferred meanings allows for penetration into the characteristics of the child's thinking activity, discovery of the interrelations between its concrete and abstract components.

Individual and group research has been devoted to this problem by A.P.Semenova in work published in 1941, 1948 and 1954 [191, 192, 190], by a research group at the Institute of Psychology of the Ukraine who published their work in the institute's transactions (Vol. V) in 1956 and in earlier papers [103, 104], and by E.N.Hopfenhaus [43]. Researches here show that the initial stages are governed by the visual content of images (a fable, for instance, is understood according to its external, direct content), the sensory content not being at first the bearer of the generalised meaning. In addition the more the child is attracted by

the direct visual content, the more difficult it is for him at first to master the generalised meaning of an image. At the same time the only way to disclose the transferred thought is through mastery of the specific content of the work, which in turn is only possible as a result of interpretation through the prism of personal experience. This aspect is also dealt with in detail by A.F. Iakovlicheva in research concerned with the understanding of a book by pre-school children [238]. Research has established specific stages in the mastery of transfer of meaning characteristic for pupils of different classes, and at the same time has shown that the same pupil may achieve different results in dependence on the content of the work.¹

The differing role of personal experience and different ways in which it is utilised in perception of works of art are covered in the researches of O.I. Nikiforova [142, 143] which approach this question from the point of view of images and the reconstruction of imagery. She shows that even in perception of specific words the subjects (schoolchildren and adults) almost always evoke images which realise a personal 'individual idea' of a word. In some cases this 'individual idea', reflecting the specific experience of the subject connected with characteristics of his personality, is close to the general linguistic meaning of the word, in other cases it sharply diverges from this. In the latter instance, the emotional saturation of the image 'displaces' the idea of the word.

Nikiforova also found and characterised different stages in the reconstruction of images when reading literature. Characteristic of the lower level is that the working images are 'out of context', when, that is, the theme or separate words are evoked in connection with understanding them and this draws the reader away from the images of the literary work. Characteristic of the higher level, by contrast, is a precise reconstruction of images written about in the text. Nikiforova notes that previous visual experience, utilised in these cases, is of a different character, it is more widely generalised, more differentiated, and does not lead to specific recollection (as is characteristic of the lower level).

An important aspect of research into the understanding of texts is the question of the role of illustrations or, in other words, the question of the interrelations of perception and the word. Contradictory opinions about the role of the visual, which used to dominate educational psychology, have been rejected and the problem finds a clear solution in contemporary experimental research. This research was

¹ The question of the interrelation of the image and abstract components of thinking activity in work on texts will be dealt with when describing problems of the mastery of knowledge.

begun in the Kharkov educational institute in 1939 and subsequently generalised in a paper by Leontiev published in 1947 [114]. The author advances the view that the function of visual material may differ in dependence upon the tasks presented in teaching. In different conditions visual material may exercise a positive influence, be useless, or even play a negative role as a factor distracting from the basic task. In recent years there has been a great extension of experimental research into the different role played by perception of illustrations in the process of understanding a text at different stages of learning and in dependence on differing material. Examples are the work of T.G.Egorov and his colleagues on mastery of the habit of reading [58, 59], and that of Iakovlicheva [238] and T.V.Kosma [101] who present interesting material.

Study of the understanding of texts leads (more directly than the study of any other problem) towards research into mental processes connected with other qualities of the child's personality. Even study of understanding the principles and rules of arithmetic has shown how significant are such aspects of personality as volition and emotional attitudes which assume a particular qualitative form in the process of understanding [123]. Wider opportunities of studying characteristics of personality have arisen in research concerned with understanding literary texts. N.G.Morozova, in the course of several researches [135, 136, 137] has noted that emotion participates in the process of understanding a text but that the activity of personality in reading is not confined to this. Full understanding of a text requires not only an understanding of thought, realised with the aid of words, but understanding of the writer's ideas about events or actions which disclose the underlying motives.

Morozova, L.V.Blagonadezhina and other researchers connect the reader's understanding with attitudes to what is read. Changes in these attitudes have been traced to stages of learning. According to the data of Blagonadezhina pupils of Class V (11–12) preserve peculiarities of perceiving a literary work characteristic of an earlier age: they identify themselves with the main hero of the work and participate in his actions and the events in which he is involved. In the study of literature in Class VII (13–14) the character of understanding of a literary work is changed; the pupils concentrate less on the chief hero and show interest in secondary personalities, participation in the hero's actions is removed to a secondary plane and the objective content of the work becomes the object of cognition and attitudes.

Essential characteristics of the child's personality are disclosed in researches into the understanding of separate aspects of a literary work; e.g. that of T.V.Rubtsova concerned with understanding of literary characters by primary and middle schoolchildren [176], that of

D.B.Praisman describing the understanding by primary schoolchildren of motives of behaviour of literary characters [162] and that of D.F.Nikolenko analysing children's perception of comic situations [145]. There should also be noted such work as that of T.I.Bochkareva [26] describing the attitudes of children in the higher classes to literary heroes which provides material characterising their ideals.

The role of associations

The complex processes of mastering knowledge are not, however, limited to questions of understanding. The processes of mastering knowledge are dealt with in the majority of researches in accordance with reflex theory as manifestations of analytic-synthetic activity of the cortex through the basic stages of primary generalisation, subsequent differentiation and higher synthesis. The realisation in these researches of the Pavlovian principle of association is an undoubted achievement of the psychology of learning in recent years, since this principle permits the scientific grounding of psychological theory and the discovery of regularities in the learning process as a single whole.

The first to study the role of associations in scholastic work, their constitution and classification, was P.A.Shevarev. In his work on the nature of algebraic habits published in 1941 [225] he established two types of connection differing in the following way: on the one hand there are united specific, single, perceptions or actions, on the other hand general properties of perception or actions. Shevarev demonstrated how connections of the second type arise and the important part they play in the scholastic activity of pupils. Further, the role of these connections and their functioning is described not only with reference to simple habits but also to more complex intellectual problem solving [226, 227].

A similar direction has been taken by research workers of the Institute of Psychology of the Academy of Educational Sciences, who have attempted to rethink the concept of association in the light of Pavlovian theory and have treated synthesis as the formation of associations and analysis as their separation, dismemberment. In material relating to the learning of different subjects, the formation of complex associations has been disclosed, marked both by quantitative changes and by qualitative change whereby one kind of association is transformed into another in the course of teaching.

While these researches are concerned with associations relating to particular subjects, the researches of the psychological section of the Leningrad Institute of Education of the Academy of Educational

Sciences devote chief attention to the formation of 'inter-subject' associations, i.e. associations formed on the basis of studying different scholastic subjects. Iu.A.Samarin has worked out a classification of associations on the basis of the principle of systematisation, i.e. the character and stages of the joining of associations in systems.

Researchers concerned with the formation and actualisation of associations in the course of learning have attached much importance to mobility (having in mind the pupils' ability to reorganise already formed systems of associations, to unite associative series from different systems to form new systems: 99, 127, 184, 185).

The mastery and application of knowledge

Characteristic of all research into the mastery of knowledge is the great importance attached to examining the process of mastery in close connection with the application of knowledge. More exactly, the mastery and application of knowledge are treated as two aspects of a single process, since pupils can only master fully that which they attempt to realise in their scholastic and practical activity. Application of knowledge, therefore, is not only a means indicating whether knowledge has really been mastered but also a means to disclosing and reinforcing it. To master scholastic material, this is to be able to use it, i.e. control it. But there is yet another aspect to the question. It is not only a matter of forming in pupils the special skills of applying knowledge, but also that from the very first stage of mastery the knowledge or habits to be acquired must appear to the pupils in the form of a problem, whose solution depends on their intellectual activity. ('An active condition of the brain', as Pavlov noted, is one of the conditions for the formation of associations.)

It is well known from the researches of both psychologists and methodologists that passive mastery does not lead to this result. In their teaching practice the best teachers make use of many effective methods of explaining new material, the essence of which is that the pupils are subsequently faced with a series of tasks which stimulate their intellectual activity, as a necessary condition of conscious mastery of knowledge.

In the application of knowledge the processes of analysis and synthesis and, arising from these, abstraction and generalisation, acquire particular importance.

Correct analysis of the object studied (whether actual or verbal) leads not only to the breakdown of the whole into parts but also to abstraction of its essential features. In order to single out essential features it is necessary to look for them as features, common to some kinds of objects but not properties of others. The features abstracted (abstracts) are

consequently singled out as *general* features and acquire as a result a generalised significance. Therefore, generalisation (like synthetic activity) is inseparably linked with abstraction resulting from analysis. Full abstraction and generalisation (i.e. the thoughtful singling out of general features or properties of objects) is realised with the aid of the verbal meaning of the abstracts whereby the result of analysis and synthesis is reinforced by the word.

In further learning there takes place a *systematisation* of the concepts mastered on the basis of establishing specific relations and interconnections between them which reflect the actual relations of objects and phenomena.

Primary generalisation and elementary analysis

In advancing from non-knowledge to knowledge the pupil meets with a number of difficulties, the psychological nature of which, as research has shown, consists in insufficient development of correct forms of analytic-synthetic activity. Researches have traced manifestations of *primary generalisation*, indicated above all in inadequate analysis of the phenomena studied, in the enumeration of those general features which have acquired signal significance for the pupils in their everyday practice or in the process of teaching, but are not in either case essential to scientific concepts. This level of analysis conditions incorrect generalisation, on the basis of 'everyday experience' or of some external feature or property of objects and phenomena. This kind of generalisation is characteristic of the first stage of mastery of concepts belonging to different school disciplines.

A number of researches have found, in relation to the mastery of grammar, that the lexics of words hinder the process of grammatical abstraction. This negative influence is explained by the fact that while in the practice of speech the real meaning of a word or sentence has a basic significance, in the mastery of grammar the meaning characteristic of the use of the word in speech does not to any notable degree determine the content of the grammatical concept, or rule, but is an inessential feature which must be ignored.

In the mastery of history confusion of historical concepts is often observed insofar as the pupils insert into these an undifferentiated content corresponding to their very limited experience of life. Thus according to the data of A.Z.Redko [166] and L.M.Kodiukova [98] pupils in the primary school lump together boyars, capitalists and landowners as rich people and slaves, serfs, peasants and workers in the undifferentiated category of 'poor'.

In science there is often primary generalisation which depends entirely on children's everyday experience. For instance, in the content of the concept 'fruit' they include such features as juiciness, its edible

character, etc. (data of E.M.Kudriavtseva, 105). The mouse is often described as a domestic animal 'because they are in houses', the crocodile as a mammal because it is 'big, eats other animals and has four legs' (data of M.N.Skatkin, 196). In differentiating the concepts 'bird' and 'insect' some children give a decisive significance to the feature of flying, which does not allow them to class as birds the domestic duck and hen which do not fly, and, on the other hand, tend to count among birds such insects as butterflies, beetles, etc. (data of M.S.Peterburgskaia, 154).

Similar facts derive from researches undertaken by the Herzen Educational Institute at Leningrad. Generalising these facts Shardakov [220] notes that it is characteristic of younger children in Classes I-IV that they characterise objects according to inessential external features and on the basis of their utilitarian or functional character ('the cow is a domestic animal, it gives milk', 'the starling is a bird because it sings').

It is obvious that all such cases of lack of differentiation and inadequacy of generalisation in children result from insufficient analysis and weak development of abstractive activity. The pupils single out those general features which either correspond to their previous experience or at once leap to the eye in perception of the object. These dominant features are widely generalised.

The consequent form of analysis, which is often a cause of the formation of inadequate concepts, is *elementary analysis*. Many children at the initial stages of learning tend to single out only some of the complex of features of a concept and this leads to incorrect synthesis—one-sided generalisation. In this case the features of the concept do not correspond with one another, systematic organisation of the concept is disturbed.

A number of researches into mastery of the concept of the root of words [15, 18, 152] have brought to light the phenomena of formalism and 'naive semanticism' in children. Formalism is indicated by the fact that in estimating the likeness of roots children direct attention only to similarities or differences in the letters constituting the word, and naive semanticism by the fact that they only consider the meaning of the word. In both cases generalisation is one-sided and therefore incorrect, since the children ignore the specific linguistic relation between the form and semantics of roots.

A similar phenomenon has been found by V.I.Zykova [76] in the sphere of mastering geometric knowledge. According to her data, when pupils first become acquainted with the properties of the circle they operate freely with the feature of the closed curve but do not use the feature of equal distance of all points of the circle from the centre so that they confuse such geometric figures as the circle, ellipse and

closed curve of irregular form. In other cases pupils take another feature as a criterion for grouping geometric figures—the presence of a point as the centre of the figure in an illustration. If two circles are presented of equal radius—one with a designated centre, the other without—many pupils think that the latter is not a circle because it has ‘no centre’.

Shardakov has also pointed to the one-sidedness of primary generalisation by pupils [220]. Though he does not allude to ‘elementary analysis’ as the cause of incorrect synthesis he has this phenomenon in mind when referring, on the basis of V.S.Ivanova’s research into mastery of conditional and temporary connections [80], to the singling out by pupils of some connections without recognising their differences and the bringing together of several connections in parallel without distinguishing the basic one. Here the one-sidedness of generalisation depends on taking one or several features as a basis for generalisation irrespective of their relations to others. Forms of elementary analysis have been found in many researches concerned with mastery of knowledge in different subjects—arithmetic [123], botany [105], reading [59, 222] foreign languages [183] and so on.

It is a characteristic of such generalisation, as the preceding material shows, that when concepts are applied only some of the ‘stronger’ features are acting, so that their action is incorrectly assessed in wider generalisation. The content of concepts is thereby narrowed—they are over-extended in some directions, limited in others. This uneven influence of different features of one and the same concept may be designated as *intraconceptual* generalisation. Thereby systematic construction of the concept is disturbed, an incorrect relation is established between its separate features; in other words the given concept is not mastered.

Another underlying cause of children’s mistakes is *interconceptual generalisation*. In this case too great an influence is exercised by one adequately mastered concept or rule on another, which indicates inadequate differentiation of one concept in relation to others. In psychology such cases are usually considered under the heading of incorrect transfer.

In this connection the question arises—what are the characteristics of the features which, according to experimental data, exhibit a ‘stronger’ tendency and evoke too wide generalisation?

Research into the formation of concepts in schoolchildren has brought to light innumerable facts indicating that such features are, first, inessential properties, perceived or represented by pupils through the senses; second, features that are to some degree associated by the pupil

with images and concepts formed in his inadequate experience of life; third, cases have been observed when incorrect generalisation arises as a result of frequent repetition of certain external conditions when applying the new concept in school exercises. We may select from a great deal of relevant research some typical examples.

Pupils of Class V (11–12), studying the geographical concept of the watershed ('the frontier between two parallel river beds'), were led to group specific cases under this concept not only by essential features indicated in the given concept, but also inessential ones: e.g. 'a watershed is at a low altitude'. When answering the question 'Is there a watershed in the range of the High Caucasus?' the pupils relied on this incidental feature and therefore answered the question incorrectly. In this case the inessential feature had a generalised influence because the pupils had a diagram depicting a watershed at a low altitude [85].

When pupils of Class VI (12–13), well acquainted with the definition of a right-angled triangle, were shown such triangles in different spatial positions they were often not only guided by the presence of a right angle but also relied on an external incidental feature—the presence of the right-angle at the base of the triangle. Therefore they failed to pick out as right-angled the triangles with a right angle above or on one side. This was conditioned by the fact that in the textbook and in diagrams drawn by the teacher and the pupils themselves right-angled triangles were usually represented with the right-angle at the base [76].

Interesting data relating to natural science derives from the experimental research of R.G.Natadze. He notes that the child has particular difficulty in mastering the essential features of a concept when visual aspects of the specific objects do not coincide with essential (non-visual) features. Thus, according to his data, pupils of Class I (7–8), after becoming familiar with the concepts 'mammal', 'fish', 'bird', 'insect', fail in relevant exercises; to take an example, they do not classify dolphins and whales as mammals despite the fact that the experimenter, when showing the relevant pictures, explains that these animals feed their young with milk, breathe air with the aid of lungs, etc. Only gradually, with the transition to Classes II and III, do essential non-visual features begin to predominate, though here it is noted that in difficult cases the children slide back to the 'phenotype approach'. Natadze holds that, in the child's cognition, the external aspect of the animal 'overshadows' the essential but non-visual features to such an extent that the child does not sense the contradiction between them [140].¹

Cases of 'naive semanticism', referred to earlier in relation to study

¹ For this paper, see p. 192 (Ed.).

of grammar and history, show that it is not only visual features that exercise a strong influence but also the thought content of speech as in concepts of rich and poor, i.e. certain elementary generalisations. In natural science a similar role is played by images of the edible nature and juiciness of fruit. Obviously this kind of generalisation of features acquires a 'signal significance' because it has played an important part in the child's previous personal experience and he understands the new concept in the sense that is most familiar to him.

The influence of frequently reiterating inessential features in the presentation of scholastic material has been mentioned in the data of Zykova, cited above, which notes, besides the influence of visual external features, that of repeated perception. There are many similar facts.

Pupils in the primary classes when introduced in grammar to the concept of the subject of a sentence are often guided by the fact that the subject takes first place in a sentence because exercises consist chiefly of such sentences [167]. Similarly in syntactical analysis a purely external circumstance, such as the number of words in a phrase, often exercises an influence. In this case pupils do not count as a sentence any phrase consisting of less than 3–4 words [150]. In forming the concept 'preposition', a widely generalised feature is the shortness of the word, so that prepositions are often confused with pronouns, conjunctions and particles [65].

Cases of inadequate analysis and synthesis, already referred to, are the result of inadequate abstraction. The distinguishing of essential features of concepts or properties of objects is hindered by the fact that these fail to correspond with the data of sensory perception or with everyday images. The visual nature of material or the similarity between inessential features of scientific concepts and everyday concepts have forged the pupils' generalisation, exercising an inhibitory influence on the process of abstraction.

It must be noted, however, that not all pupils of the same age, in the same class, exhibit inadequate forms of analysis and synthesis. The mistakes outlined above are characteristic of less developed, less able, pupils. Obviously pupils who successfully cope with their work depend to a lesser degree on sensory data and on associations established earlier which bears witness to more developed forms of abstraction and generalisation.

Promoting abstraction and generalisation

Important practical questions arise here. How can pupils whose processes of abstraction and generalisation have not reached an adequate level be assisted? What conditions should be introduced in teaching to facilitate

their intellectual activity and save them from mistakes? Many researches have recently been undertaken, in relation to different school subjects, directed to noting some of these conditions. Among them are use in the process of teaching of comparison, in the form of counterposing objects confused by the pupils, and recognition of the principle typical variants of inessential features.

The importance of comparison in teaching has long been recognised in both psychology and pedagogy. Most pedagogical researches have, however, emphasised the use of comparison to single out and unite common features and properties. The abstraction of common features of concepts or objects is of course a necessary prerequisite for the formation of any concept, as has already been suggested. But hitherto pedagogics has thrown no light on the importance for correct abstraction of cognition of typical features of different phenomena studied. Here full account must be taken of the propositions advanced by Pavlov and other physiologists as to the effective conditions for differentiation.

Differentiation, according to Pavlov, is none other than the inhibition of every accidental coincidence through the formation of inhibitory negative connections. Investigating the formation of habits in animals V.P.Protopopov and his colleagues have established [163] that the period of accidental mistaken attempts to solve problems is significantly shortened when the animal acquires experience *of what it is necessary to do and what is unnecessary*. The means leading to inhibition of mistakes by the formation of temporary connections is designated by Pavlov as that of *alternating counterposition* [151:iv, 129].

Psychological research has shown that Pavlovian methods of counterposition provide conditions which are as favourable to the elaboration of differentiation in the second signal system in the case of man as they are in relation to the first signal system in the case of animals. L.A.Shvarts [221] found, in relation to orthography and art, that children confuse rules which are similar in inessential features only when the juxtaposing and differentiating of aspects of the material which should inhibit each other is limited in the teaching; on the other hand, confusion is avoided if such juxtaposition and differentiation takes place. N.A.Menchinskaia, in the course of research into mastery of arithmetic, came to the conclusion that a necessary condition for the grasp of general rules is variation of inessential features of the material presented and constancy of the essential features [124].

A further theoretical development of the question of counterposition is to be found in the work of E.N.Kabanova-Meller [85, 86]. She emphasises the importance of generalised cognition by pupils of the

character of inessential features, which, parallel with cognition of the essential, is the shortest way to correct generalisation. In this connection she suggests that pupils must cognise the principle variants of typical inessential features. Research relating to the positive role of counterposition has been concerned with various school disciplines: arithmetic [115, 155], geometry [76], orthography [64, 17], history [39], grammar [80, 149, 169]. In some cases researchers organised experimental teaching to check the efficiency of teaching according to the principle of counterposition when applied in the usual conditions of class work; this achieved significantly better results than the usual methods.

A question of great practical importance is the stage in the study of concepts and rules at which the method of counterposition should be used, i.e. to what extent should mastery of one rule be reinforced before going on to another. We may note here the 'principle of early differentiation' which holds that counterposition produces the greatest effect the more closely it is combined with the first moment of familiarisation with the first rule [17].

The data of special research by A.V.Poliakova [159] uphold this proposition. It shows that the introduction of counterposition of a rule has the greatest effect after the first rule has been introduced and reinforced by a certain number of exercises. However this question calls for further study in relation to the confusion of similar concepts and rules.

All that has been said leads to the conclusion that since the method of counterposition is the most economic way of eliminating mistakes by pupils in the formation and application of concepts to practice, the pedagogics of this question cannot be ignored, the more so since for the systematic application of this method there must in many cases be a review of the successive steps in a syllabus and of certain methodological principles of teaching.

Image and Word

As has been seen the intellectual operations of abstraction and generalisation are of great significance to the process of mastering knowledge. It is clear that the level of these operations depends to a large degree on the character of the material analysed. It is, therefore, not surprising that there has recently been much research into the interrelations in the process of mastery of the sensory and the abstract, the image and the word.

By contrast with formal dialectical logic the process of cognition is at once a sensory, rational and practical process. Sensory cognition, acquired in the activity of man with objects, reflects particularly

correctly the features common to different objects, even in those cases when what is common cannot be generalised on a verbal-logical plane. This is designated in psychology as *practical generalisation*. It ensures correct generalisation of actions with a specific range of objects in the absence of cognition of the regularities underlying these actions.

According to the data of some psychologists these characteristics of practical generalisation depend on an incomplete form of abstraction, according to which the abstracted features are not separated from the given object or phenomenon but are noted in its constitution. As a result when a number of objects are compared their common features may be noted which, in the given conditions, allows for the same kind of action in relation to each object. Generalisation at this level of abstraction proceeds on the basis of analogy (from the particular to the particular) which permits of separation and classification of objects and phenomena.

Similar abstraction *in concrete* (the term used by G.Ia.Troshin [212]) underlies, according to Bogoiavlenski's data [17], the 'sense of language' which is formed during the mastery of speech by children and later appears in the formation of orthographical habits. The concept of abstraction *in concrete* is also constructively used by S.F.Zhuikov [63] in analysis of the structure of elementary grammatical generalisations. In view of the important role played by practical generalisation in the mastery of knowledge psychologists should be attracted to further work on this question.

However, the peculiarity of cognitive mastery of knowledge consists in the fact that, using some action on the real or intellectual plane, the pupil must give himself an answer as to *why* he acts in this way and not another. This possibility arises only with the transition of practical generalisation to the verbal-conceptual plane, because to cognise any abstraction from the whole image of a single object is only possible by means of the word which itself abstracts from reality and permits of generalisation.

Abstraction, which singles out some aspect of an object actually inseparable from it, is 'removal from reality'. But abstraction which correctly reflects reality always preserves direct or indirect connections with the source of all knowledge—sensation and perception. In Pavlovian terminology such reflection requires correct relations between the work of the first and second signal systems.

As the many facts already given about incorrect generalisation show, such correct interrelations are not easily established by children. In the process of mastery of knowledge relations between the sensory and abstract elements are not always cognised by pupils in the same way and

generalised. Some research has assisted in establishing the dynamics of this process.

A.I.Lipkina [116, 117] investigated the interrelation of these aspects of thinking at different age levels. She found that children in Classes I and II could not formulate the essential meaning of a text (when told to think out sub-titles) until they had described in words pictures shown to them in connection with the story that had been read. With pupils of Classes III and IV the correlation between the image and generalised aspects of thinking activity changed. They could formulate the essential ideas in a text without previous depiction of the ideas in pictures. Despite this, the verbal plane exercises only an insignificant influence on the pictorial (in both cases only the subject content of the story was fixed). The two planes of action are, therefore, dissociated. The seventh class composed on the verbal plane without any preparation through 'thought drawing'. Their pictorial plane was little differentiated from that of the fourth class but on the verbal plane there appeared new elements testifying to the development of the generalised aspects of thinking (evaluation of judgments and causal explanation of the events).

In Classes IX and X the elements of logical thinking predominate. This is shown not only in content on the verbal plane but also in that in composition on the pictorial plane the pupils 'move away' from description of the content of the text to analysis of it. This establishes that the verbal plane influences the process of differentiation and detailisation of children's images.

Lipkina concludes that the image and generalised aspects of thinking are developed in complex interaction and that if with primary children the image is evoked as a necessary factor aiding the singling out and generalisation of essentials, then in the activity of pupils of higher classes verbally formulated ideas to a large degree determine the character of the image.

Many other researches have confirmed the fact of the interdependence of verbal thinking and imagery in the process of development of cognitive activity. Imagery has the most importance in the figurative arts; experimental study of the psychology of child art has, however, shown that images are always clarified and supplemented in cases when the child gives a good account of the object represented (E.I.Ignatiev [81, 82]). The fact that there is a clearly marked connection between historical images and logical thinking is shown in the work of A.Z.Redko [165]. Thus, for instance, with the aid of illustrations, general images of the ancient Egyptian plough are formed with comparative ease, but pupils make mistakes in drawing parts of the plough so long as they do not understand its work and the functions and relations of its different parts,

The mutual influence of word and image in cognitive processes has also been dealt with in researches concerned with pupils in special schools. These have shown how explanation of a drawing shown to the children influences subsequent changes in imagery, what part the inclusion of speech plays in the examination of a picture, the characteristics of images formed by means of verbal portrayal, etc. [146, 147]. There has been special study of the interrelation of the verbal and the visual, both on the plane of psychology and didactics, under the direction of L.V.Zankov [70].

In all these researches the broadening of sensory experience appears as the condition for abstracting essentials and the basis for breadth of generalisation. In addition verbal thinking enables the detailising and systematisation of perception and imagery. In the process of teaching the teacher's words organise the pupils' observation towards the precise object under observation, direct analysis to differentiating essential from inessential aspects of phenomena, and finally, in verbal terms, associate those features singled out as common to a whole series of phenomena establishing their generalisation—as a concept. Such a concept, standing for a number of concrete objects and phenomena, can itself serve as a basis for further generalisation without recourse to observation. So there are created concepts of different degrees of abstraction and generalisation. But however abstract a concept its source is always the direct experience of man, his practical or intellectual activity in relation to the real world. Only in such conditions can abstraction have a scientific character, penetrating widely and deeply into the essence of phenomena. In the contrary case there may appear what Lenin called 'empty and nonsensical' abstractions.

The transition from abstract thinking to practice

In contemporary psychology research into stages in the formation of mental actions on the basis of external practical activity takes an important place. This has been generalised by P.Ia.Galperin in *The Development of Research into the Formation of Intellectual Actions* published in the first volume of *Psychological Science in the U.S.S.R.* (1959).

Mastery of abstract concepts is not, however, the final link in the acquisition of knowledge. In Lenin's formula, 'from living creativity to abstract thinking and from that to practice', the second part—from abstract thought to practice—is no less important than the first. It becomes of particular importance with the development of polytechnical education.

Some observations and data derived from research deal with the psychological formation of the transition from abstract thinking to practice and the very great difficulties which sometimes confront pupils

in this connection. Vygotski was referring to these when he wrote: 'the greatest difficulty, which the adolescent usually overcomes only at the very end of this transitional age, is the further transfer of thought or knowledge elaborated in concepts to new concrete situations which he has thought about also on the abstract plane. This transition from the abstract to the concrete is as difficult as was the former ascent from the concrete to the abstract' [35].

Despite the importance of this question it has as yet been the subject of little experimental work but there has been research which throws light on some of its aspects.

E.A.Fleshner [216] set pupils of the older classes four groups of problems in physics: (1) textbook problems of abstract content, (2) textbook problems with a more concrete content (including specific magnitudes), (3) visual-active problems of abstract content, (4) visual-active problems of a concrete content. The problems with an abstract content (1) and (3) could only be solved through the use of theoretical knowledge about functional dependencies between the weight and volume of bodies. The concrete tasks (2) and (4) could be solved as theoretical problems by determining the volume of each body and then comparing them. According to the author's findings the problems of visual-active nature with a concrete content (4) were executed worst, textbook problems with a concrete content were more easily solved (2), and finally the problems solved most easily were those with an abstract content (1) and (3).

In one of Zykova's researches pupils of Class VI were set a single geometrical problem (on the basis of a theorem with which they were familiar—to determine the longer side of a triangle according to the opposite angle) but in one case a corresponding diagram was attached, in the other a triangle of the same size and form was depicted as two sides of a roof resting on the walls of a building. The pupils easily performed the first task but had difficulty with the second. One subject clearly explained the cause of his difficulty: 'It's difficult, here (i.e. in the usual school problem) there is a triangle, but there—a roof and walls, this is why I got muddled.'

Similar data was obtained by Iakobson in relation to drawings by pupils of Class VII of a projection of a crane or excavator. Even though the instructions included the indication: 'remember the levers and the shoulders of the levers', 'remember the transmission by the blocks', some of the pupils did not recognise the cabin of the excavator as part of the shoulder of the lever. They arrived at the need for abstraction only after comparing the separate elements in the drawing in the textbook—a schema of the corresponding parts of the excavator [232].

Fleshner ascribes difficulties in solving the two kinds of physical problems to the fact that in textbook problems the relation between two sets of physical data is given to the pupils in a *readymade abstract form*, in the form of abstract concepts which the pupils were accustomed to using in physics lessons. Solution of the visual-active problems, on the other hand, required *independent abstraction* of special features from concrete data. In this case, as she points out, there arises a 'doubly charged' difficulty: the pupils must separate out the abstract relations of the concrete data and distinguish these from their visual perception of the object in question. This factor of 'readymade' abstraction exercises its influence also in the case of Zykova's subjects doing geometrical problems with the normal diagrams since the diagrams depict concrete objects in a simplified systematised aspect; the drawing of part of a building, however, requires independent analysis of concrete material and abstraction from it of inessential details. This same difficulty was observed by Jakobson.

This data clearly establishes that limitation of the visual to schema and drawings of machines and tools in teaching polytechnical disciplines, though aiding an understanding of their structure, cannot fully ensure active knowledge. The same may be said about the use of the blackboard in teaching geometry, etc.

The difficulties of making the transition from abstract thinking to practice are not, however, insuperable. To overcome them pupils must be given systematic practice in applying theoretical knowledge to the solution of everyday, practical tasks; concrete situations must be utilised while the abstract concepts are being formed so that the concepts established are mobile and active. The way the pupil makes the transition from the abstract to the concrete depends, therefore, to a considerable degree, on methods of teaching in the period of mastery of abstract knowledge.¹

The systematisation of knowledge

The process of mastering knowledge is not, however, limited to the mastery of concepts and the differentiation of some from others. Knowledge consists chiefly in systems of concepts the mastery of which establishes certain connections and relations between concepts. Research into the process of acquiring knowledge cannot, therefore, be limited to study of ways of differentiating concepts; no

¹ In this connection it is necessary to correct Vygotski's supposition that the transition from the abstract to the concrete is solely connected with the age-characteristics of the adolescent. This implies a limitation of the potentialities of children in earlier age-groups which data relating to the influence of the content of material mastered and methods of teaching show to be incorrect.

less important is an explanation as to how pupils form associations between concepts, form *systems of connections* reflecting the relations between objects and phenomena of the real world.

The mastery of systems of concepts is of first importance to the development of thinking. Vygotski noted that concepts mastered by pupils can only be fully cognised in their relations with other concepts and that the formation of hierarchies of concepts, established on the basis of relations of generality, the relations of *co-ordinated concepts*, is of universal significance in the development of thought [35].

Recent research has produced facts upholding this position. Thus Zykova has shown that separate concepts about angles in geometry (adjacent, vertical, etc.) are mastered with more understanding when they are included in the wider concept 'angles with a common apex' [74, 76]. Redko [166] has shown that concepts about the constitution of different classes ('slave', 'slave-owner') only achieve full development when the higher concept of a 'slave-owning system' has been formed, based in its turn on existing knowledge about the constitution of different classes.

But there is more to the systematisation of knowledge than logical systematisation. Corresponding to the many-sided character of relationships in the real world are many-sided relations between concepts which join these into systems (spatial, temporary, causal, etc.).

The research of V.V.Bogoslovski [14] and M.N.Shardakov [220] concerned with pupils' understanding of causally consequent connections distinguishes elementary and logical levels of causal explanation. It is characteristic of the elementary level that pupils designate only one cause of the given phenomenon or one consequence of the given cause, and that the cause and consequence indicated are often external and secondary. In mastering historical laws the children confuse cause and effect. At a higher level pupils begin to designate a number of causes. However, these causes are taken together; either partial causes are not distinguished from the general causes which unite them, or the pupils point out partial and general causes without connecting them with each other. Later pupils begin to understand the interconnection between partial causes, but do not, however, differentiate general from partial causes. Separate partial phenomena now find a correct explanation but the pupil's thought does not reach to generalisation and the formulation of general laws or rules. According to the degree of accumulation of knowledge and development of thought the pupil begins to abstract essential causal connections in different phenomena and proceeds by induction to establish general laws or rules.

Research into pupils' understanding of the relations between living plants and environmental conditions, undertaken by E.M.Kudriavtseva [106] permits the noting of some additional characteristics of the process of systematisation. The author distinguishes different types of causal explanation in dependence upon stages of concretisation.

In primary classes studying botany causal explanations of the necessity of each component of the environment (soil, water, sun) for the life of plants are common and rest on differentiation in everyday observation. ('Earth is needed because without it the plants wither, dry up'; 'Because I have seen flowers planted in soil'.) More differentiated explanations are observed in pupils of Classes III and IV. They are usually given in the form of general opinions without reference to particular observations. ('Because plants can't grow without soil anywhere'; 'Because plants always live in soil'.) Here there is wider generalisation but genuine causal explanation is lacking. According to Shardakov's material causal explanation begins with the establishment of particular relations between plants and the environment. ('Soil is needed because it has moisture.'). A correct indication of the conditions for the growth of plants is here given but this dependence is understood in an undifferentiated and simplified way. With the systematic study of botany in Classes V and VI the pupils' causal explanations begin to include generalised elements of knowledge and their differentiation from concrete knowledge. ('Because plants take nourishment from the soil—water and mineral salts.'). The content of causal explanations is therefore changed from a general undifferentiated enumeration of a onesided character into an explanation of the generalised causes of plant life each of which is specifically singled out. The establishment of causally-consequent relations between concepts leads to the formation of systematic knowledge.

Attempts have been made to classify systems of associations by Iu.A.Samarin [184, 185]. He separates associations into 'local', or 'single line', connections between different phenomena which do not belong to a system of these phenomena; limited system associations within the bounds of a given theme or chapter of a textbook; intra-system connections consisting of a systematised series of associations according to some principle (for instance, relations between historical events according to time); inter-subject or inter-system associations, establishing relations between different branches of knowledge. The author notes that the order of this classification corresponds to basic stages of difficulty in systematising knowledge. The difficulties in forming inter-subject connections have a particular relevance to the formation of a general outlook. Without special exercise in the

comparison of knowledge from different branches inter-system associations are not formed. Though in research of this kind the psychological aspect of the process of systematisation has not been fully revealed, the classification of systems of connections undoubtedly constitutes a step in this direction.

The methodological aspect of the formation of systems of connections has been dealt with by research workers of the Leningrad Institute of Education [6, 30]. Their work emphasises the importance of the principle of ordering the knowledge mastered by pupils in the syllabus of a given class and particular aspects of the transition from one class to another. In the light of this an analysis has been undertaken of school programmes and textbooks to establish the most rational succession of concepts in the school course and the possibilities of comparing and bringing together knowledge from different school disciplines.

The psychology of the formation of systems of connected concepts has been less fully dealt with than that of the formation of concepts. The data we have, however, show that in the general process of mastering knowledge two kinds of problem may be singled out. One of these is connected with the process of differentiating separate concepts, with avoiding the confusion of concepts similar in inessential features; the other problem, on the contrary, relates to the bringing together of separate concepts in a strictly scientific system—a process involving the development of traits of dialectical thinking permitting the pupil to see objects and phenomena in their different connections and relations. At a higher stage of development a similar synthesis of thinking activity results in the formation of a general outlook. This last requires special investigation.

Problem solving

The attention of many researchers in educational psychology has been drawn to the question of problem solving since this is a very important part of school work. It is precisely in the process of problem solving that pupils learn to apply knowledge. This aspect is prominent at all stages of learning—in the presentation of new material, in the reinforcement and deepening of knowledge. In addition study of problem solving throws light on the characteristics of pupils' thinking activity, their mental actions. The most widely studied process is the solution of mathematical problems in arithmetic and geometry. Recently research has been directed to analysing the process of problem solving in physics and in performing technical tasks.

Research has brought to light some characteristics of thinking in the process of problem solving common to particular spheres but has shown

in addition that particular material leaves its imprint on the thinking activity concerned, making it of a specific kind.

Problem solving has been studied from the following different points of view: characterisation of the intellectual operations used, chiefly analysis and synthesis; study of the formation of methods of analysis and synthesis applied at different stages of learning and in relation to material of different levels of difficulty; assessment of successive stages in mastering methods of problem solving, and, in particular, of the relations between concrete and abstract components of thinking activity. There has also been study of the cognising of actions in problem solving; the role of naming the typical actions used, etc.

A number of researches (by N.A.Menchinskaia [123] and Z.I. Kalmykova [94] relating to children and E.K.Andreeva [9] and V.K.Bubnova [27] relating to adults affected by injuries of the brain) have clearly indicated two basic types, or levels, of thinking activity in the process of problem solving in arithmetic (around which are grouped many intermediate stages). This means that it is necessary to bear in mind that different levels may be found in the same pupils depending on the degree of difficulty of problems.

The lower level is characterised by the following: general lines for the solution of the problem are entirely absent, the conditions of the problem are broken down into familiar partial tasks so that each is solved in an habitual way without cognition of the conditions as a whole; there is a fixation on some of the most frequently used ways of thought. There takes place, therefore, an actualisation of well reinforced methods of solution, i.e. synthesis is used without adequate analysis of the conditions of the problem.

This phenomenon finds clearer expression in cases of pathological disturbance of cerebral activity. In this case methods of action are not determined by the conditions of the problem (as a whole) but, on the contrary, habitual methods of action lead to a reconstruction of the conditions of the problem. This fact is also noted by I.M. Soloviev in study of intellectually backward schoolchildren. He notes that if the child does not find himself in a position to change and adapt his knowledge to the conditions of the task set, he 'changes the conditions of the task, adapting them to his potentialities' [201:163]. M.I.Kuzmitskaia has also studied pupils of special schools and noted that a similar transformation of the conditions of problems often takes place along the lines of reproduction of the conditions of formerly solved problems [108].

The higher level, by contrast, is chiefly characterised by the presence of general lines of solution of a problem. With this is connected a search for methods of solution and the application of various forms of analysis

and synthesis. If synthesis is used as a probe, then it at once becomes clear whether it is *necessary* to know this and whether it is *possible* to know it, i.e. the probe corresponds to what is sought and what is given in the conditions of the problem.

More or less complex problems can be solved only through 'complex' analysis, analysis which takes in not separate elements of the conditions but all of them together. In this case the pupils, intellectually mastering problem solving, do not confine themselves in their analysis at each point only to those data which must be dealt with, but foresee the further course of solution (Kabanova-Meller refers in this case to 'foresight' [86], Menchinskaja calls it 'anticipatory analysis' [123], N.I.Zhinkin 'planned synthesis' [61]). These different terms cover the same phenomenon, which is essential to a characterisation of the analytic-synthetic activity of thinking. It is also characteristic of the higher level that pupils are able to abstain from utilising the most habitual methods and do not turn to them until they have made an all-sided analysis of the conditions of the task.

Research has shown that these basic characteristics of levels of solution apply not only to arithmetical problems already referred to, but also to problems in other spheres. M.M.Vakhrushev has found these levels in studying the solution by pupils of syllogisms [29]. According to the data of Kabanova-Meller [86], Zykova [76], A.V.Stepanov [205], F.N.Gonobolin [42], L.N.Landa [110] similar levels are to be found in geometrical proofs and the solution of geometrical problems though here they are specific, conditioned by the presence of diagrams.

Kabanova-Meller differentiates the 'constructive' method of solution (use not only of full analysis of conditions but of conditions as it were 'expanded', since from them conclusions are derived and diagrams are varied according to the problem) and the opposing 'reproductive' way of solution (characterised by 'connection' of the given formulation of the question with the data of specific diagrams). Similarly Landa established how pupils of Class VIII use these probes in seeking a solution of problems. At the lower level there is a greater number of probes ('descriptive probes' and 'probes of supplementary construction') but they are not usually motivated and pupils do not know what they must achieve as a result of their use. At higher levels analytic-synthetic operations take the form of a system, and supplementary construction is motivated and directed to sorting out those principles which derive from analysis of the conditions of the problem.

Analogous levels have been found in relation to problems in physics and technology which require practical actions for their solution. Fleshner, studying problem solving in physics by children of Class VI

[216], distinguishes three groups of pupils according to qualitatively different types of solution. The first of these attempts one habitual method of solution and when this does not lead to any result ceases to try; the second group performs a number of probes, analysing the conditions of the problem in various directions, but these are not motivated and the pupils have no answer to the question as to where they lead ('it may be useful', etc.); finally, the third group makes an all-round analysis of the conditions of the problem and only subsequently resorts to practical actions.

According to the data of Iakobson, who studied the process of assembling mechanisms by pupils of Class VIII [232, 233], at the lower level of solution the pupil does not study the preliminary verbal instructions but immediately turns to manipulation of the components, performing many unnecessary probes. By contrast the higher stage is characterised by analysis both of the instructions and of the components and by preparatory planning of actions. The levels referred to are distinguished from each other not only by the character of analytic-synthetic operations but also by a different correlation of the visual-active and abstract components, and the different part played by speech in the process of problem solving. In the solution of constructive technical problems the role of the word is particularly clearly in evidence; in some cases actions are performed before the verbal instructions have been analysed, in others actions are checked and only carried through after the basic points in the instructions have been analysed and a thoughtful plan of action noted; practical probes, however, nearly always precede the verbal formulation of a proposition or recall of known laws.

The same correlation of the concrete and abstract aspects of thinking activity also occurs in relation to problems which do not include practical actions, but in this case the concept of an action acquires another sense. Menchinskaia [123] has studied this question in relation to arithmetical tasks and traces the continuous change in the relation between concrete and abstract components in thinking in the case of pupils studying arithmetic in the primary and middle school. At the initial stage, which pupils of Class I usually pass through quickly, the process of problem solving leads to use of specific actions with objects. In this case speech plays little part since it is limited to naming figures in data and results. Later action with objects gives place to action with numbers, beginning with abstract numbers and going on to naming numbers of objects. Arithmetical actions are accomplished before there is reasoning about these actions, according to the way in which a question is formulated.

These facts disclose an important regularity in thinking activity. In the course of learning, one and the same element of knowledge *changes in function*; while at one stage it appears as abstract knowledge resting mainly on visual processes (counting at first rests on actions with objects) at later stages it is established as concrete knowledge and serves in turn as a support for mainly abstract thinking operations. (Primary pupils can give a numerical result in words after this has been demonstrated to them.) In older schoolchildren, as with adults, who have acquired the skill of problem solving, a quite different interrelation between actions and the theoretical aspects of solution is observed. They do not produce any numerical operations until there has been an exhaustive analysis of the conditions of the problem on the plane of internal speech, until they have dismembered the concepts included in the task and found regularities in it. (A similar characterisation of different methods of analysis applied by adults has been made by E.I.Kalmykova [92].)

Many researches (N.F.Talyzina [209], N.K.Indik [84], A.N. Sokolov [203], L.P.Doblaev [51]) show that a 'theoretical' solution which is itself expressed as a judgment is in turn made up of two parts—'substantiating' and 'operative'. The latter term (introduced by Shevarev) is applied to a proposition which defines how it is necessary to act. In the course of learning, both these aspects of judgment are evoked in an interrelation approximately similar to that found characteristic for visual-active and 'theoretical' elements of knowledge. In the solution of problems the substantiating part of a judgment is of a more or less differentiated character.

Research concerned with analysing pupils' difficulties in mastering different forms of substantiation also shows how these may be overcome. It has shown that development of the skill of substantiating solutions depends directly on the degree of difficulty of scholastic material. Thus, for instance, pupils of Class V have already mastered this skill in relation to arithmetical material whereas in geometry it is barely established. The research of Zykova and Iu.V.Rusov [180] shows that at the initial stage of problem solving in technology, pupils make sketches and only later reason about technical principles, so that they first acquire the skill of formulating the course of construction and only later substantiate, clarify, why they design one figure and not another. In the course of learning the skill of substantiating technical principles is gradually acquired according to the way technical tasks are performed in practice. Research, therefore, reveals a number of methods of mastering abstract thinking in problem solving. In addition, it demonstrates (what is no less essential) the development in the course of learning of concrete thinking in problem solving.

Two tendencies in the development of thinking should be noted—towards higher abstraction and towards richer concretisation. (These, noted earlier in relation to the mastery of concepts, are equally relevant to problem solving.) In Class I, as has already been indicated, children learning to solve problems begin by using actions with abstract numbers and only later with concrete numbers. This fact deserves particular attention since it indicates a specific regularity. This stands out particularly clearly in the problem solving of intellectually backward children which has been specially studied by I.M.Soloviev [201]. As he notes, when solving problems with numbers, intellectually backward children operate without grasping their concretisation; as a basis for the process of solution they rest on some ‘schematic standard of verbal-numerical relations’ [201:174] worked out during their school experience. The same tendency, though less prominently expressed, is indicated by the numerous mistakes made by pupils in normal schools when designating quantities in problem solving, as well as in their mistakes in the solution of standard problems [108, 123].

At all stages of learning the presence of actual images of objects and actions, described in the text of the problems, may exercise a decisive influence on success. In the primary classes a support for imagery is necessary for the solution of all arithmetical problems, with older children and adults the use of images is required for the solution of problems of a specific structure. It is a question here of rational use of images, of ‘reducing the image load’. Lightening the burden of detail may interfere with solution, distract from basic aims cf. for this 94, 123).

In problem solving in geometry and geometrical drawing the development of images (above all spatial images) and ability to operate with them is of first importance. Here what is required of the pupils is a reorganisation of figures in the head, the drawing of new figures reshuffling visual and imaginary elements and shapes, comparison of elements seen with those imagined, etc. (The formation of spatial images and operation with them is referred to in many researches: 36, 89, 119, 133, 180, 193.)

On the basis of studying the intellectual operations which produce successful results, many researchers suggest that children might be specially taught rational methods of problem solving, emphasising that these methods (for instance, all-round analysis, variation of methods of analysis, actualisation of images, etc.) can be formulated by the teacher, brought to the consciousness of the pupils and specially formed, i.e. incorporated in habitual methods of thought. Researchers underline the generalised character of these methods, the possibility of bringing them

to bear in widely different tasks. From this point of view the existing practice of teaching problem solving is subjected to critical analysis and the experience of the best teachers, which leads to education in effective methods of thinking in problem solving, is generalised (cf. 45, 76, 94, 110, 123, 180, etc.).

As research has shown, very varied methods of problem solving reflect the complex interrelations between concrete and abstract intellectual operations, whereby methods of analysis and synthesis, abstraction and generalisation, are realised and new connections and systems of connections formed. In addition the formation of new connections only takes place as a result of the actualisation and reorganisation of associations formed in previous experience. Numerous researches have emphasised and concretised the proposition advanced by Sechenov in *Elements of Thought*: 'Not a single thought passes through a man's head in the course of his life that does not consist of elements registered in memory. Even apparently new thoughts, such as those underlying scientific discoveries, are no exception to this rule' [194:441].

The formation of habits

In study of the processes of learning, 'problem solving' and 'habits' have been found to resemble each other considerably more than is usually postulated in general psychology. This is because in the process of learning we constantly have to do with changes in the specific forms of both problem solving and habits whereby the former may itself become a habit. While in solving problems the means to solution of which are unknown processes of complex analysis and synthesis are characteristic (with the presence of 'probing' operations), in the solution of more familiar problems of a specific type analysis and synthesis take place already in the process of perception of the conditions of the task [94, 123]. Many intermediate forms have been observed in the process of learning which allow us to speak of different skills or 'habits' in problem solving.

In the theory of habits now current Ushinski's proposition as to the 'intellectual' origin of habits, their formation as the gradual automatisisation of actions, retains full force. In the light of this theory habits are characterised as the automatised component of any action.

The concept of activity in general psychology has exercised a vital influence on the theoretical approach to the problem of habits. It has ensured that the attention of researchers has been directed to studying structural peculiarities in the formation of habits [47, 113, 114]. According to the data obtained it must be the special aim of teaching to

impart a method of using actions before they become automatically used 'operations', and this must be taken to the stage of conscious regulation of the process. According to the degree of elaboration there is a conjunction of separate partial tasks and a number of partial operations in the one complete task which is directed towards another aim. Partial operations included in a more complex action cease to need conscious control, as a result of the direct connections established between separate links of the complex action the psychological structure of activity is simplified and there takes place a process of 'abbreviated' discursive thinking. A distinguishing feature of such 'conscious' habits is the possibility, in case of need, of transferring them anew to the level of conscious control.

Stages in the formation of habits in different spheres of knowledge are specific to these spheres and have been dealt with in many special researches: in relation to reading [5, 181, 182, 222], writing [46, 48, 213], arithmetic [123], orthography [17], etc.

One of the most important aspects of the psychology of habits is the *problem of repetition*. As is known, there is a theory widely accepted abroad according to which habits are formed as a result of mechanical repetition of the same action (Watson, Thorndike and others); thus the basic conditions for the formation of a habit are held to be frequency of repetition of the basic connection between 'stimulus' and 'response'. Soviet psychologists also take into account that repetition is a necessary condition for the formation and reinforcement of associations, but according to their data the act of repetition itself represents something much more complex than repetition of the direct connection between stimulus and response. Several psychologists have pointed out (S.L.Rubinstein [170], L.M.Shvarts [222], and others) that repetition in the process of exercises leads not to reinforcement of the initial methods of performing actions but to their improvement, that an action repeated is not a copy of the preceding action at all points and that there are sometimes quite radical changes. A similar phenomenon takes place in the process of thinking out the performance of actions, when the initial means of performing them is reorganised.

Pavlov's theory of the reflex nature of mental phenomena permits a more precise and specific statement of these propositions. First, in the formation of new connections repetition does not lead to the mechanical reproduction of initial reactions, usually widely irradiated, but evokes differentiated inhibition of the non-reinforced components of stimuli, which leads to a changed reaction to one and the same 'stimulus' in the form of greater specialisation. In man similar changes take place under the regulatory influence of the second signal system.

Second, there is repeated in exercise not merely excitation ('stimulus') and response but a reflex act as a whole, i.e. an act, in the central link of which there takes place complex analytic-synthetic activity of the cortex. This means that, as applied to man, the positive effect of exercise does not only depend on a repetition of visual perception or verbal excitation; it also depends on repetition of analysis and synthesis in thinking directed to correcting the initial reaction, as a result of which correct connections are reinforced and the incorrect are 'cancelled'.

It must be concluded, therefore, that when exercises are correctly organised, methods of using actions which are consciously employed by pupils and repeated are improved and reinforced; this leads also to the 'working out' and reinforcement of specific mental actions corresponding to the character of the task and the peculiarities of the material.

In the process of exercises, initial methods of action in 'probing' for means to the solution of a problem become more precise, are improved and in the last analysis only those 'courses of thought' and motor reactions are reinforced which lead most directly and effectively to solution of a problem or performance of an action. As a result tasks which were formerly 'problems' for the pupils are solved at once without extended links of judgment and deduction.

The fact that the formation of mental actions is characterised by a similar 'abbreviation' of thinking operations has been brought to light by many psychologists. Thus Vygotski noted that the development of mental actions leads in the last analysis to a dropping out of the separate links in the process of reasoning [35]. Shevarev, writing about aspects of associations, singles out special 'correctly-formed associations' the actualisation of which leads to action in accordance with a rule, though the rule itself is not cognised [224, 225]. Menchinskaia, studying problem solving in arithmetic, comes to the conclusion that automatization of thinking operations means abbreviation of the process of reasoning up to the point of complete exclusion despite the fact that reasoning continues to underly the performance of actions [124]. Galperin considers the stage of abbreviation to be one of the 'parameters' in the formation of mental actions [37, 38].

All researchers agree that mental actions result from conscious mastery of intellectual operations at the preceding stage of learning. But the question arises as to how the process of abbreviation of intellectual activity takes place. What causes abbreviation of the process of reasoning to take place, through what stages does it pass in the conditions of learning? N.K.Indik's research is concerned with these questions [84].

The theory that there are two psychologically different elements in the structure of reasoning leading to problem solving—‘substantiating’ and ‘operative’—has already been referred to. Substantiating judgment is the general theoretical proposition which is cognised by the pupils as basic for performance of successive parts of the action and answers the question, *why* it is necessary to act in one way and not another. In his research on problem solving, Indik assigns as operative elements of reasoning those which answer the question, *what* must be done and *how* to do it. These elements are closely connected with the executive parts of the action, i.e. partial operations which realise the general theoretical proposition as applied to the conditions of the given task. In the solution of complex tasks the process of reasoning is broken down into a series of links corresponding to the auxiliary operations which must be performed in solving the problem as a whole. Substantiating and operative judgments are then observed in each such link.

The author describes the gradual formation of mental actions in the following way. At first learning perfects all the links of deduction, descending from the more general proposition to the more partial. Each link in problem solving requires extended reasoning, the transition from one link to another requires meditation and deliberation. Each action is produced as a result of cognising the underlying theoretical proposition: as a result of carrying out the action the pupils learn *why* it was necessary to perform it in this way.

In the course of further learning the structure of reasoning changes in the following directions. First, there is a joining of separate links into a whole action, the transition from one link to another is now easily accomplished and finally there takes form between the executive parts of the first link and the substantiating elements of the second a direct associative connection without breaking the course of reasoning as a whole. Second, the substantiating part of reasoning becomes much less extended. This is reflected both in temporary indications and in a gradual deverbalsation of reasoning; above all in the laconic judgments of the pupils which begin to reflect only the essence of what regulates the carrying out of actions.

At the final stage the process of reasoning is maximally abbreviated and actions follow one another in a specific order without reflection. Substantiating judgments cease to play a directive role and remain in the form of ‘background connections’ which are only actualised in case of difficulty. Indik describes the process of elaborating intellectual skills as the formation of systems of connections under the regulation of the second signal system.

A.N.Sokolov, dealing with problem solving in physics, advances similar views as to the initial abbreviation and dropping out from the

chain of deduction of substantiating judgment and primary propositions [204]. He directs attention to the fact that the dropping out of substantiating judgment does not always testify to a higher level of intellectual skill and the formation of stable systems of associations; lack of the substantiating part of reasoning is sometimes due to inadequate understanding of the conditions of the task, inability to find a theoretical basis for actions. In such cases actions take on the character of chaotic probes and can only produce a correct solution by chance.

Data about the abbreviation of reasoning testify to the gradual deverbalsation of the process of problem solving. If this is examined in the light of Pavlov's interpretation of the process of automatism as a gradual lessening of the work of the nervous system, then it can be postulated that in this case we have to do with lessening of this work in the second signal system connected with a lowering of the level of its regulatory activity. In such cases in Pavlov's words, nervous processes 'can take place in a partially inhibited region of the brain' on the basis of nervous connections already established and reinforced in the first signal system (cf. 24). But the inclusion of thought processes, directed to cognising and improving methods of performing actions, does not mean the weakening of cognition of the processes of sensation and perception. Thus, for instance, data relating to the formation of motor habits in sport show that the subjects' perception of movements which attain a higher stage of mastery acquires greater precision and intelligibility. After performing exercises they can relate all the details of the movements just performed and the positions of the separate parts of the body [179]. In this connection the research of Kabanova-Meller into scholastic habits is concerned with the formation of habits of reading a topographical map [87]. She has shown that methods of establishing spatial relations between signs on a map first require a high level of cognition expressed in verbal generalisation and formulation of rules. When a high level of success is attained these actions are deverbalsated and automatised. At the same time automatism of these actions is characterised by greater ease in transforming objective interrelations into words, indicating a raising of the level of their cognition. Therefore, according to this data, habits are characterised by a twofold feature: a reduction in cognition of the action itself and a heightening of cognition of sensory elements given in direct perception or images.

Such features of the automatism of intellectual skills as deverbalsation, joining partial operations in a whole, and 'instantaneous' action, brought to light by research, make it possible to postulate that the process of formation of intellectual habits and

skills and peculiarities in their structure are subject to the same regularities as govern motor habits, to which all these features are also characteristic—as is natural, since in the learning of motor habits intellectual actions play an important part. As in motor habits, so also to the same degree in intellectual habits, substantiating elements can be distinguished providing an answer to the question *why*; in both forms of habit there can be found an operative part when it is discovered *what* to do and *how* to do it, and equally a stage of ‘working out’ the given action. The obvious basic difference between these two aspects of automatised actions is that in motor habits we have to do with real actions while in the formation of intellectual habits automatisation takes place on the plane of mental operations. Physiological data testify to regularities common to the formation of these two aspects of skills and habits. We have in mind here Pavlov’s proposition that the laws of nervous activity are the same both for the first and for the second signal system, which means, of course, that the same laws govern stereotyping of nervous activity in the case of both motor and intellectual habits.

It may be added that the automatisation of mental actions does not mean reducing thinking to a habit. To the degree that any task requiring solution requires application of knowledge to a new situation, to different material, thinking is evoked anew in its extended form, in the form of analysis of the material, differentiation of knowledge and systems of generalisation. In this case intellectual habits, like all habits, are only components of creative thinking activity which facilitate the solution of new problems.

The importance of intellectual activeness

An important condition for successful mastery of knowledge is stimulation of pupils’ interests in studies in order to increase their co-operation in intellectual activity. As is known Pavlov stressed the importance for the formation of temporary connections of ‘an active condition of the cortex’; he noted that if the brain is in a passive condition no connections will be formed. In physiological experiments unconditioned reinforcement of the orienting reaction in animals brings a heightening of cortical activity. In relation to man stimuli of a social order have the greatest significance.

The stimulation of intellectual activity in a psychological sense is connected with education of the volitional aspect of the child’s personality, of cognitive interests, understanding of the social significance of the knowledge mastered, a responsible attitude towards work. The point which has recently received most attention is the rise and influence on scholastic activity of cognitive interests.

A number of researches have shown that pupils master knowledge differently in dependence upon their attitude to learning. The formation of interest in and responsible attitudes to school work helps to transform mastered knowledge into convictions which provide a basis for the formation of a general outlook. The conditions ensuring correct formation at home and school of broadly social motives for learning have been studied. This research emphasises the influence exercised by the motivational aspects of learning on the general development of the child's personality.

Some research workers have experimentally demonstrated the possibility of reorganising scholastic activity through the reorganisation of the child's motives, changing his attitude to learning. L.S. Slavina, for instance, working with intellectually passive children of Class I, tried to overcome the children's negative attitude to thinking, to change the motives of their activity. She interested the children in certain methods of solving arithmetical problems which required independent intellectual effort by connecting these methods with a 'game', in which the children won attractive pictures. Later these methods were transferred to the children's scholastic activity [198]. F.I.Fradkina has shown that creative educational play organised out of class may have great importance [217] in the reorganisation of motives.

L.M.Ziubin [78], in a special study of the connection between intellectual activeness and attitudes to learning, found that responsible attitudes to learning and intellectual activeness are closely interconnected. However, he noted that positive attitudes to work do not always evoke a higher level of intellectual activeness but, on the contrary, the latter may arise with a generally indifferent attitude to learning. The author attributes this divergence to levels of mastery of knowledge (different stages in systematisation). Numerous researches have been concerned with conditions for the rise of interest in scholastic work [1, 11, 12, 20, 21, 79, 134, 136, 137, 157, 235]. The formation of technical interests have also been investigated [49, 153].

An approach to the problem of intellectual activeness from the point of view of the social and personal significance of the subject studied has been most fully developed by N.F.Dobrynin [53, 54, 55]. In the light of reflex theory the author advances as a general condition for the stimulation of intellectual activeness the 'signal significance' of stimuli, their living significance for a person. He does not share the view of many psychologists that the orienting reflex underlies activeness of mind. In his view the orienting reflex leads only to a noting of the necessary stimulus connected with

variable external conditions. If, however, these variable conditions do not themselves cover anything of direct importance to a person, the orienting reflex is extinguished. The intellectual activeness of the schoolchild, manifested in deliberate attention, is connected with the significance for him of the knowledge imparted by the teacher. All the necessary associations and systems of associations are created on the basis of personal and social significance.

Whether Dobrynin's view is correct or not, it must be noted that it is of a very general character, whereas in our view the point of the greatest theoretical and practical importance is *why* one or another aspect of the knowledge studied acquires a different 'signal significance' for pupils of different age levels. In the light of Pavlovian theory solution of this problem must be connected with analysis of the forms of reinforcement which give signal significance to one or another stimulus. In the case of man reinforcement has its own particular socially conditioned forms, but the role of reinforcement in the structure of cognitive activity does not detract from its significance in reflex activity.

We hold that use of the concept of reinforcement can help to enrich both the theory of 'attitudes' and of signal significance. Many facts allow of differentiation between two forms of reinforcement *direct* (unmediated) or *indirect* (mediated) reinforcement.

To direct reinforcement belong different forms of approval or praise, different expositions (verbal and written) of the faults in or correctness of a pupil's actions. Here praise of the pupil's work by the teacher plays an important role though other forms of reinforcement are possible (the influence of textbooks, the example of comrades, etc.). It is characteristic that such reinforcement is directly included in the process of the pupil's scholastic activity—is one of the links in this. The influence of approval by the teacher on the motivation of learning has been studied in numerous researches [7, 22, 32, 33, 121, 138, 206, 207, 231, etc.].

But parallel with direct reinforcement, it is necessary, in our view, to differentiate the pupils' own evaluation of the activity they undertake, which rests on what is, in their view, correct practical or scholastic experience. In this case reinforcement exercises an influence indirectly as a result of the transfer of reinforcement which has taken place in previous experience to a new situation.

Such reinforcement has an enormous importance to the formation of associations and systems of associations, since indirect reinforcement is connected with the formation and consolidation of the knowledge of a person's previous experience. The positive attitudes of the pupil to learning, the signal significance of particular components of knowledge, depend not only on the conditions

obtaining at a given moment but on the child's previous experience to which the new knowledge is added; that new knowledge which is associated with previous experience and corresponds to it finds indirect reinforcement and emerges as a factor stimulating intellectual activeness in a certain direction. The singling out by pupils of separate 'leading' features of a concept connected with their experience of life, already referred to, corresponds to this. Thereby, it is necessary to suppose, the emotional aspect of previous experience also comes into action. Included in current activity this creates in some cases a prerequisite for activation of specific methods of action; and, in other cases, for their inhibition.

Attention

Analysis of different forms of reinforcement of pupils' scholastic activity from the point of view of reflex theory permits us to pose afresh some old problems of the psychology of attention; for instance, the connection between 'lack of interest' and 'interest', the relations between 'new' and 'old', etc., which in contemporary research into school children's interests have to a large extent remained undeservedly neglected.

A question of great practical significance is that of maintaining the attention of pupils during lessons. At least two aspects of this problem may be differentiated: first, maintaining attention by stimulating activeness in the performance of school work; second, stimulating interest as a *preliminary* condition of work on new material. The great majority of researches concerned with the psychology of conscious mastery of specific school disciplines have been concerned with the first of these aspects.

This point has already been touched upon when dealing with the general conditions ensuring effective analytic-synthetic activity by pupils (the visual and verbal, comparison and counterposition, cognition of the principle typical variations, etc.). It is covered in numerous researches concerning the problem of attention [4, 41, 50, 53, 56, 168, 207, 219, etc.]. Ways of stimulating preliminary interest favourable to the mastery of new material have received much less attention. As in didactics, so also in psychology, the factors accorded importance are: conveying the aims of the lesson to the pupils, establishing connections with previous knowledge, the creation of 'problem situations', the introduction of factors which give rise to emotional attitudes to the theme of the lesson, etc. However, experimental data on this question in relation to different school disciplines are few and far between. There is some material relating to grammar, orthography, arithmetic and natural science [66, 210], and the question has been investigated on the plane of didactics [50].

Individual differences in learning

Individual differences in learning have been less studied than the general characteristics of the learning process. We may, therefore, briefly summarise the results of relevant research.

There have been different approaches. One is to study all the individual differences shown by children at a certain age and stage of learning, and on this basis to group children in categories according to differences which underlie the totality of the features [cf. 33, 186, 189 and others]. This approach might be called predominantly synthetic. The other method is to distinguish specific features of thinking activity and use these as a basis for grouping pupils in categories [cf. 28, 40, 118, 123, 152, 211, 234]. This is a predominantly analytic method. These methods supplement each other and each has its advantages. The former ensures study of the whole personality whereas the second permits the isolation of typical characteristics of thinking which directly influence the character of mastery of knowledge.

Material derived from researches of the first kind has thrown light on the combination and interaction of general qualities of personality, characteristics in the volitional and emotional spheres, traits of character and characteristics of thinking. Thus Samarin, assessing the style of intellectual work of older pupils, finds specific characteristics in the organisation not only of intellectual processes but also of volitional and emotional processes, showing the influence of the pupil's purposiveness on the process of self-organisation, including under this his general outlook, interests, plans for the future. In addition he gives attention to stages in the mastery of techniques of intellectual work.

Researches of the second type single out successive typical properties of thinking activity in the process of mastering knowledge, which exercise a specific influence on successful mastery: the flexibility or mobility of thinking processes, peculiarities in the interrelation of concrete and abstract components of thinking activity (based on different types of connection between the two signal systems—firm or, in Pavlov's term, 'friable' connections) and the character of the analytic-synthetic operations used. Recently in connection with study of technical activities another criterion has acquired importance: that is, the pupil's bias towards either theoretical or practical activity, or towards that harmonious development which characterises higher levels both of theoretical knowledge and practical skills [cf. 233, 234].

Researches concerned with the degree of stability of these qualities in pupils through several years of learning have shown *how*

characteristics in thinking are expressed in the process of mastering and applying knowledge, how they are manifested in different forms in mastering various aspects of knowledge and at different stages of teaching (according to the complexity of material in the school programme).

Of great significance for the problem of individual differences in the process of learning are the new data provided by researches into the typological characteristics of higher nervous activity in man published in two volumes under the editorship of B.M.Teplov. Attention may be drawn in particular to the attempts of N.S.Leites to arrive at a psychological characterisation of temperament through studying different types of nervous system in everyday life [111]. Leites undertook continuous observation of pupils in the higher classes of schools and carried out a detailed analysis of the characteristics of their mental activity.

In these researches an attempt is made to conjoin the synthetic and analytic approach in studying pupils, i.e. separate features of behaviour are studied but evaluation of characteristics of temperament and the corresponding type of nervous activity are kept in view. It may be supposed that, in time, researches into the psychology of learning concerned with individual differences may find place for both a synthetic and analytic approach, i.e. may achieve an evaluation of the characteristics of personality and at the same time disclose the more typical features of the pupil's thinking activity in the process of mastering and applying knowledge.

Work on problems of individual differences lays the basis for an individual approach to pupils in teaching. There has been special research into the influence of such an individual approach by the teacher on changes in the characteristics of the pupil's thinking. (Psychological research by teachers into this question has been published in a series of symposia, *Readings in Pedagogy*, which appeared in 1953, 1955 and 1956 [62, 75, 95].)

* * * *

Such are the general features of present research into some of the basic problems of the psychology of learning.

As a result of these researches, the prerequisites for effective, cognitive mastery of knowledge, ensuring the skill of applying it widely in different and new conditions, have been worked out. The need to rationalise the structure of children's books and textbooks has been pressed (cf. 125).

The psychological data accumulated provides an essential contribution to the principles of didactics (consciousness, activation of

learning, visuality, stability, etc.). In particular the principle of variation of scholastic material is of importance for the rational use of visual means of education, and for raising the level of conscious and active learning. It establishes the psychological prerequisites for effective organisation of exercises.

The results of research into the psychology of learning may be used not only in didactics but also in the methodology of particular subjects. Psychology has an important share in providing a scientific basis for the methods of teaching many school subjects: Russian language (reading, orthography, grammar), arithmetic, geometry, natural science, history, geography, drawing and others. But the results obtained have only penetrated into the practice of teaching to a limited extent. It is an urgent task to ensure that the results of research into the psychology of learning are instilled into school practice. In addition, many unsolved problems confront schools making the transition to a new, polytechnical form.

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Part Three

THE PSYCHOLOGY OF MASTERING THE ELEMENTS OF READING

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THE question of learning to read is basic to a number of problems in educational psychology. Nevertheless essential aspects of this process still await investigation. T.G.Egorov, when presenting his research, found it necessary to note: 'we cannot boast of great achievements in this field. It is enough to say that we still lack a generally accepted definition of the concept of reading itself' [3].

In the present paper we start from the proposition that reading is a reconstitution of the sound forms of a word on the basis of its graphic representation. Understanding, which is often considered as the basic content of the process of reading, arises as a result of correct recreation of the sound forms of words. He who, independently of the level of understanding of words, can correctly recreate their sound forms is able to read.

From this point of view it is obvious that reading or learning to read produces actions with the sound material of language, more precisely there are outlined the actions which make a reader and which, therefore, must be taught to the child learning to read.

1. Formation of the mental action of the sound analysis of words

To learn to read the child must be able to hear and distinguish the separate sounds in words. This point has been emphasised in the research of I.N.Shaposhnikova [8] and in the special investigations of V.E.Gmurman and R.E.Levina [4].

As an introduction to the practical learning of reading preliminary aural exercises are a step towards familiarising children with the

¹ Of the Institute of Psychology, Academy of Educational Sciences of the R.S.F.S.R. Published in *Papers (Doklady) of the Academy of Educational Sciences of the R.S.F.S.R.*, 1957, No. 1; 1959, Nos. 3 and 4. It should be noted that the Russian alphabet is largely phonetic, with one symbol and only one symbol for each sound (Ed.).

sound system of their native language. But this question has not been adequately investigated.

In teaching reading to children of five and six years old the main fact we come up against is that they do not know the sounds of language, do not hear and are unable to distinguish the separate sounds within a word. The formation of this action is, therefore, difficult.

Hearing and distinguishing separate sounds within a word does not appear to constitute a great difficulty for the literate adult. This is an illusion arising from the fact that at a higher level of development the action is already an abbreviated, generalised and well automatised mental action. In reality the position is that this is only the final form of the action of sound analysis of words. This form must be achieved in the process of learning. But the mastery of a new action cannot and should not begin with the finished form. The problem is to find the elementary form from which it is necessary to start in order to guide the development of sound analysis of words as a full mental action.

The first series of researches we conducted into the psychology of mastering reading was concerned with studying potentiality for, and the characteristics of, forming the mental action of hearing and distinguishing sounds in words in pre-school children who had not learned to read. We took as a point of departure the theoretical propositions of Galperin about the process of formation of mental actions [1]. According to these the basic stages in the formation of a mental action are: (1) establishing a preliminary idea of the task; (2) mastering the action with objects; (3) mastering the action on the plane of speaking aloud; (4) transfer of the action to the mental plane; (5) final establishment of the mental action.

The sounds of speech can only be heard or pronounced. Pronunciation is simply an action adequate to the sound material of language. Therefore it might appear that, in spite of the initial stages of mastering a mental action given above, mastery of actions with sounds must begin at the third stage, i.e. with mastery of the action on the plane of speech. Both practical pedagogical experience and special research show, however, that mastery of sound analysis directly on the basis of uttering words, i.e. on the plane of speech, is very difficult for children and does not lead to positive results. Iu.I. Fausek [7] has noted: 'Analysis of anything fluctuating is impossible and therefore speech must be materialised, i.e. the word must be depicted by graphic means'.

The present author used a method according to which the word undergoing analysis was presented in a stable and materialised form. The child pointed to a picture depicting an object under which there was a schema of the sound constitution of the word naming the object, made up of horizontal squares for the number of sounds in the word. The child

was asked to fill in this schema with counters, designating separate sounds, naming each sound.

Experimental teaching of the action of sound analysis proceeded as follows: at first the child mastered the action on the practical plane. As it was mastered to the extent that the child independently, without help from the experimenter, correctly performed analysis of the word—filling in with counters the schema of the sound constitution of the word, and subsequently naming all the sounds making up its constitution—the schema was gradually withdrawn and then the counters. There thus took place transition to the succeeding stage—the stage of mastering the action on the plane of speech. The child was presented with the word aurally and had to name in turn all the sounds in its constitution. When this action was mastered and the children could independently reproduce it, there was a transition to the next stage—that of mastering the action on the intellectual plane. The children could, without pronouncing the word aloud, name the sounds in its constitution, designate the number of sounds in the word or say in what part of the word one or another sound had place.

Research by N.A.Khokhlova aimed to clarify the relative significance in forming the action of analysis of separate stages of mastering this action. The investigation was limited to formation of the action of sound analysis on the plane of speaking aloud. In the first series of experiments the children mastered the sound analysis of words by way of pronunciation, i.e. directly on the plane of speaking aloud. In the second series, mastery of the action took place in conditions of partial materialisation: the children performed analysis using counters but the word itself was not materialised, its graphic schema was not presented. In the third series, mastery of the action began at the stage of materialised actions, then the child proceeded to mastery of the action with use of counters but without the graphic schema of the sound constitution of the word. The final tests presented the word for analysis on the plane of spoken speech. As a result the quality of correct analysis of the word was differentiated according to the criteria for defining stages of mastery of an action. The number of words learned and their character was identical.

In each series 15 children from the oldest group of a kindergarten took part, who were unable to read and who performed analysis of the sound constitution on the plane of speaking aloud. From five to seven tests were conducted with each child, lasting 20 minutes in each case. The first series did not lead to positive results. Not a single child mastered the action directly on the plane of speaking aloud. The results of tests in the second and third series are presented in Tables 1 and 2.

TABLE 1

Number of words correctly analysed

After mastery of the action by the method of the second series	31%
After mastery of the action by the method of the third series	81%

TABLE 2

Result of forming the action of sound analysis

	Action formed fully	Action formed partially	Action not formed
After mastery by method of second series	—	4	11
After mastery by method of third series	12	2	1

These data show that mastery of the sound analysis of words on the plane of materialised action has a significant effect. They show, first, that simple exercise in sound analysis on the plane of speaking aloud does not lead to formation of the action of sound analysis; second, that mastery of the action is significantly more effective in relation to the stages of its formation; third, that maximal development of the action with materialisation of the object of action, as well as of the operation itself, is necessary at the stage of mastery, after which the transition to sound analysis on the plane of speaking aloud takes place very easily.

In the researches of A.E.Olshannikova formation of the mental action was conducted to the end: sound analysis was transferred to the intellectual plane itself (i.e. performed without the participation of speaking aloud). Formation of the mental action of sound analysis was performed with nine words made up of 10 sounds (of these words four were of one syllable, five of two). Mastery began with materialised actions, after which there was mastery of the action on the plane of speaking aloud and, finally, mastery of these words on the 'mental plane': the children learned to name the sounds making up the word without pronunciation. They simply answered the questions: How many sounds are there in the word? Where does this sound come? Which sound comes first, after? Which sound comes before this one, after that one? etc.

After forming sound analysis as a mental action with nine words, made up of 10 sounds, in order to check generalisation of the action the children were given for analysis words composed of various sounds and levels of difficulty, some familiar to them in meaning and some entirely unfamiliar.

The investigation was undertaken with 10 children of the oldest group in the kindergarten (6–7) years who had not taken part in the first experiments in sound analysis. Nine to ten experiments were undertaken with each child, each lasting 15–20 minutes.

The results of these tests showed that in 8 out of 10 children the mental action of sound analysis was fully formed. After analysis of some new words on the plane of speaking aloud the action formed was easily transferred to a new word of any difficulty, including words whose meaning was unknown to the children.

This research showed that, with children of 6 to 7 years, formation by stages, even with a limited number of sounds and verbal material, can lead to a full-value, generalised in character, mental action of hearing and distinguishing sounds in words, up to the stage of familiarising the children with letters and learning to read. The research showed the conditions for the transition from one stage of mastery to another and the regularities of the connections between one stage of mastery and another.

We have at our disposal preliminary material showing that the formation of the mental action of sound analysis considerably facilitates the process of mastering reading, at the first stage of reading. Mastery of reading is not, of course, confined to the formation of this action. Research into the formation of other actions which enter into reading is being undertaken.¹

2. Formation of the mental action of word changing and its significance in learning to read

It has been shown in the preceding section and elsewhere [9] that in the period of preparation for learning to read, i.e. familiarising children with letters and their sound values, children of 6 to 7 years may easily be brought to form the generalised mental action of sound analysis of words. This has also been shown by the research of A.E. Olshannikova, relating to pre-school children [6] and that of A.K. Markova [5] relating to intellectually backward children. Children who form this mental action easily define not only the first and last sounds in the sound constitution of a word but all the sounds. In the process of forming sound analysis there takes place generalisation of the sounds of speech. Ability to hear the separate sounds in words, to distinguish one from another and to generalise sounds, is vitally important for succeeding stages in mastering reading and writing.

In our researches into the psychology of learning to read we take as a point of departure that elementary reading is reconstitution of

¹ The two remaining sections of this paper were, in fact, published two years later than this first section (Ed.).

the sound form of a word on the basis of its graphic designation. Obviously, in order to reconstitute the sound form of a word, ability to hear separate sounds in words, to analyse their sound constitution, though necessary is not sufficient. To reconstitute the sound form of a word, i.e. to read, it is also necessary, first, to know the sound value of letters, second, to be able to make the transition from designated letters to the concrete sounds within a word.

Experiment has shown that simple knowledge of the names of letters does not ensure full reconstitution of the sound form of a word. Children of 6 to 7 years already know the names of many letters, sometimes the whole alphabet, but they cannot read, and if they try to do so simply put together the names of letters. This is one of the worst habits with which many children enter school to begin learning to read and it is necessary to teach them afresh.

To know the names of letters is not to know their sound values. This is particularly true of the Russian language in which consonants not only designate several specific variants of one and the same phoneme but also two different phonemes (hard and soft phonemes being designated by the same letter). As a result it is important that a letter should not be connected with any single sound value and also that the given sound is connected with different phonemes (hard and soft).

In the Russian language the phoneme and its concrete variant the letter is determined by position in the word; of particular importance here is the following vowel. Of course the vowels *o*, *o*, *e*, *e*, *y*, *a*, but also the softness of the preceding consonant.¹ Therefore, to designate the sound form of a word and syllable it is necessary to be orientated to the succeeding letter and its sound value. Without this it is impossible correctly to designate the sound form of a syllable and word.

Learning the action of designating the sound form of a syllable as a basic unit in reading raises a difficulty in teaching children to read, a difficulty known to methodology as 'amalgamation of sounds'. This has two main causes. First, that the letter is connected with more than one sound value, with any one variant of a phoneme. This makes it extremely difficult to select the concrete variant necessary in the given case. Second, the above difficulty is conditioned by inability to orientate towards the succeeding letter, without which it is impossible to arrive at the concrete variant of the phoneme required in the given situation.

¹ In the written Russian language whether a consonant is 'hard' or 'soft' depends in practice on the vowel following it (e.g. *Dy=du* (as in do), *D?= diu* (as in dew)). The vowels, therefore, are called 'hard' and 'soft'. They are as follows, the soft in brackets: *o* (?), *o* (?), *y* (?), *a* (?), *e* (u=ee). (Ed.)

Various methods have been worked out to overcome the difficulty of 'amalgamation of sounds'. This difficulty gives rise to: (a) the need for clear pronunciation of separate sounds in sound analysis, (b) an arrangement of letters in readers, whereby the first studied are the 'continuant' consonants and then the 'stop' ones so that amalgamation of consonants with vowels is easier, (c) an order of studying sounds and letters which begins with mastery of syllables made up with hard consonants and only afterwards with soft consonants, (d) various technical methods: 'reading according to analysis', 'reading according to similarity', etc. But all this does not lead to the necessary result, and in the last analysis the children learn simply to know syllables 'by sight' without designating their sound.

We assumed that the action of designating the sound forms of syllables can be formed by familiarising children with the letters of consonants and their values. It can be formed as an internal action of *wordchanging* by which we understand a change for the child of the sound form of the word by changing one of its constituent sounds. For example in the word 'dom', the sound 'o' is replaced by 'y', producing the word 'dym', etc. Since in designating the sound form of a syllable it is particularly important to orientate to the vowel sound following a consonant, we assumed that the first need is to form the action of changing the sound form of the word by changing one of the vowel sounds entering into its constitution.

The experimental investigation into formation of the action of wordchanging and its significance in designating the sound forms of syllables was undertaken in two stages: first in 1957 with 6- to 7-year olds, then in 1958 with the preliminary group in a primary school. The results were entirely analogous.

The experiment took the following form. First we formed in the children the mental action of sound analysis of a word, according to the stages established by Galperin. The tasks were given in the form of normal lessons each lasting up to 30 minutes. For the formation of sound analysis of words 12 tasks were used. As an outcome the children could easily distinguish sounds in words of one or two syllables (e.g. *dom, canu*). Although the formation of actions was undertaken with 15 syllables, made up of 10 sounds (*a, o y(ou), u(ee), m, n, l, k, t, s*) the children began to produce sound analysis of syllables made up of other sounds, e, ?, ?, ? (ie, yo, iu, ia).

After forming sound analysis we proceeded to formation of the action of wordchanging. This was conducted in two stages, (1) familiarisation with letters designating vowel sounds, and (2) forming the action of changing the sound form of a word by changing one of its vowel sounds.

Familiarisation with letters was conducted as follows: (a) there was

sketched on the blackboard a picture of an object under which there was a schema of the sound constitution of the word-name (small squares for the number of sounds in the word); the children were given similar small pictures, (b) the sound constitution of the word was determined and the presence in it of the sounds studied was established, (c) letters designating vowel sounds were pointed to, (d) the children placed letters in the corresponding squares of the schema of the sound constitution of the word.

Three tasks were required for mastering the letters. After this the children could independently put a letter in place in the schema where the vowel designated is situated. At the next stage formation of the mental action of wordchanging took place. It was conducted according to the stages of forming mental actions, i.e. beginning on the plane of materialisation resting on the actual replacing of letters, then on the external plane without changing one letter for another and, finally, on the mental plane itself, according to the verbal instruction: 'If in the word "*lyna*" we change the sound "y" (ou) for the sound "u" (ee), what word do we get?'

In forming the action on the plane of materialisation special aids were used in the form of narrow strips of thick paper on which the vowels a, o, y, ?, u, were designated. These strips could be placed in special slots under the picture in the schema of the sound constitution of the word, in the place in the word where the vowel sound came that was to be changed. Thus, for instance, under a picture '*kot*' a strip was placed in the middle square of the schema in place of the vowel 'o'. Work took the following form: first the children determined the second sound in the word and placed the letter 'o' in the corresponding slot, then, moving the strip along so that other vowels appeared in place of 'o' they determined how the new word, or meaningless sound constitution, had been changed by this substitution. In order to make the work meaningful the children were set a task: find out, when you are substituting a letter, what word you get.

At the second stage of formation of this action the children did not proceed from practical substitution of letters. The teacher set out the letters of vowels on the blackboard and the pupils laid these letters out on their desks, and only indicated by pointing the substitution and wordchanging produced. Finally at the third stage all the work was done without pictures or schema, by ear and in the head.

The children worked very willingly. They only found some difficulty with the very first task when forming combinations of meaningless sounds. The action was formed in the course of nine tasks. Although the basic work of forming the action of wordchanging was done with vowel sounds and letters, the action became generalised and was easily transferred to changes in consonant sounds.

It was important to establish whether formation of the action influenced the children's potentiality to designate the sound form of a syllable. With this aim, when the formation was completed a special check was undertaken to find out what names of consonant letters the child knew. Then one of the letters he knew was placed before the child and after he had named it there were placed parallel with it, one after the other, all the letters designating vowels. The question was posed: 'What do we get if we put this letter?' In answer the child pronounced the relevant syllable. An analogous method was used to check the skill of constituting the sound forms of syllables with unknown letters. The experimenter placed before the child the letter unknown to him and named it. For instance, placing the letter 'f' he asked, 'Do you know this letter?' The child answered: 'no'. This letter is 'fe' said the experimenter and then adding to it a vowel asked, 'What do we get if we add this letter?' The child in answer either formed or did not form a syllable.

Control experiments showed that in the course of forming the action of wordchanging there were also formed prerequisites for the action of syllable-formation, i.e. designation of the sound patterns of a syllable. Of 17 children who systematically performed the tasks, not having mastered the task of sound analysis and entirely unable to read, 14 formed the action of designating the sound formation of a syllable with familiar letters, 13 with unfamiliar letters as well. In the case of the remaining children the action of designating the sound form of a syllable was as it were in the 'zone of potential development', i.e. they could produce this action with help, under the directions of the experimenter. To reach this stage two or three directions were sufficient after which the children produced the action independently.

The results obtained provide a foundation for the following conclusions:

(1) Formation of the action of wordchanging is of great importance for all subsequent learning of reading, since internal to this action there arise the prerequisites for the skill of designating the sound form of syllables;

(2) A full value, adequately generalised, action in reconstituting the sound form of the word as the basis for reading can be formed by familiarisation with the letters designating consonants;

(3) Since in the course of formation of the action of wordchanging there develops orientation to positional sound relations, the 'difficulty of amalgamation' is excluded in reproduction of the sound form of the syllable.

3. Formation of the action of reading syllables

The mental actions of sound analysis of words and wordchanging constitute the first two stages of the elementary learning of reading and are a preparation for the basic stage—formation of the action of designating the sound form of words, i.e. reading.

We have already shown that learning to designate the sound forms of syllables, as the basic unit of reading, raises a difficulty known to methodology as ‘amalgamation of sounds’. The prerequisites for overcoming this difficulty and for mastering the reading of syllables, as has been pointed out, are formed with the action of wordchanging. But in the researches described the formation of reading syllables was not subjected to special study. An investigation bearing on this question was specially directed to finding out whether a generalised action of designating the sound forms of syllables and words could be formed which shifted the usual difficulties that arise onto a new foundation. The experimental teaching of reading was undertaken in the preparatory class (Class O) of school No. 91 in Moscow.

The whole process of teaching consisted of three stages:

- (1) Formation of the mental action of sound analysis of words.
- (2) Familiarisation with vowels (o, a, y, ?, u) and formation of the mental action of wordchanging (9 tasks).
- (3) Familiarisation with consonants (*m, n, z-s, r-l, zh-sh, k-g*)¹ and formation of the action of designating the sound forms of syllables and words (17 tasks).

The first two stages are preparatory to the third basic stage, at which formation of the constitution of sound forms of syllables and words should take place. Because of the characteristics of Russian consonantism (the presence of hard and soft consonants) it is necessary for correct constitution of the sound forms of words to be orientated to the vowel letter following the given consonant when selecting a phoneme. Reconstitution of the sound form of a syllable or word in the Russian language is impossible without such orientation. Orientation to the succeeding letter, and the basing on this of formation of the syllable, is the primary task of the third stage.

The method of forming actions at the first and second stages has been described and it only remains to establish the method of forming the action elaborated at the third stage. Mastery of this proceeds by the stages of forming a mental action established by Galperin. At the first stage it is elaborated on the material plane and rests on the external actions of the pupil himself; at the second stage it is formed

¹ The letters connected with a dash were given together. (The consonants are given here in Latin script: ?=zh, ?=sh). (Ed.)

on the plane of speaking aloud. The transition to reading for oneself, i.e. mental reading as such, was not specially covered.

The schema of formation was as follows:

- (1) picking out learned sounds from a word;
- (2) familiarisation with letters which designate the sound learned;
- (3) including a consonant letter in the schema of the sound constitution of the word (under a picture);
- (4) including the vowel letter following on the consonant studied in this schema (the names of the pictures included combinations of the mastered consonant with all known vowels);
- (5) reading formed syllables against the background of a word;
- (6) formation of syllables by adding all vowels to the consonant learned and reading these;
- (7) reading syllables on a chart;
- (8) constituting words from letters;
- (9) changing syllables by way of changing one of the letters (vowel or consonant) and reading them;
- (10) reading words from a chart.

Since we attached special significance to formation of the action on the plane of materialisation (resting on the external action of the pupil himself) we produced for this stage a specially constructed aid, which we will refer to as 'windows'. In a small square of cardboard four such 'windows' were cut out measuring one square centimetre at a distance of two to three millimetres. In the slots of each 'window' there could be placed strips of thick paper with letters pasted on them. All the vowels already known to the children were from the start pasted on the strips for vowel letters; the consonant letters were pasted on strips as they were mastered by the children. These strips were easily moved and the children could move them upwards or downwards so that a given letter appeared in each 'window' so forming syllables and words. By changing one of the letters in the constitution of the syllable or word, they could form a new syllable or a new word. A moving strip with consonant letters was placed in the first 'window', one with vowels in the second, with consonants in the third and with vowels in the fourth. Thus the children were able independently to bring about the transformation of one syllable or word into others, which has a paramount importance for the development of 'positional reading', i.e. reading in which the reader is orientated to the positional relations of sounds in a word.

In working out the reconstitution of the sound forms of a syllable children, therefore, act in the following way: placing a letter in the first 'window' designating the consonant sound under study, they then, by

shifting the strip with the vowel letters in the adjacent (second) 'window', make up all the possible syllables with the given consonant. The fact that the letter designating the consonant sound remains unchanged and that there are changes only in the vowels ensures the formation of orientation to the vowel sound following on the consonant. This is emphasised by the fact that the letters designating vowel sounds are red, and those designating consonants black. After several consonants have been mastered the children change not only the vowels but also the consonants. Thus, for instance, in mastering the sounds and letters *z-s* they begin by forming all the possible syllables with *z*, then change the letter *z* for *s* and form syllables with this letter, and, finally, placing in turn *z* and *s* with one and the same vowel, compare the syllables they get. Comparison of this kind is extremely important for the development of phonematic hearing. Only after the children had mastered the sound forms of the syllables made, resting on an external action with objects, did we make the transition to reading syllables on charts.

When working with words the children produced any word made up of four letters in the 'windows' and, changing one letter for another, arrived each time at a new word which they read. Thus, for instance, in studying *r* and *l* the children produced the following conversions and read the words:¹ *rana-Rina-Lina-luna-Nina-Zina -zima-Sima-Rima-Roma-rosa-roza-loza-Liza-lisa*. After this practical wordchanging we passed on to reading words on charts.

For the formation of reading syllables we used a special aid which was of great importance. Usually at the first stage of learning to read, words are divided into syllables. In reading the child has before him already separated syllables which he either immediately knows 'in a flash' or reads through. Reading by syllables is, therefore, determined by the divisions given in the book. This seemed to us to be incorrect, since the child is given a readymade model which he simply reproduces. The child organises his own reading according to an orientation which is marked out for him by the teacher. But reading an unknown word requires that the child himself determines the orientation he must follow in reconstituting the sound form of the word.

To teach children independently to find this orientation we began by giving a word which was not divided into syllables. This word was printed on a special chart. The children, reading the word, joined together the sounds comprising a syllable with a pencil, distinguishing this syllable in the word and then joining it to the following one. Thus reading the word *luna* they themselves joined with a pencil the sounds constituting the first syllable, reading it and so separating it from the following syllable, and then also did this with the

¹ These words (and other examples following) are transliterated (Ed.).

next syllable, not lifting the pencil from the paper. By this external action with the pencil the children made the transition to orientation to the word resting on the movement of the fingers, and later to simple visual orientation without the support of the movement of pencil or fingers.

We attribute great importance to this method of forming successive syllable reconstitution of the sound form of words, by which the children themselves learn to determine the nodal points or orientators by which reading must proceed. The method proved fully justified.

After all ten consonant letters had been studied (half the number of consonants) we introduced a series of control experiments, in order to find out to what degree the generalised action of reading had been formed. The control experiments were conducted with each child individually. First we asked the child to read a column of words of varying difficulty, which he had not read before but were made up of letters that had been studied. The following results were obtained. The words correctly read in syllables were (1) *muka, kasha, shina*—in 100% of cases, (2) *mir, luz, suk*—in 88%, (3) *mashina, karasi, makarony*—in 83%, (4) *zhurnal, karman*—in 82%, (5) *golos, moroz, zamok, nosok*—in 76%, (6) *grom, slon, glaz, krik*—in 63% of cases. (The type of words given under 3, 4, 6 had not been met with in preceding reading practice.)

Later we asked the children to make up a series of words of varying difficulty. Out of twenty children the numbers correctly writing the following words were: *nos*—20, *luzha*—20, *urok*—15, *marka*—18, *risunok*—11.

These data show that the reading and writing of syllables within the limits of the given letters had been formed in the children. Further the children read not only the words which had been worked upon in lessons, but also words of another type, even those made up of three open syllables, two closed syllables, an open and closed syllable.

It was important to establish how far the action was generalised. This can be determined by its application in new conditions. With this aim we asked the children to read words made up of consonant letters they had not as yet studied. Some children already knew the names of these letters. These did not need help from the experimenter. The children who did not know the names of some letters asked the experimenter and then when he had named them read the word. Words were given with hard and soft consonants, i.e. with consonants in combination with e, ? (iu), ? (ia), which had not been studied. The words *sova, shuba, lina, chasy*, were read in 100% of cases; *vorota, lopata, zavody*—in 95%; the word *deti*—in 80%; *derevo, bilye, telefon*—in 67%; *Boria, Liuba, niania*—in 67%.

In order finally to ascertain the presence of a generalised action, easily transferable to new conditions, we asked the children to read a series of words written in latin script. As the children did not know the significance of letters in this script, in the course of reading they asked the experimenter: 'what is this letter?' The experimenter named the letter and the children then read it. Out of 18 children, who took part in this control experiment, those who correctly read the words given were as follows: *zima*—18, *Sima*—18, *voda*—18, *Rita*—17, *zavod*—18, *vorota*—15, *derevo*—8, *telefon*—11.

It must be noted that both in reading words with unknown consonants and in reading words written in latin script, the children made many mistakes in combining consonants with e, ? (iu), ? (ia). However reading such syllables was as it were 'in the zone of potential development', it was enough for the experimenter to point out to the child how to read such a syllable in two or three cases for him to begin to read them independently.

Therefore, in the course of becoming familiar with ten consonant sounds and letters there was formed a generalised syllable reconstitution of the sound forms of a word. It is particularly important to emphasise that the action was formed, not on the basis of knowing a syllable 'at sight' but on reconstitution of its sound form.

The whole process of our experimental teaching covered 38 tasks, each lasting thirty minutes, and all homework was excluded. Of these 38 tasks 21 were devoted to preparatory work and 17 to formation of the reading of syllables itself.

We consider that the significance of this experiment is that it shows the possibility of a relatively rapid development of elementary reading and that it discloses the genetic connection between particular stages in the formation of this action. These stages are: (1) formation of the mental action of sound analysis, (2) formation of the mental action of wordchanging, (3) formation of the action of reconstituting the sound forms of syllables and words. The establishment of these stages opens up the perspective of radically reorganising methods of teaching the elements of reading.

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PSYCHOLOGICAL PREREQUISITES FOR
INCREASING THE EFFECTIVENESS OF
LEARNING IN PROBLEM SOLVING
IN ARITHMETIC

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[ONE of the methods of approach of Soviet educational psychologists is to evaluate, against the background of psychological findings, the methods used by an outstandingly good teacher. The present article makes this approach, subsequently comparing the effectiveness of this teacher's methods with the results obtained by others.

[The article opens by inquiring what are the differences, from a psychological point of view, between problem solving and operations with numerical facts. Both doing sums and solving problems, like all thinking, involve processes of analysis and synthesis but of quite different degrees of difficulty; problem solving calls for a considerably higher level of analytic-synthetic activity. Mastery of number and of the four rules of arithmetic is necessary in order to do sums, but problem solving requires, in addition, mastery of a wide range of concepts, both concrete and abstract, reflecting quantitative relations between objects. When doing sums, the pupil need select only one element, the symbol, in order to choose the arithmetical operation, i.e. synthesis can be performed at the level of elementary analysis. In the case of a problem, the value sought, the information given in the content of the problem and the relationship between these are determined not by the separate elements but by their combination (which constitutes a certain complex), i.e. to solve a problem successfully there must be synthesis at the level of complex analysis. In operations with numerical facts there is always a single connection between the symbol and a certain arithmetical operation (e.g. the symbol+is always connected with adding). In the case of problems the same arithmetical

¹ Of the Institute of Psychology, Academy of Educational Sciences of the R.S.F.S.R. Article from the symposium, *Ways of Improving Children's Work in the Primary School* (Moscow, 1955), addressed mainly to teachers. This translation was done in the U.S.S.R.

operation can be expressed in various ways, so that more complex 'multiple' connections must be established.

[Even in a simple problem the same data can be interconnected in different ways, depending on formulation of the question. With a compound problem, choice of operation is more difficult; the learner must choose two numbers from several and combine them in a certain way, he must choose elements from the content of the problem to determine the first and subsequent operations, i.e. divide the text into separate problems, define their possible combinations, select only those which can serve as a basis for subsequent operations and lead to the answer. Such complex anticipatory analysis is essential to successful solution of compound problems.

[The solution of problems of familiar structure, and of completely new problems, involves differences in analytic-synthetic activity. When solving a number of problems of the same type the student comes to recognise relations between elements, isolating these from concrete details in the text. These relations, isolated in the process of analysis, are repeatedly connected with a certain system of arithmetical operations and this connection helps towards finding of the values sought. The physiological basis here is the formation of a specific system of temporary connections (conditioned reflexes) which becomes progressively more stable, enabling the pupil to act more easily, more automatically; this is what Pavlov called a dynamic stereotype. The basis for developing habits of problem solving is the formation of various such systems of temporary connections, or stereotypes. The solution of problems of familiar structure rests, therefore, on reproduction of connections previously made. The solution of new problems presupposes, however, the formation of new connections which involves very precise analysis. New thoughts arise only on the basis of those formed in previous experience. In the process of solving new problems analysis involves particularly isolation of those old connections through which new connections can be established. In a new problem the facts given seem at first to be disconnected, and to find the relationship between them and the answer required it is necessary to select a number of intermediate elements and analyse them precisely. This calls for special analysis of the facts given, the result sought and the functional connections between them.

[The analysis of functional connections is directed to finding regularities which throw light on the interconnections between what is given and what is sought for. The analysis of separate facts and of the functional relations between them permits discovery of certain relations between the facts and so choice of the necessary operation. Only those operations, that synthesis, is productive which leads towards the answer

sought, i.e. synthesis on the basis of a multiform anticipatory analysis. When there are extra (or surplus) operations which do not lead towards the answer, this indicates that the learner is making an isolated analysis of separate elements of the problem.

[It must be remembered that words are many-sided stimuli; the same word may be connected in one problem with one arithmetical operation, in another with a different one. If the learner becomes accustomed to using a particular word as a basis for choosing an arithmetical operation he will make mistakes. Weakness in analysis is also shown by attempts to solve problems at the level of 'incomplete' complex analysis—when incomplete combinations of elements are chosen, some elements left aside, and the content of the problem therefore distorted. Analysis is never isolated from synthesis; connections are immediately established between the elements separated in the process of analysis. The isolation of certain complexes presupposes some combination of elements into complexes, some synthesis; the basis for this is formed in the process of analysis, and synthesis is realised when this is sufficiently developed. The new fact received on the basis of synthesis is subjected to analysis, establishing a new connection between it and facts formerly known. Consequently attempts artificially to isolate analysis and synthesis in the process of teaching must fail.

[The necessary psychological foundation for correct concept formation is the assimilation of concepts in such a way that connections are established between the abstract and concrete components of thinking, between word and image. This is why the teacher should provide visual material as a foundation for concept formation; failing this, there will be inadequate interaction and formal assimilation of knowledge. But the stage of operating with concrete material must not last for too long. The teacher should only reinforce the immediate experience of pupils before conducting them through abstraction towards generalisation; otherwise there will be delay in generalising. For example, as Menchinskaia has shown, to remain too long at the stage of counting objects in Class I is to exercise a negative influence on formation of the concept of number; pupils will continue to count by ones, instead of adding and subtracting.

[Correct concept formation depends on the diversity of material used; the more various the concrete material, the more easily and correctly will the process of abstraction proceed. But there cannot be sensory experience of all objects and methods must be adopted to enable the children to extend the concept under study. Materials should be so introduced and used that non-essential characteristics are changed since this helps to stress the essential, basic, characteristics;

there should be verbal formulation of what is essential and what is not and special stress on the essential features of the concept. This differentiation can be made by way of comparing juxtaposed related concepts: e.g. the concept of 'a pair' with the concept of 'a unit'. Such comparison of related concepts makes differentiation more precise. Connections must be established between related concepts, they must be organised in a certain system.

[In order to lead pupils towards assimilation of more abstract mathematical concepts, it is necessary to intensify the processes of abstracting and generalising. One way of doing this is to translate the text of a problem into a more generalised mathematical terminology. (E.g. the problem: Three books were bought for 30 kopecks. How much was each book?' can be reformulated: 'The cost of the books was 30 kopecks. The quantity—3. The price is to be found.')

This creates prerequisites for understanding functional connections between the facts given, for forming more complex concepts of types of problem.

[To illustrate specific ways of meeting these psychological needs the practice of leading teachers has been studied. Since fundamental concepts, which form the foundation for the whole system of mathematical concepts, are formed during the first year at school, the practice of one of the best teachers in a Moscow primary school, teaching Class I, is particularly relevant: V.D.Petrova, of Moscow primary school 172.]

I

As has been suggested, to make a correct transfer to generalisation it is necessary to provide a variety of concrete material, on the basis of which various concepts can be formed. Petrova sets out to meet this need from the first days of the school year. Before the children begin to read their primers, when the first connections are being formed between the words which convey mathematical concepts and corresponding specific images, she introduces operations with a variety of objects. Besides the counters, matches, pencils, books, used in many schools, her pupils bring apples and tomatoes, cucumbers and potatoes, envelopes and pictures, Christmas tree decorations, and different coloured bricks. The children are surprised; the bricks they played with 'when they were little' become objects for serious study. Any objects—potatoes or tomatoes or various geometrical figures made out of cardboard—can be counted and become objects for problem solving. With such a variety of concrete material it becomes easier to transfer to abstraction—to the concept of number, of an arithmetical operation, a problem.

Drawing is used as a means of consolidating knowledge. Each pupil has a sketchbook in which he depicts (if in a primitive way) the number

of objects corresponding to those in problems. The teacher works to the end that children should not form a single, specific, connection (e.g. connect the word 'five' only with this quantity of concrete objects). She forms the concept on the basis of multiple connections, reflecting the composition of this number. For example, the number '5' is consolidated in the process of solving problems about apples. The children draw all the possible combinations which make up this number (one and four, three and two, etc.): these drawings help to consolidate connections between word and image.

Operating with real objects while forming abstract concepts is a necessary stage in learning. But if it continues too long, as has been pointed out above, this may have a negative influence on generalisation and will not stimulate the formation of higher forms of analysis and synthesis. The teacher, therefore, conducts her pupils from the concrete, visual image to generalisation. First she gives them a considerable variety of concrete objects, then replaces the latter with two-dimensional pictures which give only the outlines of objects with a number of details omitted. Children particularly like cutting out pictures of various objects which can then be fixed on a sheet of paper. One day, for instance, 5 pictures of chickens are put on the table. The children compose one problem after another: e.g. (1) there were 5 chickens in the yard. Two chickens hid behind the barn. How many stayed in the yard? (They take away two chickens.) (2) A big hen came up to the chickens (they add a corresponding picture). How many birds were there in the yard? Here a new generic concept is introduced and explained, and so on. Another day pictures of various mushrooms are shown and the children again compose problems concerning the number of mushrooms of various kinds, the number of eatable and poisonous ones, the total number.¹ These problems they solve, so becoming acquainted with the generic and specific concepts involved. At the first stage of schooling, therefore, the teacher leads the pupils towards mastery of more abstract concepts, establishing connections between related concepts.

Gradually the number of both objects and pictures is decreased. The teacher uses them only to introduce new concepts, when it is necessary to establish and stabilise connections between these new concepts and corresponding visual images. Leading the children towards generalisation, she begins to increase the use of images. Images are formed on the basis of operating with objects and pictures of them. Special visual dictation also serves the same end and is quite often used during the first period of teaching arithmetic. For instance,

¹ Collecting mushrooms of various types in the surrounding countryside is a favourite pursuit of Muscovites (Ed.).

the teacher shows different coloured bricks placed in different positions. The pupils look at them, count them, analyse how many are blue, how many red, how many are grouped together and so on. After this analysis the bricks are taken away and the pupils draw a picture of them from memory, according to an image, trying to reproduce as precisely as possible the colours and groups and positions of the bricks. For the next visual dictation, stars or flags of different colours serve as material and so on. Visual dictation of this kind contributes particularly to consolidating connections between word and image, while at the same time teaching pupils to reproduce a clear visual image when necessary; it therefore makes their images more precise.

Visual dictation not only stabilises concrete concepts but also consolidates immaterial, abstract concepts (on the right, on the left, up, down, beside, etc.), i.e. concepts reflecting spatial relations between objects. For example, the pupils learn the concept 'the same quantity'. The teacher shows 5 pictures of mushrooms and asks that the same number of pictures of apples, cherries, pears, be placed beside these, asks the same number of girls to come to the blackboard and so on.

The teacher then portrays 5 'chickens' on the blackboard and asks the children to draw the same number of any other object in their books. They draw any object they like—flags, stars, flowers, leaves—but the number must be the same. On the foundation of such operations the concept 'the same quantity' (as the same number of any object), which is very difficult for first-year pupils, is formed.

Here is another problem set: 'There are 7 apples on a tree and two less on another tree. How many apples are there on the second tree?' Seven pictures of 'apples' are put up on the blackboard, then 7 more and 2 of the last 7 are taken away. The children see that there is the same number of apples on the second tree, minus 2. They then count the remainder. The visual material is taken away and the teacher asks the children to draw a branch with 7 apples, and another with 2 apples less, which they do carefully. The drawings usefully illustrate how the material has been assimilated, allowing the teacher to find out who has not mastered the concept. For example, Vera Z. writes the number '7' in her book and draws two branches, one with 5 and the other with 2 apples. She has done the necessary arithmetical operation ($7-2=5$) but failed to show the relationship (7 and 2 less) in the drawing. Inna D. draws 5 apples on one branch and 3 on another. She shows the necessary relation in the drawing (2 less) but has changed the number given (as can be seen, she has subtracted 2 twice). The teacher specially analyses such mistakes with the children concerned and asks them to repeat the operation. In this case she does not use visual aids but asks the pupils to

imagine the requisite objects as clearly as possible (sometimes she suggests they close their eyes to make this easier) and to solve the problem on the basis of these images.

Careful work on concept formation is not confined to the first studies; the teacher pays great attention to it throughout the school year. She always introduces a new concept very carefully, then checks whether children have grasped it and gives additional exercises whenever necessary. For instance, she devotes considerable time to the concept 'a pair' which is difficult for first-year children. First the children are shown one pair of cherries, then they count the number of cherries in one, two and three pairs; they draw pairs of various objects, stand in pairs themselves, and count the number of pairs. This is done during the first term. In the second term, the pupils come across this concept again and some find difficulty.

For example, a problem is set: some children have made 8 pairs of small houses out of paper and 3 bigger houses, what is the total number of houses made by the children? One pupil, analysing the problem, said the number of small houses was known from the problem itself—8 pairs. Then the teacher asked 8 pairs of girls to come up to the front of the class and asked whether the total number of girls was known, and the pupil understood the mistake. Another child, a slow learner, asked to count said '8 added to 8 makes 16 pairs'. The teacher then used the useful device of contradistinction: she drew a row of eight circles on the blackboard and a row of eight pairs of circles, i.e. compared the concepts of 'a unit' and 'a pair'. In this way the concept 'a pair' was finally differentiated from the related concept.

The teacher systematically differentiates related concepts. To take another problem: 'I have three *piatachki* (5-kopec pieces) in one hand and 3 kopecks more in the other. How much money have I got?' The children find it very difficult to solve this problem though they have easily solved another of similar mathematical structure just before. It is worth noting here that at the first stage of assimilation a concept has an undifferentiated-general character. Only gradually, as a result of comparison with adjacent concepts, does real generalisation take place. At this point the children had certain concepts: 'a *piatachok*', 'a kopeck', 'money', 'coins'. They had often solved problems involving these concepts but problems that could be solved with the aid of undifferentiated concepts. This particular problem calls for really generalised and clearly differentiated concepts and this is the cause of the difficulty.

The teacher asks the children to get out coins which they have collected beforehand and begins to differentiate the concepts. She asks the children: how many coins are there in one hand? How many kopecks

are there in one coin? Then, what are the coins called? We say I have 3 *piataчки*, how can we say this in another way? Then, how much money do I have? In differentiating the concepts the pupils simultaneously establish certain connections between them, organising these according to degree of generality. They form a certain system of concepts. They learn that coins are of a different denomination and that they can count how much money there is in coins. In this way they form multiple connections which enable the solving of more difficult problems ('5 kopecks', 'a *piataчок*', 'a coin', 'money').

The teacher also begins preparing pupils for mastery of more abstract mathematical concepts (such as 'price', 'quantity', 'cost', 'distance', 'speed', 'time', etc.) which provide a basis for assimilating functional relations between facts given and so for the main mathematical regularities. At first these concepts are part of the passive vocabulary of the pupils—it is the teacher who uses them, with explanations where necessary. The children are given the following problem: 'There were 8 apples in the bowl yesterday and there are only 5 apples left there to-day. How many apples have been taken from the bowl?' Here the teacher stresses that the total *quantity* of apples (8) and the *remainder* (5) are known. Similarly she explains, of another problem, that it tells how much a purchase weighs. Here she introduces the concept *weight* and compares this with a previously solved problem relating to the *cost* of a purchase. The new concept 'weight' is introduced into questions ('How much does the first parcel weigh?', or we can say it another way, 'What is the weight of the first parcel?', 'What is the weight of the second parcel?', 'What is the weight of the two parcels?', etc.). Having introduced this new concept she frequently returns to it and stimulates the pupils to use it themselves.

In Classes II and III, the teacher begins to introduce the concepts into the pupils' active vocabulary, teaching them to translate the text of a problem into these more abstract terms. For example, when they are doing problems about functional relations between cost, price and quantity, she requires that the facts given and the value sought be expressed in the correct terms. In Class IV she begins to train the children to express both the content and solution of a problem in the relevant mathematical terms. For example, the pupils explain: 'We know from the problem the cost of the first purchase, the number of things bought, and the cost of the second purchase, and we are to find out the total number of things bought. First we shall find out the price of one thing. To do this we shall divide the cost of the first purchase by the number of things bought...' and so on. The teacher gradually leads the pupils from a visual image to abstraction, to mastery of more complex mathematical categories. Only the best pupils master them at first but

the teacher's systematic work on these concepts enables the rest of the pupils to assimilate them. The teachers at the secondary school say that the pupils taught in this way master more complex concepts at the secondary stage sooner than others.

II

Work on the formation of concepts which are necessary for problem solving is one way of increasing the effectiveness of analytic-synthetic activity. But mastery of the necessary concepts and knowledge of the corresponding mathematical regularities does not imply ability to solve more complex problems. The possession of knowledge is not enough; it is necessary to be able to use it at the right moment, to select the knowledge necessary for solution of a particular problem. It often happens that a pupil cannot solve a problem because he cannot mobilise the knowledge he possesses. Reproduction of the necessary knowledge calls for special concentration on the text of the problem, on analysing it.

As has been noted, the analytic-synthetic activity required for problem solving is more complex than that required for numerical operations alone. For the solution of elementary problems there is needed, first, ability to divide the problem into separate complexes; second, ability to subject these to special analysis and find the answer sought, the given facts and the functional relations between these; finally, ability, on the basis of this analysis, to find the relation between the given facts and the answer sought. To solve composite problems there must be division of the content into a number of simple problems and selection of the combination of the given facts which will lead to the answer, i.e. synthesis at the level of anticipatory analysis.

How should these more complex forms of analysis and synthesis be taught? Further examples of Petrova's work provide an illustration of one possible way of teaching methods of analysis and synthesis in problem solving. Preliminary division of the problem into separate complexes takes place at the outset, during the actual reading of the text of the problem. Petrova teaches her pupils to read the text correctly from the very beginning of the school year. She insists that they read it carefully, with logical intervals and correct tones. 'There is a comma there', she explains, 'you should show the break with your voice.' Words should specially be stressed when they show 'relations between the facts given' ('in', 'on', 'less', 'quicker', etc.). 'If you don't stress such short but very important words your answer to a problem may be wrong'—this is how the teacher explains things to her pupils. They understand what she means and begin to require the same

of themselves and each other, so gradually getting accustomed to 'expressive' reading.

Many teachers try to ensure that pupils know the text of a problem very well, requiring that they repeat it by heart (particularly in the case of problems set for homework). Research has shown that word for word recital of a problem does not guarantee that the pupils will correctly divide the text into separate complexes. Very often a pupil can relate the text quite correctly but in the process of solution leaves some data out of account or operates with incomplete complexes omitting words denoting the facts. Such word for word recital does little to stimulate analytic-synthetic thinking.

Reproduction of the text of the problem, dividing it into the separate facts and the question posed calls for much more active thinking and precise analysis. Petrova insists that her pupils do this from the first term in Class I.... Only after detailed analysis do the children start solving the problem. But even then the teacher often draws their attention back to the text, asking them to indicate that part of the content which determined the choice of a particular operation.... In this way the children learn to use analysis of the text as the basis for solving problems. They also become accustomed to checking the choice of operations by way of analysing the content of a problem.

The pupils also analyse the intermediate results they get in the process of solution. After doing the relevant arithmetical operation they say what result has been obtained and connect this with the facts given in the content of the problem; i.e. synthesise. The teacher gives a great deal of attention to the question posed in the problem. This is analysed in the same way as the facts in the text. In addition, she stresses that the aim of problem solving is to find the value sought, to answer the question the problem sets, and that every operation should be directed to this end.

The teacher asks the children to put a number of possible questions to the facts presented in the problem so that they find out what influence this has on the choice of arithmetical operation.... She also trains her pupils to put various questions to invoke the same operation—for instance, to the problem: 'A boy had 20 books. He gave his sister half of them', to put the questions, (i) 'How many books were left', (ii) 'How many is a half of the books?', (iii) 'How many books did he give his sister?' The children come to see that the answer to all these is provided by one operation. As a result of such work they form multiple connections which provide a basis for solving more difficult problems.

Thus the pupils are taught to control their operations by the text of the problem, the question set and the facts given. At the same time they

are taught to analyse their own mistakes.... Every wrong solution is analysed in detail in the classroom. The children say which aspect of the content has not had sufficient attention, which rule has been forgotten. In addition, all possible versions of solving the problem are analysed and each version evaluated from the standpoint of expediency, the most rational method being chosen.

[The concluding sections of the article may be summarised. The next section deals with the explanation of new problems by the teacher. It is in the process of forming a whole chain of conclusions that the pupils establish connections between the new material and previous knowledge. The more active their intellectual activity, the more easily will connections be formed and the more stable they will become. Experienced teachers, therefore, organise the explanation of new material in such a way that the pupils, as if by themselves (though, of course, on the basis of the teacher's questions) find the necessary relations between the facts and the questions posed. After this the majority of teachers are in a hurry to begin consolidating habits of solving problems of a particular type and devote too little time to extended explanations of the process of problem solving.

[As a result slow learners often fail to recollect the reasoning leading to a solution. Though they can solve stereotype problems, they cannot modify the method of solution in new conditions, i.e. their knowledge is formalised. Conscious assimilation of methods of problem solving requires not only mastery of the corresponding system of arithmetical operations but also reasoning, in the process of which pupils analyse the content of a problem and choose these operations. Several examples are given of Petrova's methods of analysis of problems with her pupils, particularly methods whereby pupils read the problem, analyse its content and reproduce the reasoning on which the solution is based. By the end of the year the majority of the children in Class I can give independently a detailed analysis of a problem involving a relatively high development of mathematical speech.

[Investigations were conducted with three parallel classes in the same school in which Petrova worked; these were typical classes, two of which were taken by experienced teachers. Too little attention was given, however, to teaching the methods of analysing problems and to consolidating the detailed reasoning leading to solution. Work on concept formation was also less systematic. Finally, experimental tests in problem solving set to all the four classes showed that Petrova's pupils achieved a very considerably higher degree of success than those in the other classes, demonstrating their ability to solve problems independently and to carry through complete complex analysis of the problems set. The conclusion is drawn that particular attention should be given to teaching methods of analysing problems and to correct

reasoning in the course of this analysis. Petrova's methods illustrate possible ways of approach. Other good teachers may be using different, more effective, methods; these should be sought out and analysed.

[The final section of the article is concerned with the solution of more complex problems of a new type in the upper classes of the secondary school where particular 'auxiliary' methods must be used. To seek out these methods a study was made of the process of problem solving by adults. Several methods were isolated: *concretisation*, whereby a problem posed in abstract form is given a concrete meaning and so solved with the aid of specific images; *abstraction*, whereby the specific details are left aside and the subject expresses the content in more abstract concepts which clarify the functional connections and mathematical relations; *graphic analysis*, whereby the subject tries to reflect the relations between facts in conventional forms (rectangular, straight lines, circles) and so to find the necessary relations; *modification*, whereby the subject modifies the problem by excluding certain facts and then, on the basis of logical explanation of the result of these changes, finds the way to solve the problem; *analogy*, whereby the subject composes an analagous but simpler problem; the use of *analytic questions* which direct the subject's thoughts to analysis of the facts and their functional connections—these help to isolate the main relations in a problem, its nucleus, and to concentrate attention here. An experiment to test the possibility and effectiveness of teaching the method of putting analytic questions was undertaken and proved successful, indicating that such 'auxiliary' methods can be taught in the regular learning situation in school.

[In conclusion, it is noted that an attempt has been made to isolate a number of requirements for the successful solution of problems and to show some of the ways of realising them in practice; there may be other ways which call for investigation and analysis in educational journals. A special study will be necessary to investigate specific features of the mastery by pupils of each 'auxiliary' method and to work out methods of teaching these in school. A team of research workers, consisting of teacher, psychologist and specialist in methods of teaching would perhaps be the best form of research unit.]

THE MASTERY OF SCIENTIFIC CONCEPTS IN SCHOOL

R.G.NATADZE¹

MANY years of experimental study of the development of thinking in concepts at school age has convinced us that what presents the greatest difficulty for the child is distinguishing the essential features of a concept and cognising their significance.

The child can easily grasp the visual properties common to a certain group of objects and abstract these, and masters concrete concepts in practice considerably earlier, i.e. at a younger age, than he can master the essential features of a concept as such. Of all the moments in the mastery of a concept the last is the cognising of its essential features and their significance, the establishment from this point of view of the essential (not simply the common) features. Our experiments have shown that the child finds it particularly difficult to master essential features when the visual image moments of specific objects do not coincide with the content of the given concept but even contradict essential (non-visual) features, and masters these features much more easily when they are organised at the visual image moments.

We undertook an experiment with pupils from Classes **I** to **VIII** (inclusive). The aim was to observe and study the process of mastery of essential features of a concept at different ages.

I

Four concepts were used in the experiment—‘mammal’, ‘fish’, ‘bird’ and ‘insect’. These concepts are among those with which children are familiar long before they are specially ‘studied’ in science lessons.

At the first stage of the experiment we found out the child’s knowledge in relation to each of the concepts named. Later, in conversa-

¹ Professor of Psychology, Tbilisi University. Published in *Materials of the Conference on Psychology* (Moscow, 1957), pp. 433–7.

tions, we gradually gave the child a simplified definition of each concept and the concepts were 'illustrated' by some pictures of corresponding (typical) animals. The pictures were distributed among the four groups.

In defining a mammal we emphasised the following features: this animal is viviparous, rears its young with milk and (by contrast with fish) breathes air through the lungs. In defining fish we emphasised that they do not give birth to young, do not rear them with milk and 'breathe water' through gills. In relation to birds we emphasised only the feature of feathers (the body covered with down) showing pictures of non-flying birds such as the ostrich. In relation to the insect we emphasised only one feature—this is an animal which has six legs.

To the features named we added repeated comparisons between the concepts, particularly mammal and fish, but also mammal and bird (in relation to birds the method of breathing was not emphasised). We went on to the second stage of the experiment only when the child had a precise and stable recall of the features named, could himself easily give a definition based on these features, and in comparing the concepts could indicate these features. It should be noted that this was easily achieved even with our youngest subjects and even with six year olds in the kindergarten with whom the experiment was also conducted.

At the second stage the child was given a series of pictures representing mammals, fish, birds and insects, and was asked to say what sort of animal each represented and to place the picture in a corresponding group. The subject had to substantiate each answer and placing of a picture in accordance with the corresponding concept. We put questions such as: 'Why do you think this is a fish?', 'Can this be a mammal?', 'Why can't it be?', etc. The conversation continued until the child, in relation to each animal belonging to a specific concept, indicated the corresponding essential features.

At the close of the second stage of the experiment the child was given unusual pictures of uncommon species of animal unknown to most young children which were attributed to the four concepts by these features. The expected mistakes were corrected by the experimenter.

At the third stage, the critical stage of the experiment, the subjects were given pictures portraying animals, which according to external aspect (as it were by phenotype) belonged to one concept but in essence (according to essential features) to another; for instance, belonged by external aspect among fish and in essence among mammals. The subjects were given pictures portraying a dolphin, a whale, a sea unicorn (narwhal) and other animals, the external aspect of which is typical of fish but which from the point of view of essential features mastered by

the subjects at preceding stages of the experiment are mammals and not fish.

They were also given pictures portraying a bat and a series of cheiropera; most of these portrayed winged animals, some of which were shown in flight. They were also given pictures of flying butterflies, the six legs being separately shown in the picture.

Thus, the task of this 'critical' stage was counterposition of the content of concepts known to the subjects in the aspect of definition of essential features and the external visual form of the object. The aim of this experiment was to clarify whether the child could analyse essential features of the concept when confronted with the visual form and how easy it was for him.

In the course of the experiment help was gradually extended to the child in the form of more and more leading questions and explanations assisting him to perform the task. When giving the child the 'critical object' the experimenter first asked him what he must know about this animal in order correctly to say what it was—a mammal, fish or something else. If this question proved insufficient, the experimenter himself informed the child about the essential features of the animal, for instance, giving a picture of a dolphin, he told the child that dolphins rear their young on milk and breathe air through lungs and therefore leap out of the water every minute, etc. Or, when giving a picture of a bat, the experimenter stressed that its wings are not feathered but covered with skin, that it does not have down on the body, that it gives birth to young and feeds them with milk, etc. If this assistance was also insufficient, the experimenter directly explained to the child what sort of animal the given animal is and why.

At the fourth stage of the experiment conversations were held, with the aim of clarifying how the child used these four concepts in the *context of intellectual operations which were not immediately directed to distinguishing essential features of the concept, which did not require direct determining of the concept and cognising of its essential features.* For instance, after the child had been told about the colossal strength and large size of the whale, he was told which mammals are the largest and strongest and which fish are the strongest and largest. Or, for example, he was told about fish (and then mammals) which have a sharp and long nose. Meanwhile, shortly before this, the subject had seen pictures of a sea unicorn with an exceptionally long and sharp nose ('horn') which could not fail to draw attention. Therefore, in the process of these conversations, it became clear whether our subjects really judged from the point of view of essential features after receiving the 'lesson' or slid back anew to the 'phenotypic' point of view, that is to say to practical operation with our concepts.

II

The experimental data collected showed that in time all the children easily overcame the 'phenotypic' point of view. Each age stage gives some step in this direction. We can give only a few basic results at basic stages of the experiment [1].

(1) Our younger subjects—children of 7 who had only just entered school—mastered well the concepts given to them at the first stage of the experiment, to the extent that, first, on the basis of correctly determining all four concepts they indicated the corresponding essential features (i.e. 'This one feeds its young with milk', 'They breathe air', 'They have lungs') and, second, they related to these concepts, almost without mistake, pictures portraying animals of a usual (typical) species. The few mistakes made were easily corrected as a result of leading questions from the experimenter.

However the seven-year-olds usually could not *substantiate* this attribution of a particular animal to the corresponding concept by referring to the relevant essential features; when they tried to explain such an attribution in answer to the experimenter's questions children of this age usually did not refer to the relevant features. Clearly, in their cognition of the concept taught to them, the essential features were not represented.

Presentation to the subjects of the 'critical' pictures showed that all the seven-year-olds without exception and without any hesitation related particular animals to one or another concept *exclusively* according to external aspect—the visual image of the animal (e.g. dolphin, whale, etc. to fish, bat to bird, etc.). Leading questions and direct explanations with references to the definitions mastered by the subjects could not make the child change this point of view. Perceiving the dolphin (in the picture) we may say he 'sees with his own eyes' a fish before him and he is not a bit interested how this in fact breathes or propagates. The external aspect, i.e. the perceived visual image of the animal, 'eclipses' to such an extent in the child's consciousness the counterposed essential 'non-visual' features that he does not sense the contradiction between them, does not *take note of the collision*.

Despite the fact that the subject correctly repeated the definitions of mammal, fish, etc. that he had mastered, and listened with interest to the explanation that the dolphin rears its young and breathes air, he was always steadfastly confident that there was before him a *fish*. To the question, what animals rear their young on milk and breathe air, the child answered mammals but nonetheless considered the dolphin to be a fish and assigned it to the group fish, though he already knew from the experimenter that the dolphin rears its young and breathes air. The child also firmly recalls that all birds have the body covered with down but

nonetheless considers the bat to be a bird although fully aware that its wings are covered with skin.

Thus, at this first stage, the child, in the conditions of our experiment, does not take his stand from the point of view of the essential features even when these are specially taught to him.

(2) At a somewhat higher level of development which is characteristic of Class II (age 8) the child, at the second stage of the experiment when putting pictures portraying common animals to the corresponding concept, *argues* this attribution, referring to the essential features of these concepts.

At this stage the critical objects are put to the concept according to essential features only after exhaustive explanations on the part of the experimenter (leading questions do not help). But this achievement is unstable enough, for at the succeeding stage of the experiment, i.e. in the process of using these concepts in the context of an intellectual operation, the child *anew 'slid back'* to the '*phenotypic*' point of view (e.g. considered as a mammal an elephant but not a whale, and the sea unicorn as the most longnosed and sharpnosed of fish).

(3) At the stage of Class III (9–10) there is a new change; though here also the attribution of critical objects takes place without a shadow of doubt according to external form, with the need *to substantiate* such an attribution ('Why do you think the dolphin is a fish?') the child now argues this attribution by referring to essential features characteristic for the given concept, i.e. 'arbitrarily' ascribes to the 'critical animal' features belonging to the given concept (attributing, for instance, the dolphin to fish, the subjects argued that the dolphin 'breathes water' with the aid of gills, spawns, etc.).

Therefore, in classifying 'critical' objects and attributing them to a concept the child in fact was wholly guided by their external aspect (the visual image). When the possibility arose of substantiating this attribution, i.e. cognising its basis and making it understandable for others, then he considered it necessary to refer to essential features but features belonging to the concrete object again *in its external aspect*, i.e. *the determining moment was again the visual image*.

Further indications of development of the phenomena with which we are concerned are illustrated in the following moments:

(1) Adequate correction of mistakes made by the children with corresponding explanations on the part of the experimenter, so that the subjects 'pricked up their ears' in relation to the remaining critical objects and, before attributing them to one or other concept, referred to the relevant corresponding essential properties of the relevant animal. For instance, after an explanation that the dolphin is a mammal, the child does not attribute the sea unicorn and other mammals to this or that concept without demanding beforehand how they reproduce and

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breathe, and after the explanation of this question, attributes them to a concept according to essential features despite the external aspect of the animal.

(2) Occasionally there is a special solution of the question: the child senses the contradiction and not ignoring on the one hand essential features, on the other the external aspect, seeks a way out in 'reconciling' both moments. Knowing the essential characteristics of the dolphin or sea unicorn he considers it a 'mammal fish'.

(3) After systematic help from the experimenter the child takes such a firm stand from the point of view of essential features that he does not 'slide back' from this point of view at the succeeding stage of the experiment. For instance, considers the whale and not the elephant as the most powerful mammal, etc.

It is not without interest to note that at the level of Class IV (10-11) there is a sudden change in the mastery of the concepts 'mammal', 'fish', 'bird' in which, of course, a great part is played by acquisition of the relevant knowledge in school at the beginning of the year. At this stage, however, there are quite a number of children who attribute species of sea mammals unknown to them (i.e. sea unicorns) to fish according to their external aspect, not putting questions about how these animals reproduce, breathe, etc.

There were some subjects (it is true only a few) who, though they remembered that the whale is a mammal, in the last analysis considered it to be a fish, which rears its young with milk and has lungs, and classified the picture standing for the whale in the group they considered as fish and not with mammals. No such cases were, however, observed above Class IV.

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PSYCHOLOGY OF THE MASTERY
AND APPLICATION BY SCHOOLCHILDREN OF
SOME CONCEPTS IN PHYSICS

E.A.FLESHNER¹

[THIS paper covers a series of researches conducted over a period of two years with pupils of three Moscow schools. In her opening pages the author notes that the question of improving the teaching of physics is a very real one. There has been much work on the problem of formalism in teaching, and emphasis has been laid on the importance of introducing visual aids, more practical laboratory work, organised visits and so on. Other writers have dealt with the divorce between theory and practice or turned to consideration of pupils' attitudes to the subject which play an important role in the assimilation of knowledge. Studies relating to the assimilation of knowledge, and to the definition of levels of assimilation, are also of great relevance. Research has underlined the importance of the principle of counterposition as applied to assimilation of knowledge, in particular as it bears on the relation between established and newly acquired knowledge.

[Research specifically concerned with physics includes that of S.I. Ivanov [3] who established a series of stages in the formation of concepts in physics; F.A.Shchepotiev [14] has studied the character of mistakes in applying knowledge and emphasised the great importance of the organisation of work in contributing to successful achievement; F.A.Kovtunova [5] has covered mathematics and physics and dealt mainly with individual differences; A.N.Sokolov [16] has analysed the structure of reasoning in the solution of problems in physics by pupils of Classes VI–VIII, in particular mistakes in deduction and difficulties in applying knowledge. Researches undertaken in the laboratory of the psychology of learning of the Institute of Psychology of the Academy of Educational Sciences have recently

¹ Of the Institute of Psychology, Academy of Educational Sciences of the R.S.F.S.R. Printed in the symposium *Psychology of Applying Knowledge in School Work*, ed. N.A.Menchinskaja (Moscow, 1958), pp. 77–129.

been generalised by N.A.Menchinskaia in a psychological analysis of difficulties arising in visual-active practical work [9].

[In psychological research abroad the problems are dealt with mainly in relation to thinking, but researches dealing with the influence of previous experience on success in problem solving have produced interesting material. First in this field were N.R.F.Maier and K.Dunker [7, 2] and a positive contribution has been made by the researches of N.E.Weaver and E.N.Madden [20] who, on the basis of experimental data, advanced as the two conditions of success 'the presence of the corresponding knowledge' and the mastery of 'research operations', the latter being defined as a comprehensive examination of the situation, i.e. closely approximating to the analytic-synthetic activity essential to the process of problem solving. The question of utilising knowledge and the conditions for ensuring success are also dealt with from another aspect by L.Szekely who has studied the influence of the conditions of acquiring knowledge on the process of utilising it [18]. In conclusions which bear on the practice of teaching he particularly emphasises that the efficacy of knowledge depends above all on organisation of the scholastic process; the methods of teaching used in the majority of schools must be changed if there is to be an education in creative and critical thinking, for there can be no advance so long as teachers merely require their pupils to memorise and remain convinced that whoever can reproduce material has adequately grasped it and can therefore apply this knowledge creatively.

[Analogous data, testifying that the presence of knowledge does not always ensure successful problem solving, have been advanced by many other researchers abroad and in the Soviet Union. But little light has been thrown on the question of the application of knowledge, particularly to practical problems, in relation to many important subjects including physics.

[The present research project was directed in the first place to discovering how the specific characteristics of the underlying associations formed in school work find their reflection in the process of applying knowledge. Parallel with this it attempted to clarify the inter-relations between newly acquired knowledge and that acquired earlier. Of particular importance was analysis of the thinking activity which takes place in the actual process of applying knowledge in physics. This problem breaks down into particular questions: how does the process of applying knowledge change in the transition from textbook problems (set out and solved verbally) to visual-active problems (presented on the visual plane and solved with the aid of manual actions) and what influence does the general stage of abstraction exercise on performance of a task.

[The data of the research was derived from material relating to the application of knowledge mastered by pupils of Class VI (ages 12–13) in the course of studying the first section of the school physics course ‘Simple Measurement’. This section was chosen because it involves study of three physical magnitudes—density, weight, and volume—the first of which is an entirely new concept for these pupils while the other two are already familiar before the study of physics begins. Preliminary investigation showed that new knowledge about volume only deepens and widens information already gained by the pupils, but knowledge connected in their previous experience with the term weight does not correspond to the new scientific content. Study of the characteristics of applying knowledge gained in different conditions was therefore possible.

[In this section of the school course visual material is extensively used and laboratory work takes a prominent place. In addition pupils do textbook problems involving the use of knowledge about the relations between magnitudes. It was therefore possible to observe analytic-synthetic activity in the process of applying knowledge to both textbook and visual-active problems. It was also important that the concepts studied represented a system of interconnected physical magnitudes. The pupils acquired knowledge about the causal connections between changes which find their reflection in a functional dependence. Performance of the corresponding experimental tasks permitted observation of the characteristics of the application of knowledge about these functional dependencies expressed in generalised form. Since such tasks require operation with abstract physical categories it is possible to bring to light the role of abstraction in the pupils’ activity and to study the influence exercised on this process by different degrees of abstraction in the tasks themselves.

[The basic methods of research were observation and experiment. The purpose of observation of lessons was to discover the educational conditions in which the pupils mastered the relevant section of the course in order to establish the difficulties that arise. Individual experimental checks undertaken afterwards were directed to discovering the specific characteristics of the application of knowledge to different kinds of problem in the given teaching conditions. In correspondence with the aims of the research the subjects were given both textbook and visual-active tasks expressed in concrete and abstract form. Analysis of the material accumulated led to propositions as to more productive ways of organising work at the given stage of the course. In order to check these hypotheses teaching experiments were organised. A subsequent experimental check brought to light the positive influence on learning of changes in the process of applying knowledge to the solution of problems.

[In addition there was a psychological analysis of the experience of an outstanding teacher in organising school work at the given stage of the course. Individual experiments conducted with pupils in her class showed the specific characteristics in applying knowledge which arise as a result of more rational organisation of conditions of work.

[To collect supplementary material the method of conversation with pupils and analysis of work produced by them under the teacher's control was used. Preliminary individual conversations permitted an assessment of the pupils' understanding of the terms 'weight' and 'volume' the scientific content of which is brought out afterwards in lessons. Conversations conducted after study of the given section of the course indicated in what way these concepts had been acquired by the pupils, and their readiness to reproduce the knowledge mastered verbally. Study of work controlled by the teacher permitted an assessment of the general level of readiness for the solution of textbook problems.

[The research was undertaken in the course of two academic years. Forty pupils of Class VI of three Moscow schools (Nos. 368, 650 and 324) took part, selected according to the degree of proficiency in physics (12 proficient, 16 average and 12 weak pupils). The number of tasks set was 520, of individual conversations 60, lessons recorded 49, controlled work analysed 267. The first stage of research was concerned with the formation and application of the concept of density, (1) by pupils studying according to the normal school course, (2) by those studying under research conditions, (3) by those taught by a highly qualified, experienced teacher. It was found that the usual method of presentation and of formulating certain rules hindered the formation of this concept; changes introduced in the methods of exposition and in formulations in the educational experiment eliminated difficulties and greatly increased (to 80%) the proportion of successes. A higher degree of success (90%) was achieved by the experienced teacher who used special methods of exposition.

[There follows here an account of the second stage of the investigation which was into the interrelations between new knowledge and that previously acquired. In the original paper this is followed by two other sections (not given here): a comparative analysis of the process of performing verbal and visual-active tasks, and analysis of the processes of abstraction in the application of knowledge.]

The interrelation between new and formerly acquired knowledge

The interrelation between newly mastered scholastic material and knowledge which the child already possesses has long attracted the

attention of educational theorists. Today it is also a matter of interest to psychologists. A number of researches have dealt with the different forms of interrelation of new and old knowledge (both that acquired in school and in everyday life); in some cases earlier knowledge facilitates the mastery of new, in others it makes it more difficult [19, 15, 17, 8, 9, 10, 4, etc.].

The importance of previous experience, above all everyday experience, in forming scientific concepts is particularly great in the learning of such subjects as physics which involves many concepts in everyday use. When they begin the study of physics, schoolchildren naturally already possess whole systems of knowledge formed in their personal life. Among these are concepts of 'volume' and 'weight' which are studied in the section of the physics course 'Simple Measurement'.

Knowledge and skills connected with the concept 'volume' are enriched and deepened in study of this term in physics lessons—the system of associations connected with this concept is extended. New knowledge is not thereby brought up against the old, does not meet with 'resistance' from it. It is, however, otherwise with the concept 'weight'.¹ A preliminary interrogation of children who had completed Class V (11–12) made it clear that the content of this concept formed in everyday experience does not coincide with the content of the physical concept 'weight'.

The physical essence of weight is the force with which a body is drawn to the ground. It follows from this that there are a series of moments which are important for the formation of a correct concept of 'weight'. We may enumerate those which must be mastered by pupils of Class VI (12–13) studying the 'Weight of Bodies'.

First, it must be understood that weight is a property of all bodies. In the interrogation we found that pupils described weight as a property only of those bodies which they had weighed on the scales. The question therefore arose as to whether they knew that weight is inherent in all bodies. They were, therefore, asked: 'Do all bodies have weight?' Those who answered in the negative were asked how, in their view, a body could lack weight and how they explained this.

The second essential moment in forming a correct scientific concept of weight is knowledge of the connection between the earth's pull and the free fall of a body. We therefore asked pupils: 'Why do

¹ With the aim of getting a general picture of the pupils' understanding of the terms 'weight' and 'volume' before studying these in physics we conducted a preliminary inquiry with pupils of Class V at the end of the scholastic year. This was undertaken in School No. 379 in Moscow and 39 subjects took part. Analogous conversations were held with pupils in Class VI after they had studied the theme 'Density'.

all bodies fall?’—and consolidated their answers with a second question: ‘Is this connected with their weight?’

The third moment, of essential importance, is the concept of force which is studied later. Therefore we asked pupils: ‘What is force? What is there in common between weight and force?’

Finally, having noted in the preliminary questioning a discrepancy in understanding of the words ‘weight’ and ‘gravity’ we asked the pupils a question about gravity and explained the interrelation between the meaning of the words ‘weight’ and ‘gravity’.¹

We may quote the record of one of the preliminary conversations, the subject of which was Zhenia A, a pupil of Class VI, School No. 650.

Experimenter: What is weight? Tell me all you know about it.

Subject: Weight is, how shall I say? It is how much a body weighs if it is put on the scales. We put it on the scales and weigh it, how much it weighs....

Experimenter: What more can you say?

Subject: That all bodies have a different weight. Some have a big weight, they are heavy, for instance that house (points to a large building on the corner and laughs) it couldn’t even be weighed....

Experimenter: You said that weight is how much a body weighs, but then you said that that house can’t even be weighed. Do you think the house has a weight or not?

Subject: If it can’t be weighed then how can it have a weight?

Experimenter: It is heavy but we cannot weigh it?

Subject: We know it’s heavier than, for instance (looks round for an object to compare. Catches sight of a machine for clearing snow in the street). It is heavier than ten of those machines.

Experimenter: You said that all bodies have weight. How do you mean?

Subject: They have weight only this is something else. Experimenter: Explain how all bodies have weight?

Subject: They have some kind of weight...how shall I say (shows effort). Well, they weigh...they have gravity. All things have gravity.

Experimenter: And what is gravity?

Subject: Gravity is what we feel when we hold a body in our hand. It is in all bodies. Even a balloon has gravity, only not much. The air in it doesn’t weigh anything but the rubber weighs. Everything has its own gravity.

Experimenter: What makes gravity different from weight?

¹ This does not, of course, exhaust the physical category ‘weight’. However, pupils of Class VI cannot master it fully since they do not yet know the universal law of gravity, nor command the concept of force as degree of change of motion, etc. For this reason we concentrated mainly on those aspects of the concept ‘weight’ of which the children’s understanding, as was shown by conversations with those of Class V, differed from a scientific understanding.

Subject: Gravity is in all bodies. We know there is gravity in them. But weight is when we know exactly how much they weigh. We get to know weight when we weigh bodies.

Experimenter: Good. Now tell me something else: do you know what force is?

Subject: Force is what is needed, for instance, to move aside that cupboard. Force is needed for that.

Experimenter: Has weight got anything in common with force?

Subject (after a pause): Yes. For instance to weigh a body you have to pick it up and put it on the scales. Force is needed for this.

Experimenter: Can you give another example?

Subject: I can't think of any more.

Experimenter: Tell me, have you thought of any reason why a body falls?

Subject (very surprised): They have gravity and can't stay in the air, they drop down.

Experimenter: Where do they drop?

Subject: They drop down, to the ground. Everything always drops down. If we throw up a ball, for instance, then after, it falls to the ground and rolls. If there is any hole it rolls down the hole.

This conversation is typical enough for the pupils of Class VI examined. The majority gave a definition of weight of this type: 'Weight is how much a body weighs'. The concept 'weight' was connected with the act of weighing by 40% of the children. ('Weight is how much a body weighs. It must be weighed and we get the weight.') Another 30% connected the concept 'weight' not with the action of measuring but with its result. For them weight is the figure making known the result of weighing. ('Weight is how much a body weighs, how many kilograms or tons.') Finally, and this is very important, 80% of subjects were convinced that bodies which they had not measured had no weight.

These data uphold the proposition that before studying 'weight' in physics the children attribute weight only to those bodies they have weighed, it is for them the numerical result of the action of weighing.

It is interesting to note that, having denied that bodies have weight if it is impossible to weigh them, the children answered the more abstract question—do all bodies have weight—positively but preferred to use in this case the word 'gravity' (as did Zhenia A). From the expressions used by the subjects it is clear that weight and gravity are, for children who have not mastered physics, synonymous concepts. There is also a basis for thinking that the content of the everyday concept 'gravity' is closer in meaning to the physical content of this concept than the content of the everyday concept of 'weight'.

To the question, whether weight has anything in common with force, several children gave a positive answer, illustrating this by the following

examples: 'When a body is very heavy you must use a lot of force to lift it on to the scale and weigh it' (Boris Y.). 'The more a man weighs the more force he has' (Valia S.). In neither of these two expressions (nor in other analogous ones) did we find anything to correspond to the physical meaning, an understanding of the connection between these concepts. The understanding of 'weight' as 'force' is lacking in schoolchildren according to the present teaching of physics. It must be brought out and reinforced in lessons.

However the concept 'force' itself, as also 'weight', is familiar to children long before studying it in the physics course. Consequently this concept has a specific content, formed in everyday life.

The pupils' answers to those questions which were directed to clarifying the everyday content of the term 'force' showed that their images of force (before studying it) are connected mainly with muscular effort; 'force is when we strain our muscles', 'force is needed when it is necessary to do (move, carry, etc.) something'. These were the most characteristic definitions of force we heard. From these expressions it followed that the children narrowed the content of this concept, limiting it only to muscular effort, having place mainly in the actions of men or animals on any other body.

Attention should be drawn to the fact that with such an understanding of 'force' it was difficult for the children to explain the free dropping of a body drawn to the ground, since the earth, according to their image can never be the source of force. The direction of the body in its free fall they explained not by movement to the centre of the earth but by movement down. 'Everything heavy goes down. When there is water and oil in a glass the water goes down. When a body is in the air it falls down and the air rises up'—reasoned one of the subjects. It was obvious from the expressions used by the children that the freely falling body is directed to earth not because it is drawn there but because that direction coincides with the downward direction. If it were not for the earth, which is a barrier in the way, the body, in the children's view, would fall farther. Such expressions as the following bore witness to this: 'Bodies fall down, to the earth, then they are stopped because this is the lowest place.'

Therefore the scientific content of the concept 'weight' does not correspond with knowledge about weight formed in the children's personal life. It is necessary to reorganise this knowledge. It should be noted that this is not adequately taken into account in advice on method. On the contrary advice is given to approach the study of the concept 'weight' as a fact, drawn from experience, depending in this way on the children's sensations received from lifting and supporting weight, observation of the free fall of a body, etc. This point of view is most clearly expressed in the methodological advice of E.N. Goriachkin who

in his book *Methods of Teaching Physics in the Seven-Year School* (M., 1948) recommends: 'No definition of weight need be given in study of the given theme but we can utilise those ideas which the pupils have about it from their own living practice.'

Following this advice the teachers in both schools in which research was taking place did not extend the physical meaning of the term 'weight' beyond the knowledge the children already had about it. No steps were taken to ensure that the pupils knew the difference between the understanding of force which had developed in their personal experience and the physical meaning of this term. In addition, the term 'force' was not only repeatedly used in lessons on the theme 'The weight of bodies' but even figured in the form of this concept: 'The force with which a body is drawn to the earth is called the weight of the body.'

As was found in the earlier research, the pupils had difficulty in mastering the new content of the concept 'weight'. They distorted the definition in lessons and made mistakes in doing work. Despite the fact that problems in which 'weight' is an unknown quantity were more often correctly solved than those determining density or volume, the pupils (as the class work showed) made more mistakes in problems 'on weight'.

When 8–10 weeks had elapsed after study of the given theme in Class VI we conducted individual experiments. The aim was to study the specific characteristics of applying a concept, formed according to the given organisation of interaction between newly mastered knowledge and that acquired earlier. Each of the 20 pupils investigated performed three tasks. Two of these were analogous to those done during lessons. These were textbook problems on finding the weight of a body according to its volume and density. The third task involved determining the weight of a glass stopper of irregular form without being able to weigh it. The pupils had at their disposal beakers and tables of density. They could therefore measure the volume of the given body, find from the table the density of glass and on the basis of this data find the weight of the object, utilising the same knowledge included in solution of the textbook problems.

The experiments showed that in a considerable number of pupils the skill of applying knowledge about weight to the solution of problems was diminished. Only 13 pupils (65%) solved the first two problems correctly whereas, in the original class work, exercises had been correctly done by 17 out of the 20 pupils. There were still worse results with the third problem, 10 pupils (50%) being unsuccessful. These pupils tried hard, though without success, to weigh the body when they had every possibility of determining its weight through density.

Postulating that the diminished success in solving problems is connected with changes in the pupils' knowledge about weight, we held a conversation with each with the aim of discovering what content this concept had for them at the moment of the experiment. Analysis of the material collected permitted a division of the children into four groups.

Group I (5 of the most proficient pupils). For these the term 'weight' was connected only with the new physical meaning. They indicated everything new without any of the everyday content of the concept (e.g. weight is force, all bodies have weight, etc.). They also correctly understood the phenomenon of falling and explained it in their own words. Comparison of the expressions used with answers given during the preliminary conversations testified to the fact that the old content of the concept 'weight' had been completely reorganised in these children.

Group II (4 very weak pupils). It was characteristic of these pupils that the expressions they used about weight almost exactly coincided with those used in teaching about the concept. A comparison may be made between answers to the question—what is the weight of a body—given by one of these pupils at both conversations. (Anatoli G, pupil of School No. 368, weak in mastery of physics.)

Preliminary conversation

Weight is when we weigh something and choose the weights, in order to get the finger of the scale level (shows with his hands the position of balance of scales). When we find the weights then we know how much the object weighs.

Following conversation

We take something and weigh it on the scales. We choose the weight so that it balances.

The units of weight are grammes, kilograms, tons. However many grammes, kilograms or tons a body weighs this is the weight.

The counterposition of these two conversations clearly indicates that the content of the concept 'weight' has not changed for Anatoli G. After the lesson he used the term 'balances', also naming the degree of weight, but for the rest even the incorrect formulation of the definition remains as before.

Such is an example of what may be found in the backward pupils of the given group. Weight, before it has been studied, is described by the pupils as the result of measurement and, consequently, as a property belonging only to those bodies which are weighed. As formerly, pupils of Group II saw no connection between the phenomenon of free falling of bodies and the earth's pull, since they preferred to consider that

bodies fall as a consequence of a property of their nature, gravity. The pre-scientific content of the concept of weight was fully stabilised.

Group III (8, mainly average, pupils). These had mastered the physical content of the concept 'weight' but there could often be observed a merging in the definition of weight of elements of the old 'pre-scientific' ideas. Characteristic in this connection is the answer of Kolia A.

Weight is the force with which a body is pulled to the earth, pressing on the pan of the scales. We see what weight it is necessary to put on the other pan and see the weight of the body. When we hold any body in the hand, then we feel it pressing on our hand because it is heavy.

In conversations with other pupils of this group it was easy to find an analogous merging of old and new knowledge. Elements of the new and the old, as in the case of Kolia A, are actualised simultaneously and independently of each other. As a consequence the content of the concept 'weight' revealed represented a conglomeration of propositions some of which were contradictory. Thus, for instance, one of the pupils, after correctly saying that a body falls because the earth pulls it, then added: 'Bodies fall because all heavy things fall down: they are stopped by the earth because they can't get through it.'¹

Thus, knowledge about weight acquired by the pupils of Group III in physics lessons, showed significant changes expressed in the 'concurrence' of two different systems of knowledge, old and new. As a consequence of this concurrence newly mastered knowledge was partly ousting that acquired earlier. Characteristic of this group was the actualisation of both systems which leads to the merging of two contents of the concept 'weight'—the everyday and the physical.

Group IV (3 pupils, one proficient and two average). With pupils of this group another variety of the merging of two systems of knowledge is observed; new knowledge is partly ousted by the old but the process of actualising proceeds otherwise—there is not such an inter-lacing of the elements of both systems as there is in the case of pupils of Group III. The pupils belonging to this group do not distort the specific concept learned in lessons but, in giving its content, draw on old propositions about weight. But there is an essential difference between the two groups. The pupils of Group IV, stating any incorrect proposition, are brought to a stop and refuse to give a further answer. We may quote the record of a conversation with one of the subjects of the group (Tamara E, proficient pupil).

¹ An analogous kind of statement in relation to botanical concepts is described by I.M.Kudriavtseva [5].

Experimenter: What is the weight of a body?

Subject: The weight of a body is the force with which the earth pulls it ... I don't know any more.

Experimenter: Tell me in your own words all you know about weight.

Subject: We know that every body has a definite weight. We see this when we put it on the scales. *When we put a body on the pan it presses it down, we put a weight on the other....*

Experimenter: Go on, why did you stop?

Subject: I think I'm saying it wrong. We learned it a long time ago and I've forgotten it.

Experimenter: Tell me what else you remember.

Subject: I only remember that when we do problems we have to multiply density by volume then we get weight. I remember too that it was shown to us that every body has gravity and *this gravity pulls them down....*

Experimenter: Why do you break off?

Subject: No, it's wrong, I won't say it.

We see that in Tamara E, by contrast with pupils of Group III, the old and new knowledge are not actualised independently of each other. In the course of conversation the pupil twice turned to everyday knowledge about weight (these sentences are italicised in the above record) and then came to a stop and in the end refused to answer. The two other pupils in this group behaved in a similar way. ('I don't remember and I don't want to talk nonsense', and 'I forget about what we learned. Why say it wrong?') Obviously in pupils of Group IV there took place a confrontation of both systems of knowledge and some of their differentiations. The old knowledge was inhibited as not corresponding to reality but the newly mastered knowledge was hardly consolidated and not always reproduced.

Thus the data of conversations showed that in a significant proportion of pupils (11 subjects—55%) there took place under the action of time essential changes in knowledge about weight acquired in lessons. These changes took place in all the average pupils and one proficient pupil and resulted in the supplanting of the newly acquired knowledge by the old knowledge.

The results of our investigation upheld facts established by many psychological researches as to the supplanting in the course of time of newly acquired knowledge by old knowledge. In particular these have been advanced in work dealing with changes in imagery [17, 4, 21].

The circumstance that the characteristics of the interaction between old and new knowledge, shown in material from different subjects and at different stages of learning, fully coincide, testifies to the fact that we have to do here with a general regularity. Its scientific basis is to be

found in the proposition that 'the old does not vanish, the new is only deposited upon it', advanced by Pavlov in his theory about the dynamic stereotype [12:313].

A question deserving particular attention is how knowledge of 'weight' is applied in the solution of problems by the pupils of the different groups. The number of correct solutions in each group taking part in the original class work and in the experiment which lasted 8-9 weeks is illustrated in the following table.

Number of correct solutions in class work and experimental tasks

Groups	No. of pupils in group	Correct solutions in class work		Correct solutions in experimental work			
				Two Textbook problems		One Visual-active	
		No.	%	No.	%	No.	%
I	5	5	100	10	100	5	100
IV	3	3	100	5	83.3	2	66.6
III	8	6	77.7	10	62.5	3	37.5
II	4	1	25	2	25	0	0

As may be seen from the table the success of pupils of Group I in applying newly acquired knowledge was not diminished. In conversations we satisfied ourselves that the old knowledge was fully inhibited and the newly acquired easily actualised, extending to effective application to the solution of problems. No change had taken place in pupils of Group II who, as was noted, had mastered nothing new about weight.

The results of the two remaining groups are of the greatest interest. In both groups there took place a diminution of success in applying knowledge. This, without doubt, is the result of those changes which, as revealed in conversations, took place in the course of time in the newly acquired knowledge. It is interesting that in the solution of visual-active problems the result achieved is worse than in the solution of textbook problems. It was precisely the visual-active problems that were not coped with in the experiment by one-third of those belonging to Group IV and more than half of those belonging to Group III (all of whom had shown skill in applying newly acquired knowledge at the time of the original exercises).

The data collected shows that success in applying newly acquired knowledge, mastered in interrelation with old, everyday knowledge, is diminished not only under the influence of time (as has been shown by a number of experiments) but also under the action of a visual-active situation. The closer the situation to everyday experience the greater the readiness to actualise old, everyday knowledge, as a consequence of which the new which was mastered by the children in lessons is forgotten though at the same time it is successfully used by them in

textbook tasks. Our data indicated that in teaching physics it is necessary to direct particular attention to the application in visual-active conditions of those physical concepts the meaning of which is subject to reorganisation in lessons.

What kind of work in organising the content of physical concepts is needed to ensure stable mastery of the given knowledge and success in applying it to the solution of problems?

According to the data of earlier experiments [1, 22, 11, 13] the most effective way of differentiating the new from similar old knowledge is that of systematic counterposition of the two in class work. Underlying the effectiveness of this procedure is the fact established by physiological research that the chief means of forming differentiation is the repeated admixture of counterpositions.

On the basis of our results we postulated that the negative influence of old knowledge on the process of applying the newly acquired physical concept of 'weight' results from a general law and may be eliminated by clear cut differentiation of the two meanings of the given term.

A further experiment was undertaken in School No. 368 when some changes were introduced in the process of studying the theme 'Weight of bodies'.

At the lesson pupils taking part in the experiment were convinced visually that force is not only muscular effort, that in addition to this kind of force there exist others—force of pressure, the force created by a stream of water moving through the air, etc. In addition, through verbal explanation a range of different aspects of force was described. All these aspects of force were counterposed to the old understanding of the term as muscular effort. Therefore all that had hitherto constituted the essence of the concept 'force' was differentiated from the wide physical understanding of it as any action of any body on another body.

On the basis of experiments and verbal explanations it was possible to establish that if, by pushing, an object is set in motion it is necessary to talk about the action upon it of force. This approach provided a basic physical characterisation of the concept 'force'. The children learned that to bring a body into motion it is necessary to exercise force on it, that without the application of force there is no change in movement.

Thus there was achieved in the lesson the basic aim of differentiating those features of the everyday concept of 'force' which could exercise a negative action on the formation of the concept 'weight'.

Further the teacher counterposed to the everyday understanding of weight and gravity as two different concepts, their physical meaning as two different terms signifying one and the same physical magnitude. Only after this was it possible to demonstrate such phenomena of weight as pressure of a solid on a support or the

stretching of a spring. Formerly the pupils, when this was shown to them, considered these as phenomena of the force of gravity and not weight so that the demonstration did not achieve its aim. Now, after counterposition of the everyday understanding of 'weight' and 'force' to their physical meaning, the children could perceive the phenomena as manifestations of force which acts on a solid drawing it to earth, i.e. were in a position to recognise the physical essence of the observed phenomenon. Familiarisation with instruments for measuring weight, with units and ways of measurement, was introduced only when it was possible to reckon with a basically correct understanding of weight already stabilised. Up to this moment there were no weights on the demonstration table in order not to fix the children's attention on the instruments and actions of weighing.¹

A check of results showed that in the new conditions the majority of pupils (9 out of 10 subjects), even the weaker ones, preserved the new knowledge about weight after a protracted interval and easily applied it in the solution of problems.

The effectiveness of the method indicated in raising the level of mastery and application of knowledge in physics was also upheld by analysis of the work of the experienced teacher V.E.Zotikov whose pupils correctly and easily operated with the concept of 'weight'. Zotikov did not only discriminate between the everyday and scientific meaning of the term 'weight' in teaching but also attempted to use all the pupils' images (for instance, about gravity) which might serve as a support for the formation of the scientific concept.

The results of the pedagogical experiment and analysis of the work of an experienced teacher fully upheld the possibility of significantly increasing success in the application of those physical concepts which are mastered in interrelation with corresponding everyday knowledge. In addition they convincingly demonstrated the necessity of special work by the teacher to differentiate new and old knowledge in class and strongly emphasised the effectiveness of methods of counterposition.

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SOME CHARACTERISTICS OF THE
THINKING OF PUPILS WITH LITTLE
CAPACITY FOR MATHEMATICS

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RESEARCH undertaken in recent years by the writer into the individual psychological characteristics of pupils' ability for mathematics (characteristics of perception, thinking, memory, imagination) has produced material towards an assessment of what is understood by mathematical ability [5, 6, 7]. In order to come to an understanding of the essence and structure of ability for mathematics it is necessary to know about incapacity for mathematics, in what this consists. We may say at once that we refer here to *relative* incapacity. Absolute incapacity for mathematics, of the nature of 'mathematical blindness' does not exist. Every normal pupil, given correct teaching, can more or less successfully master the school course in mathematics, acquiring the relevant knowledge and skills. Relative incapacity for mathematics implies that the pupils concerned find difficulty in studying mathematics and cannot count on great success either in the sense of rapid progress or level of achievement. Research into incapacity for mathematics is of obvious practical importance. In pursuing it we attempt to answer the question: how can pupils who lack capacity be brought to master the relevant knowledge, skills and habits—what are the necessary conditions for developing a higher level of mathematical ability?

We set out to analyse the nature of incapacity for mathematics. The first proposition that arises in this connection is: whether a specific role is played here by interrelation of the visual-image and verbal-logical components of intellectual activity (on the physiological plane, the interrelation of the first and second signal systems), and if so, what precisely is this role? Since mathematics is, in essence, a science concerned with the abstract, generalised properties

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of objects and their relations it is natural to pose the question: could predominance of the visual-image component of thinking over the verbal-logical component be one of the internal causes of relative incapacity for mathematics?

The specific aim of our research was to clarify *the role played by different interrelations of the visual-image and verbal-logical components in the structure of incapacity for mathematics.*

A number of psychological researches have been directed to clarifying one or another 'typological' interrelation of the signal systems in different aspects of activity. Of particular interest in relation to our research is the work of B.B.Kossov [4] which shows that different interrelations of the signal systems influence the character of mastery of mathematical material in certain ways. In the light of this it is possible to suggest that predominance of the verbal-logical aspect of thinking over the visual-image aspect is one of the components of mathematical ability. Materials from our earlier researches permit advancement of the hypothesis that it is not predominance but the stage, level, of development of the verbal-logical component of thinking that plays the decisive role.

Pavlov [8], and later A.G.Ivanov-Smolenski [3] and other researchers, have spoken only of the *interrelations* of the signal systems: of the predominance of one or the other or their relative equilibrium. For certain purposes this classification is adequate. But we were faced with the need for a broader classification, based on the characteristic activity of the signal systems from the point of view not only of their interrelations but also their *level of development*. It is particularly important in this connection to describe the 'median' type. Ivanov-Smolenski ascribed to the third type of interrelation of the signal systems those people 'in whom both are equally developed' [3:189]. But what does this mean? Equally well or badly? From the angle of our investigation this comprises the whole essence of pupils' characteristics. M.N.Borisova [2], distinguishing types of people with relative equilibrium of the signal systems, notes that 'some cognised and portrayed well, others both portrayed and cognised badly'. This, of course, is the heart of the matter. Is it possible to ascribe to one and the same type people with the indices (conditioned indices according to Borisova's method) 5-5 and 0-0? Some coped brilliantly with tasks of a 'first signal' and 'second signal' character, others showed complete helplessness in both cases. Analogous considerations also arise in relation to the first two types of interrelation. Where there is predominance of the second signal system, in some cases both signal systems may be well developed though the second predominates, in

other cases the first signal system may be very inadequately developed. We do not want to say that other researchers adhere to an inadequate classification. Every researcher has his own task. For our purpose it was important to determine not only the interrelations of the visual-image and verbal-logical components of thinking but also the level of development of each of these.

Our approach was as follows: we sought, by experimental investigation and organisation of experimental teaching for pupils with incapacity for mathematics, to distinguish different types (from the point of view of interrelations and level of development of the visual-image and verbal-logical aspects of thinking in the process of mathematical work) and compared this material with the results of investigations with these same pupils conducted by one of the method of distinguishing similar interrelations in other (not mathematical) activity.

As subjects there were selected, from a number of Moscow schools, pupils of Classes V–VII (11–14) showing incapacity for mathematics. We asked the teachers so far as possible to pick out those with incapacity, i.e. those unsuccessful in mathematics but not because of laziness, in particular, those successful in other subjects. Nineteen pupils were selected (9 boys and 10 girls). They were told that a mathematical circle was being organised for those who found difficulty in mastering mathematics and wanted to do supplementary work in this subject. We then organised experimental teaching of mathematics in the circle, beginning with elementary parts of the course of algebra and geometry worked out by our methods. In all 60 experimental tasks were set. In addition individual experiments were undertaken with members of the circle (the method of these experiments is described below).

The first stage of the experimental study showed that not all the 19 pupils selected could be classed as showing incapacity for mathematics. Several showed simple ‘neglect’ and quite quickly ‘caught up’. They could be counted among pupils with average ability or not far below the average. In sum, we found two groups of pupils: one with approximately average ability, numbering 9 (4 boys and 5 girls), and another of 10 pupils with little capacity for mathematics (5 boys and 5 girls).

Not all the pupils with ‘little capacity’ had bad marks for algebra or geometry (or for both subjects). Six had marks of ‘3’ for these two subjects and only four had a ‘2’ for algebra or algebra and geometry. As concerns other school subjects, the only pupils to have a ‘2’ were two who had this mark for Russian language. Some of these pupils were successful in other subjects and one girl, who had a ‘2’ for algebra, did

not otherwise have a single '3' but had a '5' for the majority of subjects (chemistry, literature, history, geography, zoology).¹

The method of investigation was analysis of the process of solving four series of specially constructed mathematical problems, designed to clarify some of the characteristics of the pupils' thinking (and also perception, memory and imagination) on the plane of the interrelations and level of development of the visual-image and abstract-logical components.

In addition there was a fifth series in which Borisova's method was used, that is the interrelations of the visual-image and verbal-logical components were determined in conditions of certain other aspects of intellectual activity [1].

In selecting experimental tasks we set out from the following considerations: the tasks must be (1) from different regions of mathematics (arithmetic, algebra, geometry), (2) of differing difficulty but not in any case of extreme difficulty, (3) new for the pupils (i.e. problems they had not solved). In the four series there were 47 tasks (not counting variants of the same task). The tasks were performed by reasoning aloud. The experimenter concentrated on this 'thinking aloud', endeavouring to bring out the whole actual course of the solution. In cases of failure supplementary questions were put. The knowledge and skills of the subjects at the beginning of the investigation were approximately at the same (and a sufficiently low) level.

Important supplementary material was provided as an outcome of teaching mathematics in the circle. We may give a short description of the series of tasks.

Examples of experimental tasks

Series I aimed to bring to light certain characteristics of the pupils' understanding of elementary rules, the ability to differentiate externally similar material, to produce operations corresponding to a particular rule, to formulate a rule corresponding to particular operations. There were 8 problems. We may give some examples.

1. Say what a coefficient is and indicate the coefficients in the following algebraic expressions: $3a$; m ; b ; 4 ; $3b \cdot \frac{3}{7}n$; 2 ; $4ab(3+2)$;

$$\frac{4}{5} \cdot ab \cdot \frac{5}{4} \cdot 2$$

4. Square the expression a . Double the result. Treble the expression $2x^2$. Cube the result. Give the relevant rule.

¹ In this system of marking, '5' is very good, '4' good, '3' average, '2' poor, but in fact the lowest mark, since '1' is very rarely used. (Ed.)

5. Indicate which of the following algebraic expressions is monomial, which is multinomial and why:

$2ab$; $4x^2y-1$; $x(a+b)$; $3m^3n^{a+1}x^4yza-1$; $a-b$

8. Indicate which of the following algebraic expressions is 'a square of the sum of two numbers' and explain why:

$(a+b)^2$; $(a+b) \cdot 2$; $a+b^2$; $a+2b^2$; a^2+b^2 ; $(a+2b)^2$;
 $(a+b^2)^2$; $(a+2b)^2$; $a+2b$; $(a+b^2) \cdot 2$; $(2a+2b) \cdot 2$.

Series II consisted of 7 problems, making a gradual transition from the concrete to the abstract, generalised plane. Each problem had five variants. The first variant (a) was entirely on the concrete plane, the final variant (e) was the same task but transferred to the abstract plane. The variants (b), (c), (d), made a gradual transition between (a) and (e) with consequent generalisation of an increasing number of the elements of the task. The subject was first asked to solve (e). If he could not, he was asked to solve (a) and then again turn to (e). If a solution did not follow this time he was asked to do (b) and then turn again to (e). The order of presentation of the variants of each task was therefore: (e), (a), (e), (b), (e), (c), (e), (d), (e). The tasks themselves (from 1 to 7) were arranged in an order of difficulty. We may give as an example the variants of task No. 1.

(a) The length of a room is 6 m., the width 3 m., the height 4 m. What is the volume of four such rooms?

(b) The length, width and height of a room are as before. What is the volume of n such rooms?

(c) The length and width of a room are as before, the height is a m. What is the volume of n such rooms?

(d) The length of a room is 6 m., the width and height are a m. What is the volume of n such rooms?

Series III consisted of 12 tasks of a geometric character arranged in 6 pairs, and in an order of increasing difficulty. Of the tasks joined in pairs the first (N) were solved almost exclusively by visual-image means, calling for the support of visual representation; the second task in the pair (S) presented an approximately equal possibility of solution by both visual and verbal-logical ('thinking') methods. The tasks (N) were presented first for solution without the aid of figures ('in the head'); in the case of failure figures could be used. As concerns the tasks (S) the subjects were left free to solve these, after which (both in cases of success and failure) the experimenter asked subjects to use another method of solution ('try to represent this visually, as a figure, in order "to see" the solution'; 'can you solve this problem by reasoning without the help of a figure?')

We may give examples of the tasks in this series.

(N) 3. There is a straight line in space and a point: (a) on it, (b) beside it. How many perpendiculars can we draw to the line from the given point in space?

(S) 1. There are two circles with a radius of 2 cm. and 3 cm. The distance between their centres is 10 cm. Do these circles intersect?

Series IV consisted of 20 arithmetical and algebraic tasks arranged in 4 groups according to difficulty. There were 5 tasks in each group arranged in such a way that the visual-image and verbal-logical components had a different 'specific weight' in solution.

In each group the tasks (N) ('visual')¹ were 'optimal' for the use of visual methods. They could be solved comparatively easily if the relations of the given elements of the task were expressed visually; they could also be solved without depending on any visual representation or schema but this was quite difficult. The tasks (S) and (S) ('median') provided an approximately equal possibility of solution² by visual and verbal-logical means. The tasks (M) and (M) ('thinking') did not require the support of visual representation and² could be solved simply by way of thinking. These problems could, of course, be solved by drawing on visual methods but this was difficult as it was comparatively hard to translate them into the language of images.

The order of presentation of the tasks in this series was as follows: first, tasks of the first group, second, tasks of the second group, etc. In each group the subjects were given two extreme tasks (N and M) and asked to do that which they preferred. After this they were² asked to do the other tasks in the group (proceeding from M to N, or from N to M). It was noted which method of solution the² subjects chose, whether² they needed to rely on visual images, in which task they abandoned the preferred method of solution. As in Series III, the experimenter asked the subjects to use another method of solution; to represent visually the situation and conditions of the problem, or, on the contrary, to try to solve it purely on the plane of thought.

We may give examples of the tasks in this series.²

(N) 1. A passenger fell asleep when he had travelled half way. When he awoke there remained to go half the distance he had travelled while asleep. For what part of the way did he sleep?

(S) 2. A brigade of forestry workers cut in three days 184 cubic metres¹ of logs. On the first day the brigade overfulfilled its plan by

¹ This and other similar terms are, of course, purely conditional and have a purely functional, auxiliary, significance.

² None of these problems was solved by pupils by working out a system of equations since this method of solution only becomes known to them at the close of the year in Class VII.

14 m³. On the second day it fell short of fulfilling the plan by 2 m³. On the third day it overfulfilled the plan by 16 m³. What was the brigade's daily plan?

(M) 2. A tin of honey weighs 500 gr. The same tin with kerosene in it weighs 350 gr. If kerosene is twice as light as honey, how much does the empty tin weigh?

In *Series V* Borisova's method was used to distinguish the relations between the visual-image and verbal-logical components of intellectual activity in conditions of visual recall [1]. The method comprises two series of experiments. In the first series there is calculated the predominance of the activity of visual-image components (recognition of visual forms), in the second series predominance of the activity of the verbal-logical components (description of the perceived visual image). Success in performing the tasks in each series is evaluated by a mark indicating how many tasks (out of 5 possible ones) are performed by subjects. A correlation of the marks obtained in both series characterises the relations of the visual-image and verbal-logical components in the corresponding activity of the subjects.

Results of experimental series I-IV

The data provided by the experimental mathematical series (the first four series), and also the results of continuous observation in the process of teaching mathematics (in the circle) showed that those with 'incapacity' (including the pupils of average ability) differed significantly from each other in terms of the development and interrelations of the visual-image and verbal-logical components in the structure of simple forms of mathematical activity. From this point of view several types of pupil could be distinguished. We distinguished six such groups, those with 'incapacity' finding place only in the first four groups.

Group 1 (3 subjects) was characterised by a low level of development of both the visual-image and verbal-logical components in the structure of simple forms of mathematical activity. With the inadequate development of both components went a notable predominance of the verbal-logical component.

Representatives of this group were distinguished by the following closely interconnected characteristics of intellectual activity in the sphere of mathematics.

The word prevailed over the image. Verbal impressions, even though not particularly strong, counted for more than visual impressions. In solving a number of problems, in which the word came into some 'conflict' with the image, subjects of this type set out from a verbal definition. For instance, as is known, if the coefficient

and indicator of power equal one, this is not marked in algebraic expressions. Here a special contradiction sometimes arises in the first stages of studying algebra: the pupil 'sees' that in the expression b^2 (by contrast, say, with $2b^2$) there is no coefficient, 'sees' that in the expression $7xy^6z^2$, 'x' (by contrast with 'y' and 'z') does not have an indicator of power, but he *knows* that all expressions in letters have both a coefficient and an indicator of power. The subjects of this group correctly solved such tasks. Similarly other tasks in Series I did not give rise to difficulties. The pupils correctly named as multinomial the expression $a+b$, and as monomial the expression $3m^3n^{a+1}x^4yz^{a-1}$ (though in the first instance they saw *few* letters and in the second many); they were clearly oriented to the verbal formulation and not to the image. In solving problems these subjects clearly preferred to set out from the verbal formulation of rules and not from formulae, i.e. the written expression of these rules.

It was never difficult for these subjects to vary the inessential features in easy modifications. But inadequate development of the verbal-logical component obviated the possibility of making a similar analysis in difficult cases. With a generally low level of understanding of mathematical propositions the subjects all displayed a higher level of understanding in the verbal-logical than in the visual-active sphere.

Characteristic of this group of subjects was poor differentiation of externally (visually) similar material by comparison with a higher level of differentiation of verbal-logical material. Visual mathematical propositions were frequently of a badly differentiated 'global' character.

The children often simply 'did not see' differences between algebraic expressions, though if their attention was drawn to these differences, they clearly understood what they meant. They clearly differentiated the concepts 'raise to the second power' and 'double', 'raise to the third power' and 'treble', but at the same time often confused the meaning of a^2 and $a \cdot 2$ or a^3 and $a \cdot 3$.

Ability to visualise propositions of a planometric two-dimensional, and particularly of a three-dimensional character was very poorly developed in these subjects. This appeared clearly in relation to problems in Series III, but was also experienced in teaching geometry. Not one of the pupils in this group could correctly solve 'in the head' any of the problems in this series. The pupils could not do problems with geometric figures since they could not represent visually the relation between elements of the problem, could not show this relation on the figure. Attempts to solve problems of the type (N) by verbal-logical means were without result and unhelpful in character.

We may note, in relation to these characteristics, that for pupils of this group mathematical thinking relied little on visual images. This, of course, was not because such a support was not needed but because 'logicality is substituted for imagery' (as we established earlier in relation to pupils' ability for mathematics). 'Logicality' cannot replace 'imagery', since the verbal-logical component of their thinking activity (in performing mathematical tasks), though it predominates over the visual-image component, is weak. In such cases thinking should rely on the image. But since these pupils are weak in this sphere they do not try to create such a 'support' because, from a subjective angle, this seems to them more difficult.

These circumstances explain the characteristic fact that pupils of this type usually choose verbal-logical methods of solving problems though not very strong in this direction and seldom have recourse to visual-image solution. Even when it is objectively easier to solve a problem by using visual methods, they attempt to solve it by way of reasoning.

When it is a question of transferring from the concrete-visual plane of intellectual activity to the verbal-logical plane and conversely, pupils of this group accomplish the first with less difficulty than the second. This is explained by the fact that making a transition from the plane of understanding to the plane of action, the plane of concrete application of algebraic knowledge, is difficult. While they could explain comparatively well how the cube of the sum of two numbers should be calculated, the pupils began to get confused when they tried to do an actual example. If they were given an example which they solved correctly it was not particularly difficult for them to give a logical explanation of their action.

Pupils of this group often perform abstraction hurriedly (since there is still not an adequate sensory basis for it) and because of this it is unsound. The same may be said about generalisation. They have an inclination to generalise (since the abstract-logical component predominates over the visual-image) but no great ability for it (since the abstract-logical component is little developed, as is the visual-image) and generalisation is incomplete, confused. This is well illustrated in the solution of problems in Series II. The easy problems in this series were generalised by pupils to an average extent. The third problem was generalised only after solving all the intermediate variants, and the remaining, more difficult, problems of a more generalised kind were not solved.

Though there is a general weakness in processes of analysis and synthesis, analysis is the more developed. The pupils showed little ability to synthesise perceived algebraic expressions. But sometimes, in

order to understand the meaning of one it was necessary to be able 'to see' it as a single whole. In order to understand that the expression $27x^3+27x^2+9x+1$ is an extended cube of a sum (i.e. $(3x+1)^3$), it is necessary to cognise it precisely as something unified, in the interconnection of all its parts. Such a task was particularly difficult for representatives of this group of pupils.

Pupils of this type were not distinguished by a good mathematical memory. Verbal-logical material was recalled better than visual-image material, definitions in formulations better than specific operations, geometrical proofs better than problems of geometrical construction.

Group 2 (3 subjects) was characterised by a low level of development of both the visual-image and verbal-logical components in the structure of simple forms of mathematical activity. But with this generally inadequate development of both components the first (by contrast with the preceding group) predominated. Representatives of this group were distinguished by the following characteristics of intellectual activity in the sphere of mathematics.

The image prevailed over the word. Visual impressions, though not themselves of adequate strength, counted for more than verbal impressions. Pupils of this type, when solving problems in which the word comes into a certain 'conflict' with the image, for the most part set out from a visual impression. Knowing (and knowing well) that a coefficient and an indicator of power of one is not written down but understood, the pupils nonetheless made mistakes, asserting, for instance, that the expression a does not have a coefficient, nor indicate stages, the expression $4b$ contains an indicator of power, and c^2d^3 a coefficient. It was obviously difficult for them to think of anything 'not seen'. Sometimes they preferred to write $4b^1$ or $1c^2d^3$, maintaining that 'this is much easier'. While they correctly determined the multinomial and the monomial they refused to consider the expression $x+1$ as multinomial and $2abc^2d^{x+1} m^3n$ as monomial. Verbal formulations had no particular significance for pupils of this type but were difficult for them to understand. The subjects gradually got 'confused' and produced an unthought out arrangement of words, distortions of the content of formulae. Sometimes they dealt with the matter better when in solving problems they relied on a visual-graphic expression of formulae.

Thus, pupil C solves the problem $(2a^n+1/2^a)3=?$. Attempting to formulate the rule he gives an entirely thoughtless variant of the type: 'The cube of a sum is the cube of the first number plus the square of the trebled coefficient—no, plus the trebled square of the second number...'. Of course, no verbal solution is possible. We thought that C simply did not know the formula and suggested he solve the problem with the help of the textbook formulation which he had in his

hand. Put out for a moment, C then began the solution, but shortly after became muddled. Then we asked him to reproduce the formula graphically on the blackboard. The boy wrote the relevant formula, almost without mistake and glancing at it for a moment began to solve the problem correctly enough ('first, it is necessary to cube, then to add three, which should be multiplied by the square of the first number and by the second simply', etc.). When we asked C to look at the written formula and 'construct' a verbal formula, the experience began to be difficult. Clearly we had to do here not with poor knowledge of the formula but with the fact that the visual image had more effect than the verbal.

Subjects of this group differentiated externally (visually) similar material notably better than subjects of the first group; their differentiation of verbal-logical material was very incomplete, and at times they were helpless. Variation of inessential features, even in easy modifications, was, as a rule, a difficult operation for the subjects.

The distinction between pupils of the first group and second group on this plane was as follows. The first often 'did not see' differences in algebraic expression, though they understood sufficiently precisely what these differences signify; the second group by contrast 'see' a difference (if it is sharply expressed) but do not understand, do not cognise, what it means.

The subjects of Group II long confused verbal expressions of the concept 'treble' and 'raise to the third power', 'double' and 'raise to the second power' but distinguished these same concepts expressed visually (a^3 and $a \cdot 3$; a^2 and $a \cdot 2$) and correctly interpreted the difference between them.

Pupils of this group showed weakness in visual imagery but were better in this than pupils of the first group. Like the latter they did not solve any of the problems of Series III 'in the head'. Somewhat better results were obtained when they were asked to use tables. As the pupils found the relations of elements of the task in the tables it was obvious that they represented these better by comparison with Group 1. The tasks (N) in the series were solved for the most part by reliance on visual images but only the very easy ones were done. The subjects were more inclined quickly 'to see' the solution than to reach it by way of reasoning, but because of the weakness of the visual-image component they 'saw' only what could be seen comparatively easily. We may give an example. Pupil B is doing the problem (5) 1, in Series III: 'Do the two circles intersect? Let's draw them and then we can see. First, we can measure 10 cms. distance between the centres. Now, draw the small and large circles. Of course, they don't intersect. (Experimenter: But

couldn't you have done it without drawing? Try to reason it out.) Well, it's more difficult...'

In connection with the characteristics noted we may point out that the mathematical thinking of pupils of this type needs constantly to rely on visual images. This does not mean that 'imagery' can replace 'logicality'. These pupils are not weak in the sphere of imagery but they are weak in the verbal-logical sphere. Therefore they try to create for themselves visual supports for thinking; this way is both easy for them subjectively and objectively effective.

The facts noted explain why pupils of this group usually choose a visual-image way of solving problems and seldom have recourse to reasoning. For instance, they tried to solve all the problems of Series III by their favoured way. The same applied to the problems of Series IV.

Pupils of this type found difficulty in making the transition from the concrete-visual plane to thinking activity on the abstract-logical plane. It was comparatively easy for them to perform the reverse operation, relying on the image, though both transitions involved certain difficulties. A difficulty was noted in moving from concrete operations to the plane of generalised understanding of the regularities of these operations. A pupil solved a number of similar problems which gradually led him to the thought that it is possible to calculate in abbreviated form the product of $(a+b)$ $(a-b)$. He adopted this method on the plane of concrete operations ('Why multiply it all when part of it will be abbreviated anyway? I shall take a^2 and work out b^2 '). But the pupil remained helpless when asked to try to formulate the rule in a general form.

Obviously the process of abstraction is altogether difficult for pupils of this type, even when there is an adequate sensory base for abstraction. Generalisation is a very difficult process for them. This is well illustrated in solutions of tasks in Series II. As a rule it was only after they had solved all the intermediate, transitional variants that pupils independently solved the problem in a generalised form. It took a long time for pupils of this group really to understand that by proving any one particular theorem we simultaneously prove it for all possible cases. Their puzzled questions made this plain.

These pupils, lacking a good mathematical memory, recalled and retained visual-image material better than the verbal-logical. Their recall of definitions, formulations, schema of proofs and reasoning was very bad, much time was needed for learning by heart and matter was quickly forgotten. Of the tasks in Series IV pupils remembered much the best those which they solved by predominantly visual-image means.

Group 3 (3 subjects) was characterised by clear predominance of a well developed visual-image component over a weak verbal-logical component. In a number of instances it is possible to speak of some compensation; with weakness of one aspect of intellectual activity (in mathematical tasks) its other aspect was notably activated and in some instances the visual-image component itself undertook the functions of the verbal-logical. In other instances the verbal-logical component as it were 'neutralised' the visual-image (which produces great difficulty in studying mathematics), while, on the other hand, the visual-image component sometimes activated verbal-logical activity.

The strength of visual impressions often hindered verbal-logical activity. For instance, in solving problems by application of the binomial theorem the pupils could hardly ever set out from the verbal formulation. More, they were sometimes puzzled; why were they forced to learn by heart 'confusing and incomprehensible' verbal formulations when they could more or less successfully do simple examples oriented to the letter designation of formulae?

Pupils of this type perceived a mathematical symbol as a visual image for a prolonged period. Many of them were convinced that the essence of algebra is operations with letters (not numbers with a letter designation), it was difficult for them to think of a letter as a number.

Pupils of this third group adequately differentiated externally (visually) similar material. Differentiation of verbal-logical material took place at an altogether lower level. Variation of inessential features was a difficult action for these subjects, not because they were unable to grasp the difference between the expressions $a^m \cdot a^n$ (a^m)ⁿ, but because, as Kossov has pointed out, the similar external characteristics of what is written (in terms of letters and spatial relations) makes operations more difficult for subjects in whom the first signal system predominates. Pupils who make a clear and precise differentiation of visual representations can see differences between these expressions. But the subjects could not themselves say what precisely a particular difference meant, whether it entailed an essential change of operation or not.

Pupils of this group are characterised by the presence of well developed, clear and precise visual representations, they are able to evoke an image of an object in thought and to depend on this in solving mathematical problems. But weak development of the verbal-logical components of intellectual activity leads to attempts to perform almost every task in a graphic-visual way, 'to see' the relations of separate elements. Since it is impossible to transfer every task into a 'language image' such pupils are not in a position to solve many problems (though they can sometimes do simple ones by way of

reasoning). Similarly, when a visual support is possible the pupils are successful in the majority of cases. Pupils of this group can usually do in the head the problems (N) of Series III, obviously depending in this on images. Here, for instance, is how Pupil B, solved the problem: ‘What shape does a right-angled triangle form when we rotate it on its hypotenuse?’

‘Let’s take the right-angled triangle by its acute angle and rotate it.... Now I’m rotating it. Now I’ve got a figure like a top’ (in conversation it was found that the pupil had in mind two cones with a common base and the tips turned to different sides).

Pupils of this group, therefore, usually choose the visual-image way of solving problems, having recourse to reasoning only when ‘forced’ to do so as a consequence of the failure of attempts to rely on the image.

The transition from the concrete to the plane of thinking activity on the verbal-logical plane is accomplished with great difficulty by these pupils. The opposite transition is accomplished easily; if a thought is understood, this means that it depends on a clear visual representation, if there is no understanding then in order to understand the pupil turns to the visual image. The great difficulty of a transition from concrete operations to the plane of generalised cognition and its regularities has been noted. The pupil is led, for instance, to understand the possibility of expanding a multinomial raised to a given power by means of the binomial theorem. Solving most of the easier single-type examples, his ‘eyes are opened’ to this possibility and in practice he begins to act correspondingly. But he does not in reality substantiate the given possibility since he does not recognise that it is of a general character.

All this explains why the process of abstraction presents such difficulties for pupils of this type. In order to achieve abstraction it is necessary always to abstract from that which is strong for the pupil, what gives him a certain confidence in his powers. The pupil is not in a position to do this independently—he needs continuous help. Clearly, therefore, pupils of this type meet with great difficulty in the process of generalisation on the verbal-logical plane. But in the region of concrete operations practical generalisation is accomplished without particular difficulty.

Thus, for instance, the subject Y coped well with the task of differentiating triangles according to the largest angle (i.e. in practice he generalised the feature as belonging to the group of obtuse angled triangles and related it to different such triangles) but he found it difficult to give a verbal generalisation (in the form of a simple definition).

In the study of geometry pupils of this type were comparatively well oriented to two-dimensional relations and tried to give the proof of a theorem starting out from a large number of relevant structures. They clearly attempted to arrive at a means of getting a visually obvious conclusion. It was difficult for them to construct a proof in a general form. They found it hard to understand the essence of a geometric proof, including the fact that in proving any one particular theorem, we arrive at a general result.

Analytic-synthetic activity in these pupils is more strongly expressed in visual-image thinking than in the verbal-logical. The ability to synthesise, synthetic perception of an object 'grasped' as a whole, is expressed in a greater degree than ability to analyse, though analytic ability in the sphere of visual-image impressions is also developed. Pupils of this group could, with notably greater ease than those of other groups, 'see' in extended algebraic expressions 'the cube of a sum', 'the difference of squares', or 'a sum of cubes'.

Representatives of this group recalled and retained visual-image material considerably better than the verbal-logical.

Group 4 (4 subjects) was characterised by a relative equilibrium between the visual-image and verbal-logical components of intellectual activity with a comparatively low level of development of both.

In the majority of cases it was impossible to say anything definite about predominance of the word over the image, or the image over the word. This relation arose in each case in dependence on the conditions and content of particular mathematical operations and was defined by the characteristics of the operations themselves, not the personal characteristics of the pupils. Thus, for instance, if in differentiating the monomial from the multinomial expression the image operated (it was difficult to understand that the expression $x+a$ is multinomial and b ($x+a$) monomial); the image here exercised the force of a word and produced mistakes typical for pupils of Group 2. But if in differentiating the monomial $2x^2y$ from the multinomial $3x^2+4y$ this conflicting situation did not arise, the pupils were oriented to the definition and did not make mistakes.

Subjects of this group found difficulty in differentiating both visual-image and verbal-logical material. It was equally hard for them to differentiate the concept 'the cube of a sum' from 'a sum of cubes' as the expression $(a+b)^3$ from a^3+b^3 . Successful differentiation depended not on the nature of the material (verbal-logical or visual image) but on the similarity of the object. While confusing the concepts 'the cube of a sum' and 'a sum of cubes' they distinguished the concepts 'the cube of a sum' and 'the difference of squares', and

while confusing the expression $(a+b)^3$ and a^3+b^3 they distinguished $(a+b)^3$ and $(a-b)^2$.

These pupils showed very little ability for visual representation. They could not solve any of the problems of Series III 'in the head'. With the use of figures (in a primitive form) the more simple problems (C) of this series were solved with varying success (more precisely, varying failure); the pupils could solve problems both depending on visual images and without these. Of course, when the experimenter presented a graphic schema, the image considerably assisted understanding of the task, but the pupils doing the experimental tasks had themselves to create a visual schema and this was always difficult for them. The selection of methods of solution depended fundamentally on the nature of the task.

The transition from the visual-image plane of intellectual activity to the verbal-logical plane and conversely was of equal difficulty for pupils of this type. Here everything depended more on the nature of the task than on the individual pupil.

The pupils also found serious difficulty in abstracting from a concrete task, distinguishing inessential features and generalising the essential. Sometimes generalisation was confused, without foundation, lacking an adequate sensory base, sometimes, by contrast, it was arrested; all the conditions for generalisation were present but the pupils could not abstract from the inessential features. The tasks of Series II were generalised by these pupils at different levels, depending upon the difficulty of the tasks. But even the easiest tasks required very gradual generalisation. For the generalisation of more difficult tasks considerable help was needed from the experimenter.

It is impossible to say anything definite about the relative predominance of synthesis or analysis in the thinking activity of pupils of Group 4. This depended on the character of thinking activity itself. All that could confidently be ascertained was weakness in analytic-synthetic activity.

Pupils of this type were not distinguished by a good mathematical memory. It was difficult, with the means at our disposal, to define any essential differences in the effectiveness of recall of verbal-logical and visual-image material.

* * * *

We distinguished, therefore, four types of pupil with little capacity for mathematics on the plane of different relations and levels of development of the visual-image and verbal-logical components of their intellectual activity in the process of mastering mathematics. The

two remaining groups we distinguished belong among pupils of average ability and so did not fall within our terms of reference. We may, therefore, confine ourselves to a brief outline of their characteristics.

Group 5 was characterised by predominance of a well developed verbal-logical component over a little developed visual-image component.

Group 6 was characterised by relatively equally well developed visual-image and verbal-logical components. There was an harmonious combination of the verbal-logical and visual-image components of intellectual activity with the former taking a leading and organising part.

Results of experiments in series V (Borisova's method)

We used as a guide to the level of development of visual-image and verbal-logical components the number of tasks performed by pupils (out of 5 possible tasks) in this series. The pupils were also divided into 6 groups according to correlation of the tasks performed in both series and the number of tasks performed in each series. Attention should be drawn to the fact that the results of the experiments conducted by Borisova's method were correlated with the data of our basic investigation. The groups of pupils distinguished by this method corresponded to the groups we distinguished in our basic experiment. Of 17 pupils, only 2 were allocated to different groups: Pupil B.F. was placed by us in Group 2, and by the tests in Series V in Group 6. Pupil V.S. was assigned by us to Group 4, and by the tests in Series V to Group 5. The experiments of Series V were not carried out with two pupils.

It should be noted that the use of the two methods (our own method and that of Borisova) was designed not to distinguish the typological interrelation of visual-image and verbal-logical components in general but to distinguish their interrelations in a specific kind of intellectual activity. But if we compare the data collected by different methods (e.g. by ours and that of Borisova) it is possible to assess approximately the typological interrelations of the components indicated. Equally their level of development can be defined. It is possible by logical reasoning to arrive at 8 groups according to the two parameters indicated. In addition to the six types indicated above, a seventh, characterised by predominance in intellectual activity of well developed verbal-logical components over well developed visual-image components, and an eighth type, characterised by well developed visual-image components predominating over well developed verbal-logical components. In

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practice we came across pupils with ability for mathematics who in all probability (by inquiries of a kind we did not pursue) could have been allocated to these latter groups.

Conclusions. Analysis of our material leads to the conclusion that incapacity for mathematics is not determined by an unfavourable interrelation of the visual-image and verbal-logical components of intellectual activity. Among our subjects with little capacity for mathematics were pupils representing all three types which characterise different interrelations of these components of thinking. Obviously the decisive factor lies elsewhere.

We have seen what is common from this point of view to all pupils of little capacity who belong to different types. It has been shown that all are characterised by insufficient development of the verbal-logical component of intellectual activity. If a high level of development of this component does not unfailingly determine mathematical ability, though a necessary condition for it, a low level of development of the verbal-logical component of thinking does produce incapacity for mathematics.

This does not mean that the interrelation of the given components plays no part at all here. 'Incapacity' for mathematics is 'weakness' of the verbal-logical component of thinking, and the characteristic traits of this 'incapacity' are determined by the interrelations of the verbal-logical and visage-image components of intellectual activity. This interrelation is in part determined by specific difficulties which arise in the study of mathematics and the specific mistakes made by pupils. It follows from this that different ways of overcoming these difficulties must be found, different methodological approaches in the teaching of pupils with little capacity for mathematics who belong to different types.

A low level of development of verbal-logical thinking results, of course, in little capacity not only for mathematics but also for a number of other activities. There are obviously other factors which determine 'incapacity' for mathematics and further research is being conducted in an attempt to throw light on this question.

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PSYCHOLOGICAL CHARACTERISTICS OF
THE TRANSFER OF TECHNICAL SKILLS
IN OLDER SCHOOLCHILDREN

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[THE opening paragraphs of this paper note that polytechnical teaching must not only ensure the formation of versatile technical skills but also develop the ability successfully to transfer these skills to new conditions. The development of socialist economy calls for a high degree of development of the technical skills which underly mastery of several trades. Transfer of skill is particularly important with mechanisation and automatisisation of industrial processes. This makes new demands on the worker who must not only master a wide range of knowledge in mechanics, electronics, hydraulics, industrial technology, but also be capable of applying this knowledge in different industrial conditions. Accordingly it falls to the schools to equip pupils with polytechnical skills which can be successfully transferred. Psychological study of the formation and transfer of technical skills is of great importance to the correct organisation of practical teaching in school and for the necessary strengthening of the links between school and life.]

Three years ago we studied the formation of technical skills in older schoolchildren and found that these can be divided into constructive, organisational-technological and operational skills. It was found that one of the main conditions for success in technical teaching is to develop these skills so that they function in a versatile way, are of high quality and maintain a stable speed.²

The next step was an experimental investigation directed to discovering the psychological characteristics of the transfer of a skill, of transferring the skill of working on a lathe to other metallurgical machines (drilling and milling machines). We set out with a working

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² *Voprosy Psikhologii*, 1958, No. 2.

hypothesis: the transfer of technical skills takes place most successfully when the pupils independently determine the general principles of work on machines and then make active practical use of this knowledge in performing constructive, organisational-technological and operational tasks.

Twenty-seven pupils of the Class IX (15–16) took part in the experiment. These were divided into two groups equivalent in attainment. The control group consisted of ten pupils, the experimental group of seventeen. None of these pupils had any experience of work on metallurgical machines. The basic task was first that the pupils mastered the skill of working on a lathe and then, when this skill reached a certain stage of formation, carried out some operations on milling and drilling machines.

The pupils of the control group mastered the skill of working on a lathe in the way usually followed in our schools. They were told about the structure of the machine, and introduced to its management, after which they used it to perform seven tasks, gradually increasing in complexity. After this skill had been formed to the extent that the pupils could independently perform the most complex task, No. 7, they were asked independently to prepare the components for task No. 8. This included milling planes and drilling holes in a horizontal direction, which made it necessary for the pupils to use milling and drilling machines.

The formation of technical skills in pupils of the experimental group was planned in the light of the working hypothesis. At first favourable conditions were created for actualisation of the pupils' knowledge in physics, carpentry, metal work, which was necessary to determine general technical principles and actions with such tools as the plane, forge, chisel, axe, drill, saw, file, hack-saw, etc. The experimenter directed the tasks and the pupils, with his help, determined the general properties of all the tools enumerated and formulated the general principles of work with them. Later they were given the task of applying these principles in practice in designing a metallurgical machine for the production of components of cylindrical form (the experimenter showed models of such components).

Since the ninth class took part in the experiment the structure of the lathe was not familiar and the pupils of the experimental group began independently to seek ways of carrying out the tasks set. This was reflected in the models, drawings, working drawings, sketches made by the subjects. The experimenter at the requisite time held individual conversations with the pupils, made a critical assessment of these projects and helped the subjects gradually towards correct performance of the task set. Finally the pupils drew a kinematic schema of the lathe,

in which were represented: the electromotor, belt-drive, spindle, chuck, cutter, steady rest, and other main features of this machine.

After successfully performing these various tasks the pupils came in turn to the lathe and were asked to find the parts which figured in their working drawings. Later the structure of the lathe was explained to them, and they were familiarised with work on it/The further teaching of pupils of the experimental group was according to the same programme as that of the control group.

The data obtained from the investigation served to establish some psychological characteristics of the technical thinking of pupils of this age and to determine the formation of the process of transferring skills acquired on one metallurgical machine to another. When pupils of the experimental group performed tasks in accordance with certain general technical principles and actions with different tools it was found that the majority could only formulate these principles in the presence of visual aids and in the course of practical action with the tools whose properties they were generalising. At the first stage of performing a task which involved certain general technical principles, visual aids and practical actions helped the pupils not only to analyse and compare the properties of tools but also to proceed to ways of trying out the given aspects in practice.

Other characteristics of technical thinking were also found in pupils of the experimental group in the process of working on a lathe. Analysis of the records show various general features and tendencies in the course of their reasoning.

Thus seven pupils of this group proposed to use half-round files to grind a cylindrical surface. They reasoned as follows: 'We use flat files to file flat planes. If we make a file in a circular form we can process the surface of a cylinder'. From a logical point of view this reasoning is correct, but from a technical point of view the half-round file is a very inadequate tool. Five subjects of this group proposed to make an aperture, with a diameter equal to that of the cylinder to be processed in a metal plate. They thought 'the components will be cylindrical because if we feed them through a round hole with sharp edges these will cut off the excess metal and they will become cylindrical in form'. Three pupils proposed to make a machine recalling a machine for sharpening pencils. In their view, this machine should have a cylindrical funnel, in the middle of which a sharp plate would be fastened. 'If the funnel revolves around the component', they said, 'this cutter grinds it and we get a cylindrical surface'. Among other subjects of the experimental group were those who proposed to use a modified plane with a semi-circular blade for the processing of a cylindrical surface.

It was, therefore, characteristic of the experimental group that they tried to use, in unchanged form, principles of action familiar from

previous experience with tools: the plane, file, machine for sharpening pencils, etc. The pupils proposed to change only the form of the cutting part of these instruments, so adapting it to the conditions of the task set.

Analysis of the pupils' processes of thinking in the performance of this task, showed that in the great majority of cases they proceeded from everyday observation, embodied in their practical experience, directly to practice and did not make use of recently acquired knowledge of the general principles of work with different tools. For them this knowledge was 'theory' which did not emerge in practice; when performing the technical task not one of the pupils was able independently, without the help of the experimenter, to transcend the limits of practical experience.

In order that the pupils should fully understand the practical significance of the general principles of work with the different tools made known to them, the experimenter somewhat changed the course of teaching; practical experience was now generalised in a specific formulation of general principles, which was later independently applied by the pupils to their technical task. Particular attention was given to unstereotyped use of theoretical knowledge in practice. Gradually, step by step, and with the help of the experimenter, the pupils moved towards the performance of the basic technical task of designing a machine to process components of cylindrical form. In the end fifteen of the seventeen pupils coped with it successfully.

Pupils of the experimental group were considerably more successful than those of the control group in accomplishing transfer of the skill of working on a lathe to other metallurgical machines. In the control group only seven out of the ten pupils who had successfully mastered the skill of working on a lathe were able to transfer this skill to a drilling machine, in the experimental group sixteen out of seventeen did so. More significant differences appeared when, in the course of processing components for task No. 8, there arose the possibility of transfer of the skill formed to the milling machine. In the experimental group fifteen of the seventeen pupils were successful, in the control group only two out of ten.

Analysis of the cause of these differences showed that the formation of constructive, technological and operational skills in pupils of the experimental group had a decisive influence on success in transferring skills. It was precisely this that gave teaching a polytechnical and creative character, that stimulated the pupils to independent analysis, the generalised and practical use of knowledge in the performance of different technical tasks.

Those skills were most successfully transferred which were based on knowledge and full understanding of general technical principles. The transformation and transfer of technical skills depended to a great degree on the pupils' ability to use this knowledge as a practical whole in independent work. The great majority of pupils in the control group could not successfully transfer the skill of working on one metallurgical machine to another because they had not mastered constructive skills and a knowledge of general principles. It is characteristic that in the experimental group transfer of skill was not achieved by those two pupils who at the outset of teaching failed to perform the basic technical task.

This positive influence of constructive skill on the process of transfer is explained, in our view, by the fact that constructive work always takes place on the basis of generalised ideas about the properties of objects and phenomena. It includes the active purposive selection and combination of those features and properties which the projected object should possess. All this not only contributes to the development of technical thinking, spatial imagery, creative expression, but provides pupils with technical skills of an all-sided and flexible kind, easily transferable to new conditions of technical activity. Therefore mastery of constructive skill to a considerable degree assists the transfer of organisational-technological as well as operational skills.

Operational skills are more inert than constructive skills. This is because their functioning is always connected with a certain part of a machine, they are repeatedly checked in the same conditions, quickly automatised, and corrected into a stereotyped sensory-motor habit. It is difficult, therefore, for such skills to be transformed and transferred to new conditions. Nevertheless a grasp of theory and of constructive skill, and knowledge of basic principles of work on metallurgical machines acquired in the process of constructive work, enable pupils more successfully to transfer their operational skills in accordance with new conditions.

Before the experiment and after it was completed we discovered in conversation the pupils' attitude to work in industry, which trades appealed to them most and why. It appeared that, according to the degree of success in performing tasks requiring the transfer of skills, the pupils' attitude to work gradually changed.

After the experiment, which lasted about two months, had ended, interest in industrial processes was expressed in the experimental group by seven pupils (before the experiment it had been two) whereas in the control group only one additional pupil was interested (it had been three and became four). The great majority of the pupils of the experimental group interested in industrial occupations were motivated by the fact that

in work on metallurgical machines, and also in learning to determine the technology of processing components, they saw the possibility of 'thinking out something new', 'making a necessary part', independently improving the lathe, 'getting it to work how I want', etc. These pupils were chiefly attracted by the creative aspect of work, the possibility of directing their own activity to the creation of socially useful objects and of improving the processes of production. Therefore, in the course of successfully performing tasks which provide for the formation and transfer of technical skills, there gradually arose in some pupils of the ninth class an independent interest connected with overcoming the difficulties of technical activity.

All this provides grounds for supposing that to give an active character to technical teaching is one of the most important conditions for the formation of positive, versatile, technical skills and their transfer to new conditions of technical activity.

The methods at present used to form technical skills do not observe this important condition, so that pupils are not educated in a creative approach to practical tasks. Technical learning in schools often consists, as we have pointed out elsewhere, only in the pupils copying methods of work after having mastered a certain complex of operational skills. Such learning has very little effect on pupils in a polytechnical sense, on their technical interests and versatility of skill. For this it is necessary to improve methods and programmes of technical teaching in the eleven year schools so that in the process of active and various use of theoretical knowledge for practical ends, the pupils form constructive, organisational-technological and operational skills.

Materials assembled in this investigation indicated that there are specific stages in the performance of tasks requiring the transfer of skills. At first the pupils, who had mastered a skill on the lathe, tried to use this skill in an unchanged form in work on milling and drilling machines, as was reflected in a number of mistaken actions. After they had become convinced in practice of the impossibility of performing the present task in this way they proceeded to the next stage: from application of actions to emphasis on analysis of the conditions of the new task, to explanation of the principal differences between work on a lathe and on other machines. As a result of these intellectual actions they defined the conditions which were common to the earlier work and the new work and those which differed, so opening up the possibility of using the new machine for the performance of new technical tasks. Here there always has place recognition and assessment of identical and different actions as between the new productive task, and that performed before. As a result there arises in the first place analysis of separate features and on this basis there is an

active refashioning of knowledge and skills. We may quote a relevant section of the record.

Experimenter to Pupil V.I.: You have to prepare a drawing of this component of No. 8. Read through the draught and explain how you envisage it. (The pupil draws the component in an axometric projection and correctly explains its structure.)

Experimenter: Now say in what order the component should be processed.

Pupil: First we fasten the blank and grind it in order to make three cylindrical planes. Then cut the middle of the cylinder and bore its side surface with a bore of diameter 5.2 mm. After that it is necessary to cut the flat, to trim and cut out the component from the blank with the cutter.

Experimenter: Should all these operations be done on the lathe?

The pupil thinks and then answers hesitantly: The first and last operations can be done on a lathe, but I don't know how to cut off part of the side surface and to bore the hole. (Later he comes to the solution): I shall do all I can on the lathe and then it will be easier to see how to process it. (The pupil begins to process the component but after grinding cylindrical planes stops work, looks at the draught and asks the experimenter): How can I bore the hole here? (The experimenter suggests that he think for himself and find the answer independently. The pupil takes the component from the chuck and tries to fasten it in such a position that the hole can be made by the bore in the back mandrel. After some attempts he becomes convinced of the mistakes he is making and comes to the conclusion): None of this can be done on a lathe.

Experimenter: Look at these machines, and see whether it is possible to use them for processing the component.

The pupil goes up to a milling machine, looks at it for a long time then exclaims, pointing to the feed table: Here is a support like in the lathe only it has a vice instead of a chuck in which the component can be fastened, then the side surface can be filed off as is shown in the draught, and the hole drilled with a hand drill.

At this stage of the transfer of a skill the pupil attempts to find on the unfamiliar milling machine those parts which are to be found on the lathe, and to use them for the performance of the task set. Examining the milling machine he first singles out the feed table precisely because it is similar to the well-known support on the lathe. However he notes differences in the structure of those assemblies: thus on the feed table there is no cutter holder but there is a vice. Recognition of this fact gives rise to associations formed with other, more familiar tools; that is, the file and drill. Hence the approach is adopted: to use the vice, file and drill to perform the set task.

The given stage of transfer of skills is therefore characterised by a tendency to use practical experience in an unchanged form. In cases when existing skills are applicable to the conditions of the new task transfer may now be completed. But in our experiment the pupils should have attempted to explain the chief differences between the lathe and milling machine. After this there usually begins the succeeding stage in the transfer of a skill, the main feature of which is analysis and generalisation of the differences in structure of the familiar and unfamiliar machines. Here knowledge of constructive work on the lathe and of specific general principles of work with metallurgical machines, acquired by the pupils at the beginning of the experiment, begin to exercise an important influence.

Thus pupil T asks the experimenter to start the milling machine. Then he puts an aluminium plate in the vice and slowly turning the handle of the feed table brings it near to the cutter. But the cutter does not reach the material. The pupil does not give up and tries to fasten the plate higher in the vice but this does not produce the desired effect. Then he comes to the conclusion: it must be possible to raise this support. After some search he finds the mechanism for raising the table and turning the handle raises it to the necessary height. He then feeds the aluminium plate to the cutter and, having seen that it makes filings and leaves an even surface, concludes: 'Now everything is clear. The rotating wheel with teeth serves instead of the cutter on the lathe, only there the component was rotating, here it is the cutter.' Having stopped the machine the pupil examines the cutter and adds: 'Yes here the teeth are all sharpened to a cutting edge. On this machine we can make a slit, as with a hack-saw, and process different surfaces in the same way as with a file. On the lathe you can't do this. There the component rotates and the cutter is stationary'.

Synthesis of the results of all this analytical activity usually gives rise to a generalised idea of the schema of those practical actions which can lead to the successful transfer of skills, so that the level of these generalisations, their fullness and adequacy in great part determines the success of transfer. Thus the way is prepared for transition to the stage of practical accomplishment of the transfer of the technical skill. At this stage the correctness of the intellectual actions, approach, propositions, used earlier, is checked in practice. An objective criterion of such a check is provided by the products of technical activity, their correspondence to the task set. All this helps the pupils to develop self-control and the ability objectively to evaluate both achievements and inadequacies in technical activity. Success in the transfer of skills is one

of the most reliable indications of the stage of generalisation, of the depth and effectiveness of knowledge. In cases when it becomes clear as a result of practical checking that the technical task has not been fulfilled, the pupils usually turn to analysis of the conditions of the task. However, now the stage described above in the process of transfer, and the corresponding intellectual actions, take place in a foreshortened form. Analysis and generalisation of the experimental data assembled fully upheld our working hypothesis and permitted the establishment of a number of psychological characteristics in the transfer of certain technical skills in older pupils. It seems to us that study of these characteristics may have a bearing on improving the programmes and methods of technical teaching.

Conclusions

(1) Those technical skills are most successfully transferred which are based on knowledge of general technical principles and principles covering work on metallurgical machines. The formation of such skills is possible when teaching stimulates pupils to systematic application of their knowledge of these principles in the performance of constructive, organisational-technological and operational tasks.

(2) The transfer of technical skills is accomplished by older pupils in different ways; the pupils often transfer constructive skills comparatively easily but experience serious difficulty in the transfer of operational skills. However, mastery of constructive skills assists the successful transfer both of organisational-technological and operational skills.

(3) Transfer usually begins with attempts to apply existing knowledge and skills directly in the conditions of the new task. When the pupil is convinced of the impossibility of performing this task by these means he begins in more detail to analyse, compare, counterpose, the conditions of the new task with the conditions of that activity in which the skill subject to transfer was formed. Here there is always recognition and singling out both of different and identical features as between the new technical task and that performed earlier. As a result there is first evoked analysis of the differences, and on this basis there is an active working over of knowledge and skills; this denotes, in particular, a separating out of the features of the task which call for transfer of skill. On the basis of synthesis of the results of all this intellectual activity there usually arises a generalised representation of the practical actions which can lead to successful transfer of skills. Such generalisation is necessary in order that the pupil can envisage adequate concrete ways of transforming and realising his existing practical experience in the new conditions of technical activity, and the level of

generalisation, its extent, in large part determine success in the transfer of skills.

Later transfer actually takes place. At this concluding stage the correctness of intellectual actions undertaken earlier is checked in practice. In cases when this does not give a positive result the pupils usually turn to analysis of the conditions of the task and the above-described process is repeated. Now, however, some of its stages may be abbreviated.

The confirmation of theoretical conclusions in practice assists towards the successful transfer of skills; the pupils gradually begin to acquire the versatile skill to perform different technical tasks of the given type.

In the process of successful transfer of technical skills the pupils' attitudes to work are changed, they are attracted by the active aspects, connected with overcoming difficulties in technical activity. This in its turn helps successful formation and transfer of technical skills.

COMBINATION OF THE VERBAL AND VISUAL IN TEACHING

L.V.ZANKOV¹

IN his work the teacher combines words (stories, exposition, questions, replies, etc.) with various visual means (objects and processes in nature, models, pictures, etc.). This is a key feature of teaching practice and successful teaching depends to a considerable extent on the correctness of the combination. Closely allied to this question is that of the interaction of word and image in the mental activity of children particularly in the course of mastering knowledge in school.

This matter has often been broached in psychology and has been the subject of much research. Thus the researches of L.S.Vygotski [3], A.R.Luria [19] and others have emphasised the role of speech in the development of perception in children. B.G.Ananiev has drawn attention to the role and organisation of the process of observation, an important aspect of which is the breaking down of a task into separate sections by way of a series of questions [2]. A.N.Leontiev [14, 15] has made an analysis of the use of visual material in teaching from the point of view of the cognition of different aspects of a visual object (for instance, a visual aid may serve to create a specific image or may be used with the aim of disclosing the essentials of the phenomena under study).

The interrelation of word and image in the mastery of knowledge has been widely studied in researches under the direction of N.A. Menchinskaia [e.g. 20, 10, 12, 17]. In particular, these have brought to light the conditions in which variation of inessential features of a visual object makes abstract and generalised propositions, formulated in words, accessible to pupils. Other important connections and interrelations have also been found.

¹ Of the Institute of the Theory and History of Education, Academy of Educational Sciences of the R.S.F.S.R. Published in *Voprosy Psikhologii*, 1957, No. 6, pp. 40–57. This article is slightly abridged.

The interrelation between sensory and logical components of the cognitive process runs like a red thread through researches undertaken under the direction of Ananiev. This has been studied in relation to material on quantitative imagery and number habits [16] and the teaching of drawing [4], and there has also been analysis of difficulties in mastering reading and writing [1] and investigation of the development of perception in children [18].

The interrelation between different properties of objects and mastery of the meaning of corresponding words has been investigated in comparative studies of normal and intellectually backward children [27]. There has also been comparative study of the interrelation of verbal exposition and perception of objects in the formation of images [21, 25], research into the differentiation of similar objects [22], practical actions [23] and the characteristics of the process of comparison [9].

Pedagogical aspects of the use of the word and visual means in teaching have been dealt with in didactics. Thus B.P.Esipov [6] notes as sources of pupils' perception of new material (1) the words of the teacher (explanation, exposition), (2) direct observation of the objects and phenomena under study, (3) visual aids portraying the phenomena studied, (4) textbooks and other written material. M.A. Danilov [5] differentiates two forms of cognition and mastery of knowledge by pupils: direct perception of the object studied and indirect cognition in which the teacher's explanations take first place. M.N.Skatkin [24] devotes attention to the teacher's direction of observation by the children.

Research into the interaction of the verbal and the visual in teaching was undertaken under our direction in 1952 [7, 8]. The researches to be outlined in the present article were concerned with special study of the combination of the teacher's words and visual means. In order that the work might serve to improve the practice of teaching it was necessary to discover the most effective means of combining the verbal and visual in given conditions and to give a preliminary explanation of their effectiveness. Subsequently it was necessary to turn to the results achieved, i.e. to study the quality of mastery of knowledge, and, in order to explain the effectiveness of the best methods, to penetrate into the process of mastering knowledge itself.

From the whole range of teaching we chose for investigation the teacher's exposition of new material. From among visual means we selected objects and processes in nature and portrayals of natural objects (models, pictures, etc.). Thus the object of the investigation was the methods used in lessons of combining the teacher's words and visual means closest to nature in the exposition of new material, and the course of the pupils' mental activity in relation to different methods of

combining the verbal and visual. We attempted to study these combinations in their connections with other phenomena, particularly their dependence upon the aims of the lesson.

In the light of all this the study of lessons was a central methodological point and was undertaken with a view to formulating questions. Lessons were observed without interference by the researchers. Analysis brought to light different methods of combining the teacher's words and visual means and resulted in assessments of their effectiveness.

Simple observation, though essential to establish the typical features of general teaching practice, could not provide material for evaluating the effectiveness of specific methods. To this end the teaching experiment was used, in the form of experimental lessons, conducted under the usual classroom conditions, and experimental tasks performed by a small number of pupils.

We adjudged the quality of knowledge according to data obtained from individual conversations conducted after each experimental lesson. Conversations conducted before the lessons served to establish the level of knowledge with which the pupils of parallel classes entered on these lessons. Comparison of the record of conversations conducted before and after lessons (preliminary and subsequent conversations) provided a sufficiently exact assessment of what precisely the pupils had learned in the given lesson. In addition the pupils did control work performing different tasks with set material. In order to assess the stability of the knowledge mastered individual conversations were conducted a considerable time after lessons.

Since differences in the quality of mastery of knowledge might be conditioned by dissimilarities in the constitution of parallel classes, we excluded this possibility by way of cross study. Thus, having distinguished four forms of combination of the verbal and visual, of which Forms I and III were comparable, we gave each class concerned lessons according to both these forms of combination; the case was similar with Forms II and IV.

Such methods of investigation as observation of pupils in lessons, individual conversation, etc., cover the elements of a psychological description and analysis. But they are manifestly inadequate when it comes to explaining the effectiveness of certain methods of combining the verbal and visual. In this connection we used experimental-psychological methods of research and physiological analysis.

These methods were applied to single out typical phenomena which have place in classroom practice and to study these on experimental models. To construct models the simplest variant of the given phenomenon, which nevertheless preserved its specific nature, was

selected. The pupils' mental activity was studied according to experimental methods used in psychology and the physiology of higher nervous activity.

When a comparative evaluation of certain methods of combining the verbal and visual had been made and substantiated the results were applied in teaching. The improved methods, having been tested in practice, were correspondingly amended in preparation for general use.

As may be seen from this account there was in this research an organic connection between study of the methods used by the teacher and of the pupils' mastery of knowledge. Another characteristic was the bringing together of study of typical features of classroom practice with experimental study of the regularities connecting specific forms of these phenomena.

The present article will deal with only certain sections of the research.

The effectiveness of different forms of combining the verbal and visual

On the basis of the factual material we collected and also of data derived from psychology and didactics, we distinguished basic elements which reflect in a generalised form the similarities and differences between various combinations of the verbal and visual. These elements are the *forms* of combining the verbal and visual. Four basic forms were distinguished in relation to the presentation of new material in lessons.

The characteristic features of Form I are as follows: the teacher's words direct the pupils' observation and knowledge of external aspects of an object, but the pupils themselves derive the directly perceptible properties and relations from their observation of the object.

The basis for distinguishing this form of combination is the specific function of the teacher's words and of the visual means used in the process of learning. In this form of combination the teacher's words designating the object at the requisite moment do not impart information to the pupils but serve to rouse them to observe the object, to direct the process of observation into the specific channel of studying the external aspect of the object. Correspondingly the specific function of visual means in the given combination is determined by the fact that the pupils gain knowledge about the external aspects of the object by observing it, not from the teacher's verbal exposition.

An example may be cited from a botany lesson in Class V concerned with the cellular structure of the leaf. Questions were put to the pupils which called for a description of the given object. For instance: 'Turn to

the outer layer of the leaf: how are the cells distributed?' 'Look at the cells of the pulp, do they closely adjoin one another, like the cells of the outer layer?', etc. The lesson was not, of course, confined to differences in the tissues of leaves but went on to other points which we did not cover as they dealt with connections beyond the limit of direct perception.

The given form of combination of the verbal and the visual contrasts with another which we called Form III. The following are the characteristic features of this form; the pupils acquire information about the external aspect of the object, its directly perceptible properties and relations, from the teacher's verbal exposition while visual means serve to reinforce or concretise this verbal exposition.

As an example of Form III we may take an extract from a lesson on the same theme. The teacher herself gave an exposition of the necessary information: 'The outer layer of the leaf is made up of cells closely adjoining one another. The cells making up the pulp of the leaf are arranged in many rows, but loosely, with inter-cellular spaces'. This verbal description accompanied the pupils' observation of the corresponding aspects of the object.

In this case it is the specific function of the verbal to provide information about the external aspect of the object. The specific function of the visual means is that it reinforces or concretises this exposition; the pupils do not gain new information about the external aspect of the object from perception of it since they already have this information from the teacher's verbal exposition.¹

In the course of our research certain correlations between the effectiveness of Forms I and III came to light. In this article we can only give data relating to particular lessons but they were found to be typical.

We may take examples from botany lessons in which the microscopic structure of the leaf is studied. An important aspect of these

¹ The two other forms of combination distinguished, not covered here, are used in study of the connections and interrelations between phenomena. In Form II the teacher's words lead the pupils, on the basis of observation they have undertaken and knowledge they already have, to cognise and formulate connections between phenomena which are not directly perceptible; i.e. the teacher's words do not guide observation but guide interpretation of the given observation and selective reproduction of former knowledge, while visual means serve as a support, reinforcing, concretising, verbal exposition. In Form IV this combination is used differently. While the pupils observe a visual object the teacher gives an exposition of connections which they cannot directly perceive, drawing conclusions, unifying or generalising different data, i.e. the teacher's words cover connections and dependencies between phenomena and the function of the visual object is to serve as a starting point for this verbal exposition.

lessons is to familiarise the pupils with the directly perceptible properties of an object so that Forms I and III of combination of the verbal and visual are used.

A comparison of the frequency of use of Forms I and III in such lessons is given in Table 1; this gives the absolute quantity of cases of application of each of these forms of combination.

TABLE 1
Forms of combination of the verbal and visual in botany lessons on the microscopic structure of the leaf

Classes	Forms of combination	
	I	III
V ^m	10	8
V ^h	0	15

As may be seen, in Class V^m Form I was predominantly used and in Class V^h only Form III. Table 2 gives the total number of answers by pupils in individual conversations, divided into two categories, the correct and incorrect. In addition we have noted the number of cases in which no answer was given though the corresponding material had been set out in the lesson. Five pupils from each class took part in the individual conversations (two proficient, two medium and one weak).

TABLE 2
Number of answers in individual conversations after a botany lesson on the microscopic structure of the leaf

Classes	Total Questions	Answers		No answer given
		Correct	Incorrect	
V ^m	55	42	2	11
V ^h	55	23	6	26

The correlation between the number of correct answers and the number of cases when an answer was lacking reflects the extent of the pupils' knowledge. The correlation between correct and incorrect answers characterises the accuracy of knowledge. The data given above indicate wide differences between pupils of the two classes in relation to extent of knowledge; the number of correct answers given by pupils of Class V^m was almost four times the number of cases of lack of an answer; there were less correct answers given by pupils of Class V^h than there were cases of failure to answer. Differences in accuracy of knowledge may be clearly discerned. In Class V^m incorrect answers were less than 5% of correct answers, while in Class V^h the corresponding proportion was almost 25%.

These data were supported by analysis of control work performed by all the pupils in both the parallel classes. Analogous results were obtained from questions concerning the position of leaves on the stalk, the internal structure of the stalk, etc.

The greater effectiveness of Form I combination in familiarising pupils with the appearance of objects was also found in the teaching of geography and history and of elementary science in the primary classes.¹

The effectiveness of the different forms of combination of the verbal and visual varied in relation to different sections of the syllabus. We may illustrate this with material relating to Form I, by comparing the results of lessons on the external structure of the leaf with the results, already given, of lessons on the cellular structure of the leaf.

TABLE 3

Forms of combination of the verbal and visual in botany lessons on the external structure of the leaf

Classes	Forms of combination	
	I	III
V ^m	11	12
V ^h	0	16

Comparison of Table 3 and Table 1 shows that frequency of use of Forms I and III of combination was approximately the same. But differences in the mastery of knowledge as between pupils of Classes V^m and V^h were much less after lessons on the external structure of the leaf than they were after lessons on the cellular structure of the leaf. This may be seen by comparing Tables 2 and 4 (though the latter covers the additional category of 'inadequate' answers).

TABLE 4

Number of answers in individual conversations after a botany lesson on the external structure of the leaf

Classes	Total Questions	Answers		Incorrect	No answer given
		Correct	Inadequate		
V ^m	55	36	5	1	13
V ^h	55	26	6	3	20

The lesser variation in effectiveness as between Forms I and III in this second lesson is conditioned by the fact that less differentiated

¹ We found analogous differences in effectiveness between Forms II and IV of combination of the verbal and visual.

and precise observation is required when studying the external structure of the leaf than when studying its microscopic structure. An analogous variation in the effectiveness of the given forms of combination was found in the case of other material, when the objects observed had marked or slight similarities. This variation increases considerably when words are required to make a more precise analysis of an object. It was also found that Form I combination is of greater effectiveness in relation to accuracy in the mastery of knowledge.

Experimental data bearing on the variations in effectiveness of different forms of combination

As has already been noted, a psychological and physiological analysis of the mastery of knowledge is essential in order to explain variations in effectiveness of different forms of combination of the verbal and visual. In this connection an attempt was made to discover the characteristics of the pupils' mental activity in order to arrive at an understanding of the physiological mechanisms which underlie the mastery of knowledge according to use of different forms of combination. Here we took as a point of departure Pavlovian experimental data which have brought to light the laws governing higher nervous activity.

It must be noted that investigation of the interaction of the two signal systems has as yet thrown no light on the specific forms in which general laws find expression in the process of mastering knowledge in school. An experiment was undertaken in this direction by I.I.Sborovska. The methods used were grounded on the speech-motor methods of A.G.Ivanov-Smolenski [11], the cornerstone of which, as is known, is acceptance of the particular importance of speech signals in the higher nervous activity of man, but these methods could only provide a basis. It was necessary to construct a form of experiment which could serve as a model of pedagogical phenomena and, more important, provide an answer to the specific questions under study. Direct stimuli were employed but these were predominantly visual with a greater or lesser number of properties (for instance, geometric structures and flat figures of different forms and colours of a greater or lesser degree of similarity).

In addition the experiment was varied in relation to the character of the verbal exposition to the subjects. Preliminary verbal instructions, which are widely employed in the laboratories of L.A.Orbeli, V.P.Protopopova, A.R.Luria, A.N.Kabanov, provided a basis. The speech-motor method was used to obtain material which could be compared with facts obtained from the experiments conducted with preliminary verbal instructions. These instructions figured either in the

form of general indications ('When you see a circular figure, press'), or as a reinforcement which was graduated in two degrees ('When the figure is not circular, do not press', 'When the figure is not quite circular, do not press').

The experiments were also varied in other directions. In some the series of verbal instructions were not accompanied by indication of a 'model' of those objects to which the pupils must react by pressing on the bulb. In others, the experimenter, when giving the verbal instructions, indicated to subjects an object representative of the category of objects to be shown. For instance, simultaneously with the instruction 'when you see a circular figure, press', a circle with a diameter of 34 mm. was shown.

When we chose direct stimuli we had in mind one of the essential differences in pupils' knowledge resulting from use in lessons of Form I and Form III combination of the verbal and visual. When Form I is predominantly used, pupils' images of the external aspect of objects differentiate well between objects. When Form III is predominantly used there is hardly any differentiation of objects according to their external aspect.

In this connection emphasis was given in the experiment to differentiation of similar objects. Thus a circle was shown and ellipses either markedly differentiated from a circle (e.g. 50×25 mm.) or similar to a circle (e.g. 50×45 mm.). Consequently the degree of similarity of the objects presented was graduated. The basic indices, according to which we judged the character of the conditioned reflex activity produced were the latent period of the motor reaction, the content of the verbal answer, the relation between the motor reaction and verbal answer. The subjects were pupils of Classes I, II and III.

We may now turn to the facts. In order to make a clear exposition we will use material obtained in the series of experiments with one particular group. With the same aim facts were obtained from another series of experiments; we have in mind, in particular, the formation of conditioned reflexes in relation to stimuli (visual, aural) and generalisation of the conditioned connections formed.

When preliminary verbal instructions took the form of general indications, primary generalisation of conditioned connections became prominent; the subjects could not differentiate even a very dissimilar ellipse (e.g. 50×25 mm.) from a circle. The latent period of reaction to presentation of the ellipse was no different from the latent period of reaction to the circle.

When the verbal instructions were made more precise the subjects began to differentiate the ellipse which differed considerably from the circle. However, when there was a close similarity (e.g. an ellipse of

40×36 mm.) there was a motor reaction from the child (cf. extract from the record of 26.12.55).

Record of 26.12.55. Katia, 7 years

Instructions: 'When you see a circular figure, press.'
'When the figure is not circular, do not press.'

Stimuli	Conditioned reaction (latent period in seconds)
Circle of diameter 40 mm.	0·98
Circle of diameter 40 mm.	0·79
Ellipse 40 × 36 mm.	0·36
Ellipse 50 × 25 mm.	—
Circle of diameter 40 mm.	0·56
Circle of diameter 40 mm.	0·34
Ellipse 40 × 36 mm.	0·58

As is known, the basis for differentiation of closely similar objects is the fine functional mosaic of excitation and inhibition in the cortex. We may note, therefore, that in the case cited this mosaic was not formed even as a result of making instructions more precise. For differentiation to be achieved it was found inadequate to proceed only along these lines. In the experiment referred to above even a second degree of precision in the instructions ('When the figure is not quite circular, do not press') did not result in differentiation of the ellipse of 50×45 mm. from the circle. This ellipse was then presented in a vertical position after which differentiation did take place; the child did not then react to the given stimulus in any spatial position (cf. extract from the record of 26.12.55). There were later introduced 12 ellipses with different half-chord ratios all of which were differentiated from the circle, i.e. there was adequate generalisation of the inhibitory connections formed.

Record of 26.12.55 (continued). Katia, 7 years

Supplementary instructions: 'When the figure is not quite circular, do not press.'

Stimuli	Conditioned reaction (latent period in seconds)	Comment
Circle of diameter 40 mm.	0·52	
Ellipse 50 × 45 mm.	0·72	
Ellipse 50 × 33 mm.	—	
Circle of diameter 50 mm.	0·90	
Ellipse 50 × 45 mm.	0·46	

Ellipse 50 × 45 mm.	—	Vertical
Circle of diameter 50 mm.	0·76	
Ellipse 50 × 45 mm.	—	

Changes in the position of the object or presentation of the object in another colour constitute an element of newness which is a condition evoking intensive orienting-investigatory reactions. The indication according to which we assessed the intensity of the orienting reaction was the latent period of the child's motor reaction; a sharp increase in the latent period testifies to the maintenance of an inhibitory process which is characteristic of the orienting reaction. Thus, when in some experiments the ellipse was presented in another colour the latent period was 1.20 seconds whereas the median latent period in six preceding reactions was 0.46 seconds (cf. extract from the record 16.3.56).

Record of 16.3.56. Vitia, 9 years

Instructions: 'When you see a circular figure, press.'

'When the figure is not circular, do not press.'

Stimuli	Conditioned reaction (latent period in seconds)	Median latent period in seconds
Green ellipse 40 × 36 mm.	0·31	0·46
Green circle diameter 34 mm.	0·64	
Green ellipse 40 × 20 mm.	—	
Green circle diameter 34 mm.	0·40	
Green ellipse 40 × 36 mm.	0·56	
Green circle diameter 50 mm.	0·50	
Green ellipse 40 × 36 mm.	0·37	
White ellipse 40 × 36 mm.	1·20	
White circle diameter 34 mm.	0·88	
White ellipse 28 × 25 mm.	—	

As a result of the intensive orienting reaction the ground was prepared for subsequent differentiation of a white ellipse very similar in form to a circle. The presence and intensity of the orienting-investigatory reflex play an essential part in specialised generalisation of positive and inhibitory connections.

Explanation of the variation in effectiveness as between Forms I and III of combination of the verbal and visual must be confined to a brief consideration of the main points.

The basic point is the correspondence of the given form of combination to the didactic task. When the latter consists in study of the external aspect of the object the teacher is concerned to ensure that the children adequately perceive the properties and relations of visual objects. In Form I of combination the teacher directs the

process of observing the object which is undertaken by the pupils. When Form III is used the pupils do not gain anything new from observing the visual object by comparison with the content of the teacher's verbal exposition. Characterisation of Forms I and III of combination, in relation to school work, allowed for some explanation of variations in their effectiveness. However, there could be no explanation of the kind sought without drawing on experimental data disclosing the characteristics and mechanisms of pupils' mental activity.

The teacher's verbal exposition, accompanying demonstration of the visual object, could in fact be described as directed observation. But, if this is so, why do the data relating to directed observation indicate much less satisfactory results than is the case when questions are posed directing observation to the object without explaining its properties?

The facts collected in the course of experiments and their interpretation throw light on the basic grounds for the superiority of Form I combination and the ineffectiveness of Form III. The results of the experiment upheld the preliminary explanation of the variation in effectiveness as between Forms I and III. Use of Form I evokes intensive orienting-investigatory reactions. The constant mobilisation of the orienting reflex promotes an active condition of the cortex which, as is known, plays a key part in conditioned reflex activity.

It is appropriate to introduce here data relating to the double action of stimuli which acquire the significance of conditioned stimuli. Such stimuli, as P.S.Kupalov [13] has shown, evoke on the one hand a conditioned reaction and on the other affect the tonus of the cortex. Kupalov emphasised the role of the orienting reaction in the formation, specialisation and generalisation of conditioned connections and this idea has since been upheld in papers submitted to the conference on the orienting reflex held in 1957 [26].

Mobilisation of the orienting-investigatory reaction leads to excitation of certain dynamic functional structures of the cortex. There then becomes manifest the advantage inherent in the first signal system of fineness of analysis: a functional mosaic is formed which serves as a basis for the differentiation and regrouping of similar objects. Thus the necessary prerequisites are created for elective, specialised generalisation of conditioned connections which takes place in the process of the joint work of the two signal systems, at a higher functional level than primary generalisation.

Our factual material gave grounds for concluding that these neurodynamic relations are of great importance in explaining the effectiveness of Forms I and III of combination. But these were manifested particularly clearly in our data because the subjects were

primary schoolchildren, so that the age characteristics of higher nervous activity in the young child (weakness of the second signal system, etc.) were reflected. When Form I is used with young children, therefore, the characteristics of this form of combination, which creates the most favourable conditions for joint work of the two signal systems, are thrown into sharp relief.

We may now turn to a particular variant of combination of the verbal and visual, that is those experiments in which verbal instructions were accompanied by showing a 'model' of the object to which the subject must react. In these the instructions given were: 'When you see a circular figure, press' while there was simultaneously shown a green circle with a diameter of 34 mm.

Record of 12.11.55. Liuda, 7 years

Instructions: 'When you see a circular figure, press', simultaneous showing of a green circle of 34 mm. diameter.

Stimuli		Conditioned reaction
Circle diameter	34 mm.	0·81
"	" 34 mm.	0·78
"	" 34 mm.	0·67
"	" 50 mm.	—
"	" 34 mm.	0·76
"	" 50 mm.	—
"	" 40 mm.	0·98
"	" 28 mm.	—
"	" 40 mm.	0·75
"	" 50 mm.	—

As the above record (12.11.55) shows reactions took place only to objects identical with that shown, or very similar to it. In this case, therefore, the general character of the verbal instructions had no effect. It would seem that verbal instructions given in a general form ('When there is a circular figure, press') should cause the child to react to every representation of a circle. In fact showing a 'model' of the visual object with the instructions led to fixation of the reaction on the given stimulus. (An analogous phenomenon was observed in forming inhibitory conditioned connections to ellipses).

These facts may be interpreted as follows. By contrast with specialised conditioned connections, formed as a consequence of internal inhibition, the given form of specialisation is primitive, arising at a much lower functional level. The mechanism of this specialisation is a different form of inhibition, an external or unconditioned inhibition. This is, so to speak, an inhibition 'lower' in the nervous system—an inhibition of an inductive kind. When verbal instructions are accom-

panied by the showing of a 'model', a strong centre of excitation is formed at a specific point in the cortex, evoking inhibition of negative induction at neighbouring points of the cortex.

Conclusions

The work undertaken disproved, both on the methodological plane and on the basis of specific experimental research, the proposition that the word is 'omnipotent'. This is of no little significance. In education it is generally held that the word must supplement other methods of teaching. But statements to this effect are for the most part platitudinous. What is relevant to the essence of the teaching process, to methods of teaching and the organisation of a lesson, is the actual role of the word and of ways of using it, and this has not been clarified in any detail.

There are many good examples of purposeful, intelligent and precise use of words in teaching practice and these should be scientifically analysed. But verbalism has still not been overcome in the schools and words are often used in a primitive and inadequate way.

Our analysis of lessons and study of children's mastery of knowledge, in relation to the problems under review, show that even a slight change in the character of the teacher's verbal exposition can result in marked variation in the mastery of knowledge, in the results of teaching. Still more instructive in this connection are the data derived from application of psychological methods of research with use of physiological analysis.

In the experiments discussed above we arrive at a position which may at first glance seem paradoxical: the word, which in its nature is the source of generalisation, does not directly produce the desired generalisation of the properties of objects and actions directly perceived by the pupils. To ensure such generalisation special measures must be taken to stimulate the cortex and therefore to bring into action the advantages of fineness of analysis inherent in the first signal system.

The investigation also shows that the mere fact of using visual means in lessons does not ensure that verbalism is eliminated and a higher level of mastery of knowledge achieved. It is necessary to use those forms of combination of the verbal and visual which show higher effectiveness in relation to the given school work and to use them in specific conditions.

More than this, the use of ineffective methods of combining the verbal and visual may hinder the elimination of verbalism and improvement in the quality of mastery of knowledge. First, because there is an illusion that all is well which is an obstacle to improving teaching. Second, because pupils form a specific attitude to visual

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means, the visual object serves not as an object of study but rather as an aid to the reproduction of verbal knowledge.

In addition, unintelligent use of visual means may lead to a sharp diminution in the generalising role of the word. This is shown by the experiments in which verbal instructions are accompanied by showing a 'model', which indicate that in such cases primitive specialisation of conditioned connections results.

In relation to general teaching practice we found that use of Form III combination of the verbal and visual means markedly predominates over use of Form I. Many teachers in the primary and subsequent classes hardly use Form I of combination at all. It is necessary, therefore, sharply to increase the specific weight of Form I of combination in the case of work directed to study of the external aspects of objects. In addition, a rational balance in the use of Forms I and III of combination should be achieved. There is no need to enlarge on the fact that Form III is in general more economic in expense of time. This means that it is inexpedient to use Form I in cases when there is no significant difference in effectiveness between this and Form III.

The organisation of teaching along the lines suggested brings into play an important internal reserve, at the core of the educational process, to raise the quality of educational work in the schools.

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PSYCHOLOGICAL ASPECTS OF ARTISTIC EDUCATION

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I

IT would be wrong to suppose that the psychological basis of artistic activity is solely 'aesthetic feeling'. 'Art', wrote Chernyshevski, 'is produced not by an abstract striving towards beauty (the idea of beauty) but by a combination of all man's efforts and abilities' [1]. A similar idea was expressed by Turgenev, when setting out his own views on art in opposition to those of Chernyshevski: 'Art is such a tremendous matter that the whole man with all his abilities is hardly equal to it' [2].

Art has a profound and far-reaching effect on very different aspects of man's psychology—not only on imagination and the senses, as goes without saying, but also on thought and volition. Hence its enormous significance to the development of consciousness and self-consciousness, in moral education and the formation of a general outlook. Artistic education is one of the most powerful aids to a full and harmonious development of personality.

It is often said that artistic pursuits presuppose the presence of corresponding abilities in the sphere of sensation and perception (musical hearing, sense of rhythm, etc.), discrimination in emotional response, expression and so on. From a psychological point of view this is not sufficiently precise. If artistic activity only 'presupposed' the presence of these abilities, if it were only the arena for their manifestation, its educational significance would not be very great.

All abilities are formed and developed only in the process of activity, primarily in activity which of necessity requires the ability, which cannot be undertaken without it. The abilities needed for the pursuit of art are, therefore, formed and developed in the process of artistic activity. But since such abilities are created on the foundation of pre-

¹ Of the Institute of Psychology, Academy of Educational Sciences of the R.S.F.S.R. Published in *Sovetskaia Pedagogika*, 1946, No. 6.

requisites in the child, different children undergoing the same form of education will manifest widely varying abilities. Artistic education has the most immediate influence on aspects of the psyche which are primarily affected by the forms and emotional nature of art. Artistic pursuits are, therefore, primarily a school for perception, imagination and feelings.

II

In aesthetic perception the significance of the sensory form of things—‘sight’ and ‘hearing’ themselves—differs from that in other aspects of perception. What is important in ordinary, everyday perception is not so much the ‘sight’ and ‘sound’ of things as their meaning. I meet a man in the street: in the great majority of cases the whole content of the act of perception consists in this, that I know him as ‘so-and-so’ as a result of a single cursory glance. If the ‘sight’ of the man attracts my attention this is usually only to the extent to which it ‘stands for’ something: ‘He looks awful! Can he be ill?’ Listening to a speaker, do we not often ‘hear’ something besides the meaning of the words and the expression? Even in relation to intonation we usually ‘hear’ not so much this itself as its ‘meaning’: ‘he seems offended’.

To see and hear with the eyes and ears of an artist—a painter, an actor—is something entirely different. The artist Mikhailov in Tolstoi’s *Anna Karenina* ‘remembered all the faces he had ever seen’ but ‘did not remember a man’s name nor where he had met and spoken to him’. This directly contrasts with the fact that names usually call to mind faces. For Mikhailov the face was the ‘identifying feature’ of a man and he perceived and recalled everything to do with its external aspect and internal expressiveness.

The figurative arts call for clearcut perception of the actual ‘aspect’ of things, a raising of the veil of the habitual-schematic image which hides this from the usual everyday gaze. There results, in part, a diminution in the constancy of forms, magnitudes and colours characteristic of usual perception. When, therefore, the child portrays what he sees, he inevitably learns to see things anew, more precisely and exactly.

The same obtains in the case of aural perception. It is generally accepted that music calls for hearing of a specific kind. This applies equally to poetry which calls for a developed and discriminating perception of the sounds of speech. From a psychological point of view the concept of ‘poetical hearing’ is as legitimate and necessary as that of ‘musical hearing’. The actor (or artist in reading) must undoubtedly develop a special kind of ‘hearing’: if intonations are to be reproduced there must be ability to hear their nuances precisely.

Creative writing presupposes the development of various (ideally all)

aspects of perception.¹ The writer's 'eyes' differ from those of the painter (to describe in words implies seeing otherwise than when portraying), just as his 'hearing' is different from that of the musician or actor. But without a very discriminative development of both 'seeing' and 'hearing' (as also other aspects of sensation) creative writing is impossible. To give some idea of the continuous 'cultivation of perception' which is an essential link in the work of the creative writer an extract may be given from a letter written by Turgenev as a young man:

Every evening, before I go to bed, I stroll in the courtyard. Yesterday I paused and began to listen. These are the different sounds I heard. The sound of blood in the ears and of breathing—the rustling, the unceasing murmur of the leaves, the chirping of grasshoppers, there were four in the trees. The fish made a slight noise on the surface of the water, like the sound of a kiss. From time to time a drop fell with a slight silvery sound. A branch snaps—what has broken it? There is a remote sound—what is it? Steps on the road? Or the whispering of a human voice? And suddenly the fine soprano of a gnat sounding just by one's ear [3].

All forms of artistic activity call for both cultivation of the senses and the development of such complex perceptual abilities as, for instance, powers of observation. Artistic education must, therefore, always cover the education of perception. This is one reason why it is of importance to general education; by educating the ability to 'see' and 'hear' art creates the prerequisites for deepening and extending knowledge of the world.

III

Imagination is the creation of new forms with the material of earlier perception. It plays a vital role in every kind of creative work. It is essential not only to the activity of the inventor or experimenter but also in more abstract regions of science. 'It is absurd to deny the place of fantasy in the very structure of science,' wrote Lenin [4]; and again 'it is essential even to mathematics, the inauguration of differential and integral calculus would have been impossible without fantasy' [5].

Nowhere, however, does imagination have such exceptional importance as in art, in the process of artistic creation. Forms of imagination have place in science only when the scientist's creative thought is incorporated in material. In art the creation of forms is the direct task of the creator: the artist—the writer, painter, composer, actor—

¹ To the question, 'What kind of perception provides the foundation for the formation of images (visual, aural, etc.)?', Maxim Gorki answered 'All perception, that goes without saying.' *How We Write* (Leningrad, 1930), 27.

embodies in forms his own ideological intentions. Imagination, therefore, takes a central place in the process of artistic creation, and this means that all creative activity in the course of education can serve as a powerful means of developing imagination.

Education of the imagination, however, serves other aspects of artistic activity besides the creative in the narrow sense of the word (creative as 'composition'). Of particular importance psychologically is 'reproductive' imagination, that is, the organisation of images in accordance with given instructions (a schema, draft, etc.). Imagination of this kind underlies, for example, musical execution—the construction of musical forms on the basis of written notes.

Reproductive imagination is particularly clearly displayed in the reading of literature—the construction of images on the basis of verbal description. This is not, of course, the case with all reading. Reading which merely has the aim of knowing 'what is said here' and 'what happens next' does not call for active imagination. But reading which thoughtfully 'sees and hears' all that is in question, which transfers the reader into the situation portrayed so that he 'lives' in it—for this active imagination is essential.

Gorki's description of his first literary impressions indicates the immense force reproductive imagination can engender.

I remember I read Flaubert's *Simple Heart* one evening, sitting on the roof of a shed where I had hidden myself to get away from crowds in a holiday mood. I was entirely overcome by the story, altogether deaf and blind—the depiction of a common old peasant woman, a cook, who performed no heroic deeds, committed no crime, cut me off from the noisy spring festival. How could such simple, familiar words used by a man in a story about the 'uninteresting' life of a cook so agitate me? This was an incomprehensible puzzle and—I do not exaggerate—many times, mechanically and like a savage, I held up the pages to the light as if looking for a solution between the lines.

And I was entirely defeated when I read the pages in Balzac's novel *The Wild Asses Skin* where he describes a banquet at the banker's, at which some twenty people are speaking simultaneously making a chaotic noise, but I could hear the many voices. Even more important, I not only heard but saw, saw the eyes, smiles, gestures of the speakers, though Balzac described neither the faces nor the appearance of the banker's guests [6].

It is not everyone who can read literature in this way. This is the very stuff of mastery which requires study, which children should be educated to achieve, the realisation of which leads to extending and deepening their imagination.

IV

Art is not only imagery but also emotional cognition of the world. It is this that determines the formation of artistic perception. If scientific observation is sometimes called 'thinking perception' then aesthetic perception may be called 'feeling perception', emotional perception. To understand art means, above all, to feel, to experience it emotionally, and thereby to think about fundamentals. The perception of art must begin with feelings; it must proceed through them; without feeling it is impossible. But, of course, artistic perception involves much more than feeling. It is perception which, beginning with 'feeling', later, and as a consequence, becomes 'thinking' and very deep and penetrating 'thinking'.

This aspect of the psychology of artistic perception was always strongly emphasised by Belinski: 'Poetry first grips the heart and later transfers to the head' [7]. 'With poetry it is first necessary to feel in order to understand thought' [8]. 'Enthusiasm is the first and necessary moment in the study of poetry' [9]. To understand art 'in the head without the participation of the heart', this, in Belinski's view, 'is hardly more than if it were to be understood with the legs' [10].

In this sense it can be said that artistic perception must always be emotionally direct. Lack of such 'directness' towards works of art implies lack of a specifically aesthetic attitude to them. It is one of the most difficult tasks of artistic education to preserve emotional directness, through a growing realisation of attitudes to art, its content and techniques. The example of great artists shows that this problem can be solved. This, for instance, is how S.V.Obratsov describes Stanislavski:

Stanislavski is a wonderful audience, both sincere and direct. There are expert spectators who know, perhaps, how to give advice or judgments but are incapable of looking. It is difficult to act before them. There is nothing of this about Konstantin Sergeevich. He shouts with laughter and rejoices aloud, his eyes kindle, there is nothing, not the slightest indication, of the professional appraiser.... It is the ability to preserve direct perception of life and art, not in a narrow professional but in a live way, that has brought Stanislavski success, a success, indeed, unequalled in the history of world theatre [11].

It is inadequate to affirm that the problem of preserving emotional directness can be solved; it should rather be said that unless it is solved aesthetic development is altogether impossible. Though perception of works of art must be 'direct' and emotional, the potentiality for such perception, in particular in relation to great works of art, is not itself 'directly' given; it calls for a great deal of preliminary work, a certain 'readiness', a developed culture both in a general and specifically aesthetic sense.

Thus Belinski, who persistently stressed the need for a direct-emotional approach to works of art, stressed with equal firmness that this presupposes a great deal of preparatory work: 'Without preparation, without passion, without work and persistence in developing and refining the senses, no one comes to art' [12]. There must be the same kind of study as in the case of science, because for a true understanding of art, for true enjoyment of it, consistent study is needed, increasing study, and of many things which, of course, fall altogether outside the sphere of art' [13].

Much of what has been said also applies to music—music is often thought of as the 'language of the senses'. A drawing or picture is primarily a portrayal of certain things with the help of line and colour but this does not always have an aesthetic significance, an emotional effect (for instance, an illustration in a textbook). The same may be said of literature, of verbal description in the wider sense of the term. Music, by contrast, has no significance outside the emotional reaction to it. It does not figure for the child as an aesthetic object but is expressed directly and specifically to his senses. When this is not the case it has absolutely no meaning for him. Chernyshevski, asking 'What need is it that causes man to break into song?', rightly answered 'it would seem that this is a need quite distinct from a striving towards beauty'. Singing is 'a product of the feelings', it is, 'in essence', 'an expression of happiness or sorrow' [14].

Art, then, is one of the most powerful means of educating the senses. It develops emotional sensibility, compassion, receptivity. It broadens man's emotional experience not only by reflecting intimate feelings known to him but also by disclosing new feelings previously unknown. Nikolai Ostrovski wrote of this very simply and convincingly:

You know why I love music so? I have known much blood and suffering during my life. I grew up in hard times. We did not spare our enemies nor take care of ourselves. Now I am a writer and it falls to me to write about life. The scenes of the civil war, the feeling of hatred towards the enemy, are fresh in my memory. But in my life I knew nothing of love. Here Chaikovski evoked thoughts, discovered to my soul intimate feelings, whose very existence I had not so much as suspected [15].

Art, more particularly music, does not, of course, necessarily evoke intimate and 'tender' feelings; it can equally well evoke manly, heroic feelings, feelings of every kind whose existence a man has 'not so much as suspected'. But it is not enough to say that art provides rich emotional experience. It provides emotional experience of a specific kind: it provides not merely simple experience of feelings but also understanding of them and leads through understanding of feelings to mastery of them. 'The more affect comes under our control...', wrote Spinoza, 'the more we master it by understanding' [16].

All artistic activity—both creative in the strict sense (composed) and executive—normally leads to the development of valuable abilities, to the combination of emotional sensibility with self-mastery. Such a combination is essential to artistic creation which is impossible in the absence of deep emotional involvement; impossible, too, without the full participation of all abilities, and without that ‘tranquillity’ which to Pushkin was one of the distinctions between actual inspiration and simple ‘enjoyment’ [17]. Genuine artistic perception not only extends and deepens emotional life but also fosters the ability to master and govern one’s own feelings.

V

The perception of art is an active process which embodies motor moments (rhythm), emotional experience, the work of imagination and ‘thinking operations’. These last have a particular importance in young children. Whether or not children’s literature is intelligible is determined primarily by its potentiality in realising internal activeness—putting oneself in the place of the hero of the story and acting with him.¹ Analysing the reasons for the success of the old, classic, children’s stories—the reason why children can listen to “The Red Cap” ‘twenty times on end’—S.Ia.Marshak justly notes: ‘This is because every proposition in the story, the succession and logic of motives, is so clearly in its place that each child can put himself in the place of the heroine of the story, can take part in “The Red Cap”’ [19].

For children of pre-school age listening to a story is to a considerable extent ‘thinking play’. This is why they love endless repetition of the same stories and the extensive use of repetition in traditional children’s tales. Internal activeness changes in form in dependence on the child’s age and level of development, but in one form or another it continues to be the ‘living spirit’ of artistic perception.

‘It is possible perfectly to understand reality in thought’, wrote Belinski, ‘but at the same time to be entirely outside it’ [20]. The primary educational significance of works of art is that they provide an access to ‘internal life’, the possibility of experiencing an aspect of life, bringing to birth a general outlook. It is also important that in the course of such experience attitudes and moral judgments are created which have incomparably greater force than judgments which are merely communicated and understood.

We may cite an example, belonging to an early age, which provides a simple case of the rise of new values as a result of ‘experiencing’ a

¹ This aspect is given primary importance in some interesting research undertaken in the psychology department of the Kharkov Pedagogical Institute [18].

story read [21]. Children of the age of two to three were read (or, rather, told) the following story:

Once there lived a boy. His name was Kolia. Kolia had a doll, Natasha. Kolia built a house with bricks, a lovely house, and the doll Natasha lived in this house. A dog came running in and knocked down the doll's house. The doll was left without a house and began to cry: 'Now I have no house, I have nowhere to live'.

Of the twenty-eight children who heard this story only four, in subsequent talk with the experimenter, adjudged those figuring in it: i.e. said the dog was 'bad' because it 'knocked down the house'. In the case of the more backward children the story, though fully understood, produced no evaluation. Some affirmed 'the dog is nice'; one, explaining this, said 'I saw a dog in the street: a little white dog'. Slavina explains this result as follows:

The expressions 'knocked down the house', 'have no house' are well known to the child from practice. He knows it is possible to knock down a building of bricks, he has done it himself. But he does not represent concretely that 'to knock down the house' means to be left 'without a house' and that this means 'to have no house'. He does not feel that 'to have no house' means not to have shelter: no shelter from the snow, no place to eat, no refuge from heat and cold, etc. As a result, recalling the 'knocking down of the house' he does not experience this as a 'catastrophe' for the doll and the story does not evoke the corresponding attitudes.

It should not be thought, however, that this result is determined by the age of the children, that in the third year of life the child is incapable of 'experiencing' a story and arriving on this basis at new moral judgments. An experiment conducted with another variant of the same story produced entirely different results. In this second variant some new phrases were introduced (those given in italics).

Once there lived a boy. His name was Kolia. Kolia had a doll, Natasha. Kolia built a house with bricks and the doll Natasha lived in this house. *The doll was happy to live in the house. Her bed was in it, she slept in it: there was a little table where she played and ate.* A dog came running in and knocked down the doll's house. There was nowhere now for the doll to live: *nowhere to put her bed, nowhere for her to sleep; there was no table and nowhere to eat; it began to rain and there was nowhere for her to shelter.* Without her house the doll cried.

Of the twenty-eight children who heard this variant, twenty-two evaluated the characters in the story. Even the boy who, after the first variant had

called the dog 'good', motivated by meeting with a little white dog in the street, now affirmed that the dog was 'bad' and to the question 'Why is the dog bad?', answered: 'It knocked down the house.' In the second variant no evaluation is made of any characters, least of all the dog, so that the children's evaluation could not arise from the story. It arose because in this case the children experienced the doll's 'catastrophe' at being left without a home. It is, of course, impossible to point here to artistic perception in the real meaning of the term. But in relation to what we are considering here this example is well worth study: it is a simple illustration that 'experiencing' a story can create new attitudes and evaluations and that this depends on features of the story.

A very similar case from a psychological point of view (though it relates to a considerably older age group) is that described by Chekhov in his story 'Home', which is often cited in relation to the education of children in art. The story relates that the seven year old Seriozha smokes. No amount of persuasion, moral teaching, examples ('The father Ignati died from consumption. If he had not smoked then perhaps he would be living today') had any effect in inducing a negative attitude to smoking, no matter how many people stressed 'it is wrong to smoke'. He came to this conclusion 'of himself' as a result of hearing a very naive story about an old Tsar and his son the Tsarevich who smoked. The story ended thus:

The Tsarevich, as a result of smoking, became ill with consumption and died when he was twenty years old. The crippled and sick old man was left without any help. There was no one to govern the state and protect the palace. Enemies came, killed the old man and destroyed the palace. There are now no cherry-trees in the garden, no birds, no blue-bells...so it is brothers.

For Seriozha's father, who related the story, it was entirely unexpected that it 'produced a strong impression'. 'His eyes clouded with grief, something like a look of fright; he gazed pensively at a dark corner for a moment, then quivered and said in a despondent voice, "I won't smoke any more".'

It is interesting to note that in both the cases cited the effective variant (the second variant of the story of doll and dog and the story about the smoking Tsarevich) does not differ from the ineffective (the first variant of the experimental story and the information about the father Ignati) from the point of view of the story, the subject, of 'action' in the wider sense of the term. The effective variant differs only in the additional descriptive elements (concretised features and situations) and in the expressions (which are emotionally charged). This appears to contradict the view so often emphasised that children's stories should give a straightforward portrayal of action without any writing up, characterisation and so on.

Any work of art can be of educational value if it impels the child to take up a certain position, begin to 'live' in this situation and so to look at the world and people's characteristics and attitudes from the angle this position dictates.... The first strong impression made by art on those who later become great artists is often described as emotional captivation with a hero and his deeds in which aesthetic and moral experience come together in an undivided whole. An example is M.N.Ermolova's description of her first theatrical (and aesthetic) experience:

I remember that, when I was only three, I sat in a prompter's box on my father's knee and gazed avidly at what was taking place on the stage. What I saw there was a handsome man in a torn cloak, climbing over an iron gate; this was the 'Spanish Gentleman' of I.V.Samarin. Of course, I do not remember what the play was about, nor the actor's performance, but I had an indelible impression of how beautiful, how noble, he was, that he protected and rescued someone, and finally that he was delivered from all the misfortunes that threatened him—all these pictures come to life in my memory and are clear to this very day [22].

Here there is recalled a clear visual image ('a handsome man in a torn coat climbing over a gate') and a still clearer moral-aesthetic radiation from it. The content of this aureole, determining the 'indelibility' of the impression, is in itself a moral value ('how noble he was, that he protected and rescued someone'), and a clear feeling with the hero ('that he was delivered from all the misfortunes that threatened him'). But this aureole is experienced aesthetically—'how beautiful he was', beautiful because he protected, rescued someone and luckily escaped all his troubles, perhaps because he climbed over the gate with captivating grace. Both moral and specifically aesthetic experience and evaluation in the perception of art arise on the basis of internal activeness, 'living with the hero', without this it would not be fully artistic perception.

VI

Artistic education, besides promoting artistic perception, must also be concerned with productive forms of artistic activity—what is usually called child art.

A harmonious conjunction of these two aspects is seldom to be found in traditional educational practice; there has usually been a one-sided approach varying in relation to different arts. In the figurative arts children were taught to paint and model (i.e. their creative capacities were developed, well or badly) but there was very little concern for perception. In literature there was experience, good or bad, of

perception but without any concern for the development of creativity. In music attention was confined to execution (including, of course, singing), little was done to provide the kind of teaching to develop musical perception, while creative work, or composition, usually found no place.¹

It has often been argued that creative activity in music and literature is the province only of particularly gifted individuals and therefore has no place in the education of the majority of children. Psychological findings have proved this to be incorrect. It has been shown that to draw young children into creative work instead of merely 'appreciation' (and not only the particularly gifted) promotes general artistic development, answers fully to the child's capabilities and potentialities and is altogether natural to him. Productive activity may be more natural, easier for young children, than 'appreciation' in particular fields. The research undertaken in Kharkov, referred to above, testifies to this. For instance:

The pre-school children did a little performance before those of their own age. It was evident that the young pre-school child found it considerably easier to be an actor than a spectator. As an executant he was very well orientated in portraying events, but as spectator he was bored and understood little of what was going on 'on stage'. It was amusing that at the end of the performance all the spectators usually assembled on the stage and took part in the spectacle [23].

From a psychological point of view this activity is not, of course, artistic so much as play activity, and in play the position of spectator is very difficult because of the absence of understanding. All these facts are worth considering since they bear, if not on the history, then on the 'pre-history' of the child's artistic development.

Diaries covering the development of children indicate that between the ages of three to four and six to seven many develop gifts for music, literature, acting, of a creative kind (leaving aside cases of outstanding talent) and do so independently, i.e. without any educational stimulus [24]. Sometimes such independent artistic activity at pre-school age has a considerable place in the child's life and takes on the character of improvisation, the degree of synthesis varying; this is at once composition and execution both of a text, music and sometimes also elements of acting and dancing. For one child the centre of gravity lies in composing a text, the melody simply serving this, for another composition of a melody is the centre of gravity and the words may be almost nonsense; but both understand their activity in the same way—'I am singing my song'.

¹ The work of individual teachers, who strove to build up a system of musical education on the foundation of 'creativity', is only a brilliant exception which contrasts sharply with the 'regulation' traditional musical education.

Another example may be given: a great many children of school age—and not only the younger ones—can be carried away by ‘storytelling’ which from a psychological point of view undoubtedly represents literary creativity of the type of improvisation. It is worth noting, first, that to be carried away by ‘story-telling’ is not characteristic only of those with special literary gifts, second, that in the majority of cases it arises entirely independently, i.e. answers to the child’s real and insistent needs. These, obviously, are the prerequisites for developing creative composition on the part of the majority of children.

The child’s productive artistic activity (child art) develops from play, which is the leading activity at pre-school age, and the prerequisites for it are created in play. But the essential difference between the two is that creative activity produces a product, a result, while ‘the motives of play activity lie not in the result of actions but in the process itself’ [25]. Artistic creation can, of course, produce deep satisfaction, happiness, enjoyment. The writer obviously feels the need to write, the singer to sing, the actor to act. But in all these creative activities the object is the result, the product. The young artist works not for the sake of creating but in order to have created.

A pointer to development is, therefore, the transition from activity directed only to the process itself to activity directed to the outcome—a transition noted by A.N.Leontiev in the case of ‘developed play-dramatisation’ which arises at the close of pre-school age (6–7 years), as distinct from the usual ‘playing of roles’ of the pre-school child. In the latter case the ‘motive for the child is not portrayal of a particular given personality but performance of his actions’ (the child strives to behave like a chauffeur, a doctor, a pilot), while in play-dramatisation ‘the child’s achievement covers not only portrayal of the person whose role falls to him but also the way he does it. To this extent play-dramatisation is one of the forms of transition to productive, or, more precisely, aesthetic activity’ [26].

There is ‘directness towards the product’ only in the measure that artistic activity becomes purely subjective, activity ‘for oneself’ and as interest arises in perception of its effect on others. When the musically gifted child of pre-school age sings ‘for himself’ he does not envisage that his song exists for others; this is not yet artistic-creative activity, though it may be unconditionally ‘musical’, i.e. an altogether sincere expression of feeling in musical intonations. Only at a more advanced stage of development does the need arise to share ‘one’s own song’ with others, even to influence others by it. This naturally leads to concern about the song, its production and ‘quality’. The material of diaries, already referred to, provides some ideas about this transition from singing (and ‘composition’ of songs) for its own sake, to singing directed to the perception of others.

One of the chief features, and the main problem, of artistic education is that the child's creative activity cannot be motivated as solely scholastic activity. When it is a case of doing mathematical problems it is unnecessary that pupils should feel the work necessary in itself, to give it meaning in this sense apart from the scholastic purpose. But a purely scholastic motivation is inadequate in the case of art. It is impossible to compose, to act, to paint, *merely* by engaging in the given activity: some part of the child's artistic effort must be directed to creating a product which has an effect, which matters to somebody, and this involves some consciousness of its potential social value. In the absence of this furtherance of the child's work will result only in the development of certain formal skills.¹

There is, of course, a place for purely scholastic work in artistic education. It may even take a greater place than the specifically 'creative' but it cannot be the only form of work, least of all at the initial stages when the foundations of attitudes to art are laid.

VII

The most important condition for child creativity is sincerity. In the absence of this all other values lose significance. This is the natural satisfaction of the creativity deriving from internal needs which arises independently in the child without any intentional educational stimulus. But it is inadequate to take only this into account in relation to organised education. Many children do not give evidence of it, though when their participation in artistic work is organised they may show outstanding ability. This raises a major educational problem—to find a stimulus that will bring to birth in the child a genuine and actual desire to create.

Tolstoi laid great emphasis on this and provided one of the main solutions to the problem in his article 'Who should teach whom to write; should the peasants' children teach us or are we to teach them?'. The paradoxical title need not deter us. This article has a psychological and educational insight which makes it one of the most worthwhile documents in the literature of artistic education. Intending to prove that 'we should not teach' the children of the peasantry to write, Tolstoi demonstrates in the most convincing way that the child can be educated in literary creativity.

He does so in describing work in his school at Yasnaya Polyana. For a long time, Tolstoi relates, he could not draw the children into

¹ It is interesting to note that the child 'story-telling' to which I referred above, which plays a considerable part in developing creative ability, usually develops as narration not to adults but to comrades, i.e. listeners to whom it appeals, who are gripped by it, to whom it is 'necessary'. The adult only becomes a real listener when he can sincerely be carried away by these stories, by their objective artistic effect, and is not merely hearer and critic.

composition. They did not understand the main point; why they should write, what is the good of writing.’ ‘Taking account of their inclinations, I set particular, artistic, pathetic, ridiculous, epic themes for composition—with no result. This is how I accidentally hit on the present method.’ The ‘present method’ was as follows. Tolstoi began, in the presence of the children, to write himself on the proposed theme: ‘Now who can write best? I as well as you’. The fact that he was a writer, that he, an adult, was also writing, naturally produced great interest. The writing finished, Tolstoi read his aloud: ‘They did not like it, nobody praised me.’ Then he describes his plan. ‘They began to prompt, to correct, to introduce their own propositions, to argue.’ ‘All were enormously interested. It was, of course, new and fascinating for them to assist in the process of composition, to take part in it.’ ‘For the first time they felt the fascination of expressing artistic needs.’

One boy, Fedka, participated wholeheartedly in the work: ‘His eyes shone, almost with tears: black, slender little hands were convulsively clasped; he became angry with me and incessantly drove me on—Have you written it? Have you written it?—was all he said to me.’ (At this stage the common work was written by Tolstoi and the children only dictated to him.) ‘We worked from seven to eleven o’clock in the evening; they felt neither hungry nor tired and even grew angry with me if I stopped writing.’ Fedka was ‘agitated and could not go to sleep for a long time’. ‘I felt that from this day a new world of pleasure and suffering had been opened to him—the world of art.’

An effect so strong is, of course, in part explained by circumstances absent in normal educational practice—the children were partners in the creative process of a Tolstoi. But the point is the educational principle applied. This was also applied in a more elementary form in the teaching of painting when Tolstoi did not act as teacher. In this case the teacher made a sketch on the board and ‘as it developed it was copied by the boys’. ‘That they saw the drawing take form under their eyes was of great importance. In this case the pupils see the painter’s sketch as a skeleton on which the body later takes shape.’ Thus, the first moment of Tolstoi’s attempt to involve the children in artistic creation is to show them not merely the product but the actual creative process—the process of writing, drawing and so on—so that they can, as it were, see with their own eyes how it is ‘done’. In the Yasnaya Polyana school this was the outcome of the method of teaching drawing. But Tolstoi’s method of involving the children in composition, employed with such notable effect, had an additional significance. The key aspect of this is the common work of teacher and pupils.

Tolstoi affirmed that what makes composition difficult is ‘the mechanics of the task’ and that these involve the following:

first, from a great many thoughts and images, selecting one; second, selecting words to clothe it; third, remembering it and finding a place for it; fourth, remembering what has been written in order not to repeat oneself, not to let anything drop, and ability to coordinate what comes after with what has gone before; fifth, and finally, thinking and writing simultaneously without allowing the one to hinder the other.

With rare pedagogical tact and mastery Tolstoi proceeded in this way. Initially he ‘took upon himself’ almost all the mechanics, leaving to the children only one moment (the second) out of the five—‘to clothe the images and thoughts in words’. Later, he gradually transferred the remaining moments of ‘the mechanics of composition’ into their hands: ‘I allowed them to choose, then to improve the writing and finally they themselves undertook the actual writing.’ It is this particular ‘division of labour’ that contributed so greatly to the success of Tolstoi’s method. When the boys had attempted earlier to work independently—even after the preliminary success in drawing them into co-operative work described above—they found the work beyond their powers, the result was not satisfying and so did not give them an inclination for the work.

The educative aspect of Tolstoi’s method is not only that he accustomed the children to a creative atmosphere and disclosed to them how the creative process operates in composition, but also that, as a result of co-operation at the outset of the work, he provided the possibility of achieving a worthwhile product, one that fully satisfied the children’s artistic taste. By reducing the gap between the children’s taste and their potentialities, what they could do in a way satisfactory to them, Tolstoi’s method converted the children’s work into sustained, serious, creative work. This is not, of course, the only way of stimulating children to creative activity. There cannot be any ‘one’ solution to this problem since, first, there are differences between the various arts, second, there are differences between children. As to the latter it should be stressed that an individual approach is nowhere more important than in artistic education. All children, depending on their particular talents, approach even one sphere of art in different ways. Here, it is not merely the ‘level’ or ‘degree’ of giftedness that is important—how gifted a child may be in the particular form of art—but also the place these gifts take in his character, his type.

There is a clear illustration of this in Tolstoi’s article. Not all the children were drawn into composition in a similar way under the influence of his method. It was most effective in the case of two boys,

Semka and Fedka, and they came to creative writing in psychologically different ways. Semka, to whom Tolstoi applies the epithet 'positive', came to creative writing by way of observation and imagination, that is, 'objective imagination'. 'Semka, it seemed, saw and wrote about what was taking place before his eyes: stiff, frozen, sandals, with the dirt trickling off them as they melted', etc. 'For Semka a predominantly objective image was necessary; sandals, a greatcoat, an old man or old woman, often without any connection between them.' In his writing 'the particulars are very correct, as it were poured out one after another'. 'The single reproach that could be made against him was that these particulars were depicted only at the present moment and had no connection with the general feel of the narrative.'

Fedka set out from feelings. Some of the features of his emotional involvement in the creative process have already been outlined. These were not only manifested in his external behaviour but in the creative process itself. 'Fedka saw only the particulars which aroused in him a feeling such as that of looking on a known person.' It was necessary to him 'to evoke feelings of pity with which he himself was inspired'. It is in this way that Tolstoi explains the remarkable 'wholeness of feeling' which differentiates Fedka from Semka.

There are to be seen here in embryo two sharply contrasted types of creativity, which are usually called objective and subjective. This terminology is acceptable in a psychological sense if it is considered as a characterisation of the creative process. But it cannot be extended to characterise the product of art: a man with a subjective form of creativity (of the type of Fedka) may produce work which is to a high degree objective. It is more precise to say that in the process of creation the first type proceeds predominantly from imagination, the second from feelings.

These two approaches are typologically very important and are most clearly evident at the first contact with art. In this connection another example may be cited—the approach to music in childhood of two great Russian composers, Chaikovski and Rimski-Korsakov. Both these were brought up in homes where music was loved but in an entirely dilettante way and in which it played a modest role. Neither had much chance of hearing good music and both learned to play the piano on the whole in an amateurish way. The external conditions for their musical development were, therefore, fundamentally alike. It is the more striking that they came to music in different ways, that it touched different 'strings', satisfied different needs.

For Chaikovski music was primarily a source of tremendous emotional force and a means of expressing his feelings. His first musical impressions were connected with a small mechanical organ at home. In later life Chaikovski often spoke of the 'transports' he experienced in

early childhood listening to the organist playing excerpts from Mozart's *Don Giovanni*. At the age of five, under the influence of these impressions, he began to pick up piano playing. His governess, Fanny Dürbach, related that the small Petia was 'always nervous and sad after long improvisation at the piano'. One day there were visitors and the whole evening was spent in musical entertainment. When Fanny took Petia to the nursery he could not sleep but with shining eyes, excited, began to cry. Asked what was the matter: "Oh, that music, the music.... Take me away from it, it is in me here, here"—said the boy, sobbing and pointing to his head—"it gives me no peace". Chaikovski's musical creativity began in the form of improvisation on the piano: written composition came much later. Improvisation, playing the piano, was the most direct way of expressing his feelings; at the age often he wrote in a letter to Fanny that he played the piano 'when sad' [27].

For Niki Rimski-Korsakov the emotional aspect of music had hardly any importance. He came to music by way not of the feelings but of imagination and a marked ability to master musical material (absolute pitch and a remarkable musical memory). His imagination, which was particularly strong and productive, was manifested mainly in play which moved over into dramatisation (play, it should be noted, by himself, as he grew up without playmates), and in constructive activity (play in a watchmaker's, the actual dismantling and assembling of old watches, the building of ships and so on). 'I was very inventive in play', notes Rimski-Korsakov recalling his childhood in his reminiscences. One occupation which provided rich opportunities for imagination was the composition of music. 'In play, by imitation, entirely in this way, just as I dismantled and assembled watches, I sometimes tried to compose music and write down notes.'

This occupation had less fascination for the future composer than playing at travelling and other forms of play. But because of his outstanding musical abilities it brought results and so served as one outlet of a need to compose, to invent, to construct, to combine, etc. The young Niki's musical abilities were truly remarkable. As he also recalls, 'I was not yet two when I could distinguish all the melodies my mother played to me'. At the age of four, 'I could hum correctly what my father played and often sang with him; later I myself began to pick out on the piano the pieces I had heard my father play on the harmonium'. Here he showed absolute pitch. Soon after he 'arrived independently at the point that I could write down on paper what was played on the piano' and soon 'began to reproduce in my head from written notes without playing on the piano'. At the age of ten to eleven he was writing quite complex compositions. In all this there is little to be discerned of an emotional attitude to music, little evidence of its emotional effect. 'It is impossible to say that I loved music at this period, I bore with it.' 'I do not

remember that music gave me great pleasure at that time.’ ‘I did not particularly like music, or, though I liked it, it hardly ever gave me great pleasure’ [28].

As has already been suggested, such typological differences in artistic gifts and in the approach to art show particularly clearly at an early stage of development; later they become blunted and the more so the more harmonious is artistic development. These qualitative differences in the approach to art of different children indicate not only the need for an individual approach in education but also the danger of using any single criterion in judging giftedness, artistic gifts included. Different forms of artistic activity affect different aspects of the personality. It is possible to ensure the full and successful artistic development of all children only if note is taken of the form of art closest to each and in this sphere a way of approach is found which corresponds to individual capacities. As Tolstoi rightly said: ‘I think a need for enjoyment of art and service to art is inherent in every human personality and that this need has a right to be and must be satisfied.’ All children, not only those who show special artistic gifts, have the right to a full artistic education.

VIII

The psychological content of artistic activity cannot be reduced to aesthetic experience in a general sense of the term, to experience of ‘beauty’ or ‘the beautiful’. Nevertheless, in the absence of a ‘sense of beauty’ it loses its specific character and may be deprived of all meaning. In this connection two psychologically essential points may be emphasised.

The first is that perception of ‘beauty’ necessarily includes a moment of evaluation. Herein lies one of the main differences between the ‘beautiful’ and what is simply ‘liked’ or ‘gives pleasure’. The education of artistic taste—and this is an important aspect of all artistic education—develops an ability to gain pleasure from works of art of high quality: this is education of an evaluating attitude to works of art, the formation of a specific system of aesthetic judgment. This moment of evaluation is an essential component not merely of artistic perception but also of creativity. Tolstoi’s conclusion that ‘in a writer, the thinker, artist and critic must act simultaneously’ [29] also applies to child art to the extent that it is truly artistic and productive and not merely play activity. From the moment that the child ceases ‘activity for himself’, i.e. play, and his perception is directed to the products of others, it inevitably includes aesthetic evaluation.

Without the development of aesthetic evaluation the development of other artistic abilities loses meaning. Artistic creativity is impossible in the absence of imagination. But, as the great artist Goethe noted,

'Nothing can be more terrible than imagination without artistic taste'. Tolstoi had this in mind when he said that 'the chief quality in all art is a sense of proportion'.¹ In relation to Fedka, referred to earlier, Tolstoi delights most of all in his 'sense of proportion' which 'was extraordinarily developed. He writhed at every superfluous detail suggested by any of the other boys'. 'This sense of proportion, which is acquired with tremendous difficulty and application only by the rare artist, was of a pristine strength in his innocent childish soul.' What was the criterion of this 'sense of proportion'? Obviously it was an emotional criterion, being carried away by feelings which must be expressed in the story he was writing. ('It was necessary to Fedka to evoke the feelings of pity with which he himself was inspired.') These feelings 'negated', in Tolstoi's expression, all that was superfluous to their full expression.

Here we may observe a point of general importance. The boy is moved in his creative process mainly by feelings of a moral order, pity for the old beggar represented in the story, and this moral feeling in its psychological nature is the foundation on which there developed what so much fascinated Tolstoi: exquisite subtlety, aesthetic evaluation, an almost infallible sense—in relation to the given material—of artistic proportion. This clearly indicates that aesthetic feeling does not arise and grow from some self-contained source in man's mental life, independently of the development of other aspects of personality such as the moral and intellectual.

The second essential point is that artistic evaluation in perception of art is an active process, more than this, it is a 'skill' which must be learned. It is, of course, to a considerable extent connected with artistic creativity (including execution). From the moment that this becomes an activity, 'directed to the product', it also becomes 'labour'—of all work the most subtle, painstaking and difficult.

Nevertheless artistic perception and creativity are only aesthetic activities if they produce aesthetic pleasure, or—in the words of Chernyshevski—that 'flash of joy', 'that special feeling, proceeding from disinterested joy and rapture which is called aesthetic pleasure' [30]. Pleasure is not essential to doing an arithmetical problem or geometrical theorem. It is, of course, very good if such work evokes intellectual pleasure but this is not an essential condition without which it cannot be successfully done. It is another matter with art. If a poem by Pushkin is the subject of study it must be a source of aesthetic pleasure; otherwise the subject is deprived of meaning and study of it becomes even more meaningless. In this lies one of the major difficulties for the educationist.

¹ Tolstoi often reiterated this idea in different forms.

IX

Art serves life and the child's artistic activity must, from the very outset, be linked as closely as possible with life. Love of art must, of course, be encouraged and the more gifted the child in a given aspect of art the more important this is. But with great gifts there is sometimes a risk that 'love of art' may obscure life itself, with its many-sided interests and relations. Such an attitude is harmful to artistic education and may even lead to personal catastrophe, like that of Pushkin's Salieri. This does not mean, of course, that limits must be set to the love of art. This is not the issue; the question is the relation established between art and life at the very first stages of artistic education. The 'greatly loved art' must not become a wall, cutting off from the world, but a path to the world, a window through which life may best be seen, a means of reflecting and expressing one's own impressions of life, a language for communication with people.

Stanislavski, whose whole life was fully and unreservedly spent in the service of art and who cannot possibly be accused of inadequate love of art, told his pupils: 'If you fence yourselves off from life you shut yourselves in a box; if you try to put up a partition between yourself and the rest of the living world, on the excuse of giving the whole of yourself to the stage, what kind of life can you reflect on it?' [31]. This implies, on the educational plane, that artistic education must not be separated from general education. The aim should be that all those concerned with artistic education look upon themselves primarily as teachers with general educational aims, and, on the other hand, that all teachers see artistic education as an essential, integral part of their work.

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