THE INFLUENCE OF CONTEMPORARY SCIENCES ON CURRICULUM

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The task of this contribution is to investigate the ways in which contemporary sciences influence the conception of curricula, with special reference to the experience gained in Czechoslovakia. Thus I shall deal with this factor only and omit the others, such as the arts, productive and other activities, as well as social, psychological, cultural and other influences. Science is a factor exercising at the same time a most profound influence upon the curriculum especially of secondary schools and one with which the curriculum is in marked contradiction.

1. MUTUAL RELATIONSHIP BETWEEN SCIENCE AND EDUCATION

On the one hand, science influences the curriculum and other problems in education, but, on the other hand, education is an indispensable precondition for the development of the sciences. Nowadays science, if it is to develop, needs a wide background in two senses :

(1) A certain level of scientific thinking on the part of common people and especially of the leaders of certain branches in the life of society. Without that level of education it would not be possible to introduce any innovations.[1] The education of a research worker and of a man in practical life should be on the same level in spite of the fact that the orientation of their activities tends to differ. The difference in the level of their education would be an obstacle to their collaboration.

(2) The development of science depends, apart from other factors, on the quality of the education, and of the curricula, that research workers have received in schools.

The mutual relationship between science and education has been expressed on the one hand, in university lectures and other forms of the dissemination of scientific knowledge for the laymen, by the interest of scholars in the conception of curricula of secondary and even primary schools, and by their authorship of school textbooks, and, on the other hand, in scientific work done by primary and secondary school teachers. For example, it was a very good tradition of the Annual Reports published by individual secondary grammar schools in Bohemia in the past that they always included a scientific article written by a member of the staff. The fact is that outstanding books have been written and much outstanding research has been done by teachers.

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1) According to the investigation carried out by Ladislav Tondl the insufficient education of managers slowed down the absorption of the results of science in practice. (Konference Cesty vědy do života, Liblice 1967, str.21, vyd. Socialistická akademie).

However, all these activities have been interrupted to a great extent : though outstanding scholars are assembled in research institutions they generally have no pupils ; scientific work is becoming more and more complicated and, on the other hand, work within the schools has also assumed a more complex character ; this together with the increase in the number of women teachers has slowed down scientific pursuits of teachers.

This gap between the sciences (and humanities) and education is detrimental to both education and science.

The main link between science and education is effected in the preparation of textbooks and curricula. It is here that science exercises an impact not merely on the selection of the subject matter, but also, and particularly, on the conception of subjects and on the conception of the curriculum as a whole.

2. TRAITS OF CONTEMPORARY SCIENCES

The contemporary development of science, referred to as the "science explosion" is characterized (1) by the growing extent of knowledge, which doubles every 10 years ; (2) by the growing number of persons working in institutions engaged in direct, or mediating research activities, the number of these having doubled during 15 years; (3) by the growing funds devoted to research ;[2] (4) concurrently with the growth of the external traits, by the expansion of science, scientific methods and findings almost in all fields of social life, and the growing social relevance of information resulting from science which has come into existence. This role of scientific information is intimately linked with the growing rationality of decision procedures and with the transition from decision-making on an empirical, or a purely experimental, basis to theoretically founded decisions ; (5) by the supposition, on the basis of extrapolation, that the mobility of scientific research and its results will be further intensified, particularly in the sense that the process of the transportation of scientific information between the centres of science and various fields of social, cultural and economic life will be speeded up, so that the average time lag between the moment of discovery and the moment of its application in extra-scientific life will be shortened.[3]

Many changes have occurred within the structures of individual sciences and in the character of scientific research, when compared with scientific knowledge of the 19th century, because of the necessity of interdisciplinary teams, of the complexity of investigations, and of the more abstract level of scientific concepts etc., as analyzed by many scientists.

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2) The figures are summarized and analysed e.g. by Luděk Pekárek in *Veda a vzdělání*, Socialisticka akademie, Praha, 1968, p. 25.

3) Points 4, 5 are explained by Ladislav Tondl, *Role and Task of Science in the Contemporary Scientific and Technological Revolution*, Paper No. 6 for the Conference "Man and Society in the Scientific-technological Revolution", Márianské Lázně, April 1968, Philosophical Institute of the Czechoslovak Academy of Sciences, Prague 1968, pp. 5-12.

3. THE CONSEQUENCES OF THE DEVELOPMENT OF SCIENCES FOR CURRICULA

It is not possible here to deal with the history and with the contemporary development of the impact of the sciences on curricula in detail. However, the outline above indicates some tendencies and problems in the curriculum making process, this being a field which is between education and sciences and which needs a dialogue and a clear competence of representatives of different branches.

First of all, the development of sciences (and also of other factors determining the contents of education) has resulted in a revision of the attitude to almost all problems in education, and particularly to the conception of curricula. As the expression of this impact the history of education shows many changes in the systems of secondary schools and their curricula which have occurred since the second half of the last century.

These changes have affected even the secondary grammar schools, schools with old and strong humanistic traditions. These schools were very good in their conception during previous periods but this traditional conception has become particularly obsolete. Some particular solutions were employed there, for instance, the theory which emphasized the training of intellectual skills and so defended the teaching of Latin; the establishment of new kinds of secondary grammar school like the so-called reformed secondary grammar school (reálná gymnasia, reformní reálná gymnasia, reálky) and secondary technical schools, as endeavours were made to include new facts and theories and new sciences in the curricula without changing their basic conception ; and, finally, the endeavours to establish a new balance between sciences and humanities.

However, the effect of all these measures was very limited. For example, the attempt to include new discoveries in the curricula was followed by an increase in the number of subjects and by an abundance of information in all subjects and, as a result, instruction suffered. All experience with partial improvements has shown that the principles of curricula ceased to be reliable and that it was necessary to answer the question of what should be the conception of contemporary and future curricula.

It is not accidental that all the contemporary theories of the contents of education, and particularly of the curricula, reflect the development of sciences and humanities. This is the case of the theory of "Fundamental Knowledge" by the Czech educationalist Otokar Chlup aiming at a wider cultural orientation of pupils and trying to combine the cultural and psychological aspects, just as the theory of Jerome S. Bruner, emphasizing the structure of knowledge, "Die Theorie der kategorialen Bildung" by Wolfgang Klafki or "Die Theorie des Elementaren, Typischen und Exemplarischen" in Germany as well as the experiments carried out by Elkonin and Zankov in the Soviet Union, aiming at a closer relation between the primary school curriculum and contemporary science, and many experiments within individual subjects.

But at the same time all these theories have remained only partial. They give a solution to some problems of the principles of contemporary curricula, but they are far from being a comprehensive theory which would be able to deal with the curriculum as a whole.

Some points have become more or less clear now :

(1) From the fact of the increasing extent of scientific knowledge as well as from the expansion of scientific knowledge and methods into almost all branches of life an assertion may be derived that education in science has become necessary for all, not only for the education of scientific workers, but also for mastering of the ways of scientific thinking and of the systems of scientific knowledge by laymen.

(2) Scientific knowledge is now so vast and is growing so rapidly that it cannot be acquired in any complete sense by the time pupils leave school. Since this is so, instruction can no longer aim at completeness. It can only be effective if it is deep and leads to an insight into the fundamental structures of knowledge, into "organizing ideas", as J. S. Bruner called it.

The analysis by Radim Palóuš of the evolution of chemistry textbooks in Bohemia during the last hundred years, as well as the analysis by Luděk Pekárek of the evolution of contemporary physics showed a tendency towards a more theoretical level of knowledge. Palóuš came to the conclusion that a hundred years ago the structure of chemistry as a subject in the secondary school consisted of three levels of knowledge : (1) the knowledge of individual concrete facts and descriptions — this was the main part ; (2) some technological knowledge ; and (3) theoretical knowledge, which was poor, isolated from the previous two levels, and which did not form the framework of the subject. Theoretical knowledge was considered as having the same meaning as the knowledge of concrete facts. This structure has been changing substantially during the last hundred years. The role, proportion and the number of concrete facts has decreased while theories have become the groundwork of the subject. Here the method of historical analysis and of extrapolation showed a tendency towards a more theoretical level of knowledge.

Radim Palóuš' statements[4] are supported by the investigations of the physicist Luděk Pekárek who analyzed the development of contemporary physics.[5] According to Pekárek it is not necessary to acquire many items of knowledge of each complicated system. It is enough if the pupil understands the main points, the idea of mutual relationships, everything else being capable of being derived by deduction.

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4) R. Palóus, Cile védeik, *pracovní a technické výchovy v chemir*, ab. Pedgogického ıstitutu c Praze, Prírodní vedy II, Praha, 1960.

5) L. Pekárek, *O moderní fyzice*, Praha, Cs.spol.pro sírení politických a vedechých nalostí, Praha 1964, p. 8.

(3) Theoretical knowledge and the method of scientific thinking are closely linked. It is not possible to develop intellectual skills and abilities without learning matter and also it is only possible to discover the skills and abilities of pupils through the learning matter. Sciences can now play a similar role in the training of intellectual skills to the one played by Latin in earlier times.

(4) The rapid transfer of the results of science into extra-scientific application lowers the value and significance of technical application in the curricula and enhances the weight of theoretical knowledge afforded mainly by general education. Moreover, the utilitarian conception leads to a reduction in general education and in theoretical subjects, and, as a result, the practical function of education tends to suffer as well.

(5) The relations between teachers and pupils, if they are to develop the pupils' capacities for independent thinking, must be more liberal, the repressive role of the teacher being reduced. For instance, the problem solving method, the method of discovery, of discussion, etc., are expressions of such relations.

(6) Other consequences operate in the field of curricula, for instance, the necessity of the teacher's active contact with scientific work. Such contact is an unavoidable prerequisite for innovations in curricula. When, for instance, Ivan Málek invited several teachers in his Biological Institute to work there for three months as members of a research team, the teachers found that their experience of scientific work very markedly influenced their work at school.[6]

4. UNSOLVED PROBLEMS

The preceding analysis has shown some consequences for curricula and syllabuses and for the solution of other problems in education of the development of contemporary sciences. But there remain unsolved problems.

(a) The theories and consequences outlined above can be considered as hypotheses and have not been fully realized. For example, a new conception of mathematical instruction devised by the famous mathematician Cech in Czechoslovakia failed. The cause of this failure was obviously not in the conception itself, but probably in the influence of tradition, in that the new conception was implemented by traditional methods and that the teachers did not understand and accept the conception, or were not able to change their routine, or, finally, that the experiment in one subject remained isolated while the conception of other subjects did not change.

(b) The general tendency towards a higher theoretical level of the subject matter involves a danger that the school might stress the training of intellectual skills and underestimate other domains, such as the affective or psychomotor, that subjects like literature or music might adopt the same tendency, which would be contrary to the idea of modern schools.

(c) The impact of sciences on the curriculum does not solve all problems, especially the relations between sciences and humanities, or, in other words, between the humanistic and scientific principles in education. This is not merely a problem of the proportion between these two groups of subjects, which has been settled in the twentieth century in favour of sciences, but one of their mutual relationship, particularly in the sense of the "humanization of natural and technical sciences".

To illustrate this problem let me quote two eastern philosophers. According to Ras Vihary Das "the prestige of science in the contemporary world seems to be largely due to the services it renders to militarists and industrialists . . . When you pursue knowledge, not for its own sake, but for the sake of the power it brings you to dominate nature and men, you have already started on a wrong path with a perverted mentality. It is therefore no surprise to find the great harm science has done and is doing to the spirit of man, as an ally of unholy powers, as an engine of destruction, as an instrument of exploitation and profit".[7]

What R. V. Das says here at least is that sciences are not able to solve the problems of the individual and of society, that they are blind in this sense just as the humanities are in technical problems.

In a similar way Humayun Kabir says : "The triumphs of science led men to believe that education of the intellect would lead to a change of heart and allow all men to meet on a common level of rationality. That hope has not been realized. This has induced in some a curious sense of helplessness and an attitude of fatalism reminiscent of days when man had no control over the forces of nature. Increasing knowledge of external nature helped man to overcome his primitive fatalism. It may be that increasing knowledge of man's inner nature will help him to conquer the fatalism of the modern age".[8]

For the school it implies at least the understanding of the coherence between nature, society and man. From this point of view a curriculum would appear to be an indissoluble unity, in the same way, as it was — though on a different basis — in the Middle Ages.

L'INFLUENCE DES SCIENCES CONTEMPORAINES SUR LES PROGRAMMES SCOLAIRES

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La science exerce une influence des plus profondes sur les programmes scolaires, spécialement dans les écoles secondaires. Elle dépend cependant de l'enseignement pour son propre

6) I. Málek in *Veda a vzdelání*, Prah, Socialistická akademie, 1968, p. 7.

7) R. V. Das, "The Concept of Man and the Philosophy of Education in the East and the West", In : *Humanism and Education in East and West*, Unesco, Paris, 1953, p. 78.

8) H. Kabir : "The East and the Problems of Education" in : *Humanism and Education in East and West*, Unesco, Paris, 1953, p. 114.

développement. En dépit de l'existence de cette relation, les chercheurs et les enseignants ont de plus en plus tendance à travailler séparément. Leur seul point de rencontre se situe lors de la préparation des manuels scolaires et des programmes.

L'explosion scientifique contemporaine est caractérisée par l'expansion de la connaissance (qui a doublé en 10 ans), le nombre de personnes engagées dans la recherche scientifique (qui a également doublé en 15 ans), les sommes de plus en plus importantes consacrées à la recherche et enfin par l'application de plus en plus répandue des méthodes scientifiques à tous les domaines de la vie sociale et spécialement aux techniques de prise des décisions.

Le développement des sciences (entre autre) a eu une influence considérable sur les programmes des écoles secondaires, même dans les collèges, qui ont une forte tradition humaniste. De simples modifications telles que l'introduction de nouvelles connaissances dans les programmes, se sont avérées désavantageuses. La conception de base des programmes actuels et futurs a été remise en question.

Les travaux de Otokar Chlup, Jerome S. Bruner, Wolfgang Klafki, Elkonin et Zankov ont porté sur ces problèmes mais les théories qui en ont résulté sont incomplètes. Il est clair cependant que la connaissance de la science (maîtriser les méthodes de la pensée scientifique) est devenu nécessaire pour tous. Une telle connaissance ne peut plus être complète. Elle ne peut être efficace que si elle va en profondeur et conduit à une introspective des structures fondamentales de la connaissance.

Un examen de l'évolution des manuels de chimie utilisés en Bohème au cours des cent dernières années révèle, selon Radim Palóuš, qu'au début, la chimie à l'école était une science descriptive n'offrant qu'une petite connaissance technologique et théorique. Les conclusions de Palóuš selon lesquelles une approche théorique a modifié les autres sont vérifiées par les études du physicien Ludek Pekárek sur le développement de son sujet.

La connaissance théorique et la pensée scientifique sont étroitement liées. Les sciences ont un rôle à jouer dans la formation des capacités intellectuelles, rôle similaire à celui joué par le latin autrefois. Pour permettre aux élèves de développer des forces indépendantes de pensée, le rôle du professeur (qui devrait être en contact direct avec la recherche scientifique) doit être plus constructif et moins répressif.

En mettant en oeuvre les changements recommandés, certains problèmes peuvent survenir. Les professeurs doivent bien comprendre ces changements qu'on leur demande de mettre en oeuvre. Les expériences sont souhaitables mais ne doivent pas être effectuées isolément. Un accent non justifié sur les activités intellectuelles pourrait voir jour. On devra se souvenir que les sciences ne peuvent résoudre les problèmes de l'individu et de la société. Un programme, qui devrait former une unité indissoluble, doit équilibrer dans l'éducation les principes scientifiques et humanistes.