RESULTS FROM THE ROSE PROJECT AND SCIENCE EDUCATION IN POLAND

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Abstract

During the last years many changes in organization of educational processes, aims and teaching contents as well as methods used by teachers have taken place. ROSE research carried out in Poland in 2003 provided the data contributing to better understanding and evaluation of effects of these changes. The research confirms that the pupils have much better attitude to biology and geography than to chemistry and physics. It was also found that pupils having worse scores in science exhibit more positive attitude to it which is confirmed by the ROSE research results concerning all participating countries. Differences in interests of girls and boys are typical of both sexes.

Introduction

The economical development of each country, whose target is material goods production, particularly in those technologically advanced, depends largely on the well-qualified staff and on the level; of the whole society education. This is well known truth responsible for achievements of the countries that have undergone fast industrial and economical transformations during the last several scores of years. Therefore it is obvious that the problem of science and technical education subjects is of primary importance when further development is targeted. The additional and equally important argument justifying interest in teaching those subjects is increasing importance in everyday life of the knowledge they include. Thanks to it one can make use of various products of contemporary industry in a proper way. It is also indispensable if we want to take a conscious part in making decisions concerning the closed environment e.q. connected with natural environment protection.

Adjustment of science education to satisfy the requirements is in many aspects a difficult task requiring various actions. First of all, it is necessary to determine the current state of teaching these subjects in a given country. At the same time very specific and precise aims as well as ways of the assumed changes realization should be determined. Therefore knowledge of factors responsible for course and effects of teaching these subjects is indispensable.

For a few years there has been carried out the international comparative research projects “The Relevance of Science Education” (ROSE) whose aim is getting to know some factors of importance to learning of science and technology (Schreiner and Sjøberg 2004). Poland is also a participant of his project. The research carried out by the authors of this paper resulted in the data that are applied in the comparative analyses concerning all the involved countries (Schreiner and Sjøberg 2006).

These data can be also used to determine the factors affecting science and technology teaching in a given country. So far many works referring to individual countries have been published (Alonso and Mas 2006: Anderson, Sjøberg and Mikalsen.2006: Jenkins 2005: Jenkins 2006: Jenkins and Pell 2006a; Jenkins and Pell 2006b: Jidesjö and Oscarsson 2006: Lavonen, Juuti, Uitto, Meisalo and Byman 2005: Matthews 2005: Ogawa and Shimode 2004: Schreiner 2006: Teppo. and Rannikmäe 2004; Trumper 2006). Therefore in the analysis of the obtained data we focused on searching for the factors in the context of changes in education occurring in Poland for several years. Consciously we did not stress application of statistical methods providing much reliable, accurate and detailed information. However, it is often difficult to pick out the most essential information. We rather attempted to find suitable dependences based on aims, contents, methods and conditions in which science and technical education proceeds. Therefore we were able to give their probable explanation at once referring also to the results of other research on a given problem. Then we assumed that the conclusions obtained from this analysis may indicate occurrence of analogous dependences in other countries which were not the subject of researchers’ interest.

Current state of science education in Poland

Great changes in science teaching caused by various factors have taken place during the last few years in Poland. As a result of educational system reforms in 1999 compulsory education lasts 9 years including six-year Primary School and three-year Junior Secondary School. During the first three years of Primary School within the integrated education pupils get acquainted with the elementary issues concerning nature in their closest surrounding and with operating common technical devices. The subject “Science” appears in the fourth form and is taught three hours a week for the three successive years. Besides, the timetable includes the subject “Technique” whose aims is among others, teaching elements of information technology. In Junior Secondary School science subjects i.e. biology, chemistry, physics and geography are taught separately. Each of them is taught totally four hours a week in a period of 3 years. e.g. 2 hours of biology weekly in the first form and 2 hours in the second form. Teaching “Technique” is also continued. All senior secondary school pupils are taught biology, chemistry, physics and geography totally 3 hours a week for the period of the first two years. The pupils interested in these subjects can have optional classes on advanced level.

The aim of the reforms was also adjusting the contents and methods of teaching to contemporary requirements. Core curricula were elaborated for each subject. Only the handbooks taking into consideration the contents included in the core curriculum for a given subject are admitted to be used at school by the Ministry for Education. At the same time some attempts were made to encourage teachers to give up the methods based on memorizing large amount of information and undertake those arousing pupils’ activities and their acquiring various skills. There were introduced external exams to provide objective information about pupils’ achievements on different levels of education.

It is too early to estimate if the desired effects in science teaching have been achieved. The Polish educational system was also affected by other factors connected with political, social and economic transformations taking place during the last several years. Poland is a country where the financial means spent on education are not relatively high. As a result, classes are numerous and teaching aids equipment is insufficient. This makes difficult to conduct lessons securing pupils' cognitive activity, using inquiry-based teaching methods that is of particular importance for science subjects. Also teachers' attitude getting involved in the changes of the educational system at the very beginning searching for new methods and better qualifications is of significant importance. However, in time their engagement becomes weaker and many of them come back to the old methods of teaching. This is indicated, among others, by the fact that handbooks based on learning by heart enjoy popularity among teachers again. Also the national exams are criticized that they check memorizing information to a large extent and skills of using the acquired knowledge to a small extent.

Despite the critical evaluation, the external exams are one of main sources of information about science teaching level. The first external exam for the pupils leaving Junior Secondary School was held four years ago. It had two parts: humanistic and mathematics-science. In the successive years the average scores in the mathematics-science part were as follows (Table 1):

Table 1

Year	2002	2003	2004	2005
Average scores (%)	56.32	51.5	48.98	48.52

This does not provide information about absolute level of pupils' knowledge as the score depends on degree of difficulty and kind of examination tasks. However, more detailed data obtained during this exam allow e.g. to compare pupils' achievements in different regions or areas (urban/rural) in which the school is located.

The external exam for the pupils leaving Senior Secondary School was held for the first time in 2005. The number of pupils taking exams in science subjects was: biology 72315 (23.4% all school leavers), chemistry 24495 (7.9%), physics and astronomy 17309 (5.6%), geography 76283 (24.7%). The pupils could take them in 0-level (ordinary) or A-level (advanced). The average scores (%) in individual subjects were as follows (Table 2):

Table 2

Subject	Biology	Chemistry	Physics and Astronomy	Geography
0-level	65.68	70.1	60.8	56.6
A-level	49.50	50.5	32.2	50.1

Also in this case it is not possible to compare the pupils' achievements in the above mentioned subjects as the scores obtained by them depend on the degree of difficulty of examination tasks for each of them. However, some interesting conclusions can be drawn comparing these scores with the number of pupils choosing a given subject.

PISA investigations (http://www.pisa.oecd.org) provide the information about the level of science teaching in Poland compared with other countries. In 2000 the score for Polish pupils in science performance was 483, the lower score than the average one (500) for all countries taking part in the investigations. The next investigations in 2003 showed that according to the international scale Polish pupils scored 498 on the average. This score does not differ statistically from the average one for all investigations and Poland found itself among the countries where pupils achieved better scores in science performance compared to 2000.

The fact that the number of pupils enrolling for the university studies requiring knowledge in science does not decrease compared to the trend in other countries is another indicator informing about the state of science education in Poland.

Results of ROSE survey in Poland

ROSA investigations carried out in Poland in 2003 provided additional information allowing for a more complete evaluation of science teaching level. The research included the pupils of the third i.e. last forms of Junior Secondary Schools. At the time they started education in this form, they were mostly 15 years old. To choose the sample schools there were taken into consideration: area (urban/ rural) and region to which the school belongs based on pupils' achievements in external examinations (higher or lower scores compared with the average). The number of pupils from urban and rural schools as well as from the regions differing in pupils' achievements in external examinations was proportional to the whole population. The total number of pupils taking part in the research was 654 including 368 girls and 286 boys.

Analysing the obtained results the main attention was focused on the answers on group of items "What I want to learn about?" given by the pupils taking part in research. Totally there were 108 items classified into suitable subjects from the natural sciences considering the contents by the research organizers. Also the context of items, which was derived mainly from sociological theories and review of research in science education (Schreiner and Sjøberg 2004) were taken into account. According to the research assumptions they will allow to determine interest in science and technology as well as to inform how curricula can be constructed in order to meet the interest of different groups of learners.

The list of items found to be the most interesting by pupils is given in Table 3.

Table 3

	Item	Mean
E42 –	Phenomena that scientists still cannot explain	3.47
E11 –	What we know about HIV/AIDS and how to control it	3.25
C13 –	Why we dream while we are sleeping, and what the dreams may mean	3.19
C11 –	Life and death and the human soul	3.19
E13 –	How different narcotics might affect the body	3.19
E9 -	Sexually transmitted diseases and how to be protected against them 3.14	
C8 -	The possibility of life outside earth	3.13
C15 –	Thought transference, mind-reading, sixth sense, intuition, etc.	3.12
A40 –	How to exercise to keep the body fit and strong	3.08
E40 –	Inventions and discoveries that have changed the world	3.08

The items referring to the phenomena not known yet (E42, C13, C11, C8 and C15,) or human biology and health (E11, E13, E9 and A40) are predominant. The fact that the pupils show great interest in the problems included in the first group of items is undoubtedly interesting from sociological and psychological point of view confirming role of emotions typical of this age. It is not of great practical importance in teaching as it is hard to imagine that items of this type are included in science and technological subject curricula. On the contrary it indicates the need for such teaching of these subjects that pupils appreciate importance of scientific knowledge and are critical about all information appealing to parascientific knowledge. However, great interest in the second group of items concerning human biology and health is fully justified. This justification will be discussed further while presenting the pupils' attitude towards the items depending on the fact which teaching subject they are connected with.

The items that the pupils are the least interested in are given in Table 4.

Table 4

	Item	Mean
C1 -	How crude oil is converted to other materials, like plastics and textiles	1.57
A15 –	How plants grow and reproduce	1.90
E1 -	Symmetries and patterns in leaves and flowers	1.90
E17 –	How to improve the harvest in gardens and farms	2.03
A21 –	How different musical instruments produce different sounds	2.04
A17 –	Atoms and molecules	2.04
A2 -	Chemicals, their properties and how they react	2.08
A47 –	How petrol and diesel engines work	2.11
A4 -	How mountains, rivers and oceans develop and change	2.11
E22 –	How different sorts of food are produced, conserved and stored	2.16

In this case there can be distinguished two groups of items, the first referring to chemical knowledge (C1, A17, A2, A47 and E22) and the second to plants (A15, E1 and E17). As also in this case both groups of items are connected with suitable teaching subjects, justifications of probable causes of pupils' unwilling attitude towards them are presented below.

More information was provided comparing pupils' opinion about the items connected with the curricula of individual science subjects taught in Polish schools. Therefore successive questions in the group "What I want to learn about" were analyzed comparing them with the teaching contents of biology, chemistry, physics and geography curricula for Junior Secondary School. Based on this, the items typical of the contents of these curricula were chosen. The obtained sets of tasks differed partially from the evaluation accepted during questionnaire construction. Moreover, as the group of items related to biology was much larger than that of the items related to chemistry, physics and biology, they were additionally divided into five groups: plants, animals, human biology, health and sexual education.

The extent of pupils' interests in the items related to individual subjects is as follows (Table 5). The items corresponding to each of four subjects did not cover all curricula contents in a representative way as it was not the aim of research. However, keeping it in mind, some regularities related to pupils' interest in individual subjects can be observed. As follows from the comparison of the data in Table 5, the least interest is shown in chemistry and the most in biology. Average interest to a close extent is shown in geography and physics. A similar attitude to science subject follows from the other research, including Polish pupils (Janiuk 1997). It shows that more than half of the students found physics as not interesting subject.

Table 5

subject	Numbers of items	Mean
Biology (totally)	A7, A8, A9, A10, A11, A12, A13, A14, A15, A20, A26, A27, A28, A29, A37, A38, A40, A42, A43, E1, E7, E8, E9, E10, E11, E12, E13, E16, E17, E18, E19, E23, E24, E25, E31, E32,	2.70
♦ Botany; plants	A15, A28, E1, E17, E18, E19, E25	2.20
♦ Zoology; animals	A12, A13, A14, A20, A27, E16, E24	2.67
♦ Human biology	A7, A11, A40, A43, E13, E23	2.82
♦ Health	A26, A29, A37, A38, A42, E7, E8, E10, E12	2.88
♦ Sexual education	A9, A10, E9, E11, E31	3.00
Chemistry	A2, A17, A31, C1, E26	2.13
Geography	A3, A4, A5, A 24, A25, A35	2.43
Physics	A19, A21, A30, A36, A43, A46, A48, C2, C3, C4, C16, C17, E2, E21, E27	2.46

In the case of biology and geography only about one fourth of the students under investigation share the same opinion. Chemistry took up an intermediate position. The same tendency is also shown in choice of science subjects in the final Senior Secondary School exams (Table 6).

Table 6

subject	number of pupils taking it	% of those taking the ordinary level	% of those taking the advanced level
Biology	72315 (23.4%)	35%	65%
Geography	76283 (24.7%)	50%	50%
Chemistry	24495 (7.9%	10%	90%
Physics	17309 (5.6%)	3%	97%

Both biology and geography are chosen by over three times larger number of pupils compared to the number of those choosing physics and chemistry. This exam can be taken in two levels: ordinary and advanced and its scores count for university enrolment. As follows from the scores in Table 6 chemistry or physics was chosen only by those pupils who were going to study the university subject requiring knowledge of chemistry or physics.
More detailed information about the causes of differences in attitudes of pupils under investigation towards individual science subjects was provided by the analysis the items related to them. Table 5 shows that in the case of biology, its sections were of different interest for pupils. They were most willing to study the problems related to sexual education. This can be explained referring to the pupils' age as at that stage of development the problems related to sexual education become of significant importance. Probably there is still another reason. Though this subject is included in biology curricula but for cultural reasons, attitude of education authorities and insufficient teachers' preparation, they are not taught in a way sufficiently modern and in accordance with the pupils' needs. The problems related to health and human biology enjoy comparably great interest. This may be caused by the fact of their usefulness in life of every man. Young people aged 15-18 are in the adolescent period when the interest in their own body, its functioning as well as in factors having positive and negative effects on human health and life appear. Four items in this range are found among then recognized as the most interesting by pupils (table 3). However, the least interest was shown by both girls and boys in the problems related to plants. The issues of this type appear in successive educational stages and are dealt with in an encyclopedic way with insufficient level of visualization that is indispensable while discussing the contents of this type. These are surely the most essential reasons for small popularity of botanical issues among pupils. This explains the fact why three items in this range were found to be the least interesting by the pupils under investigation (table 4).

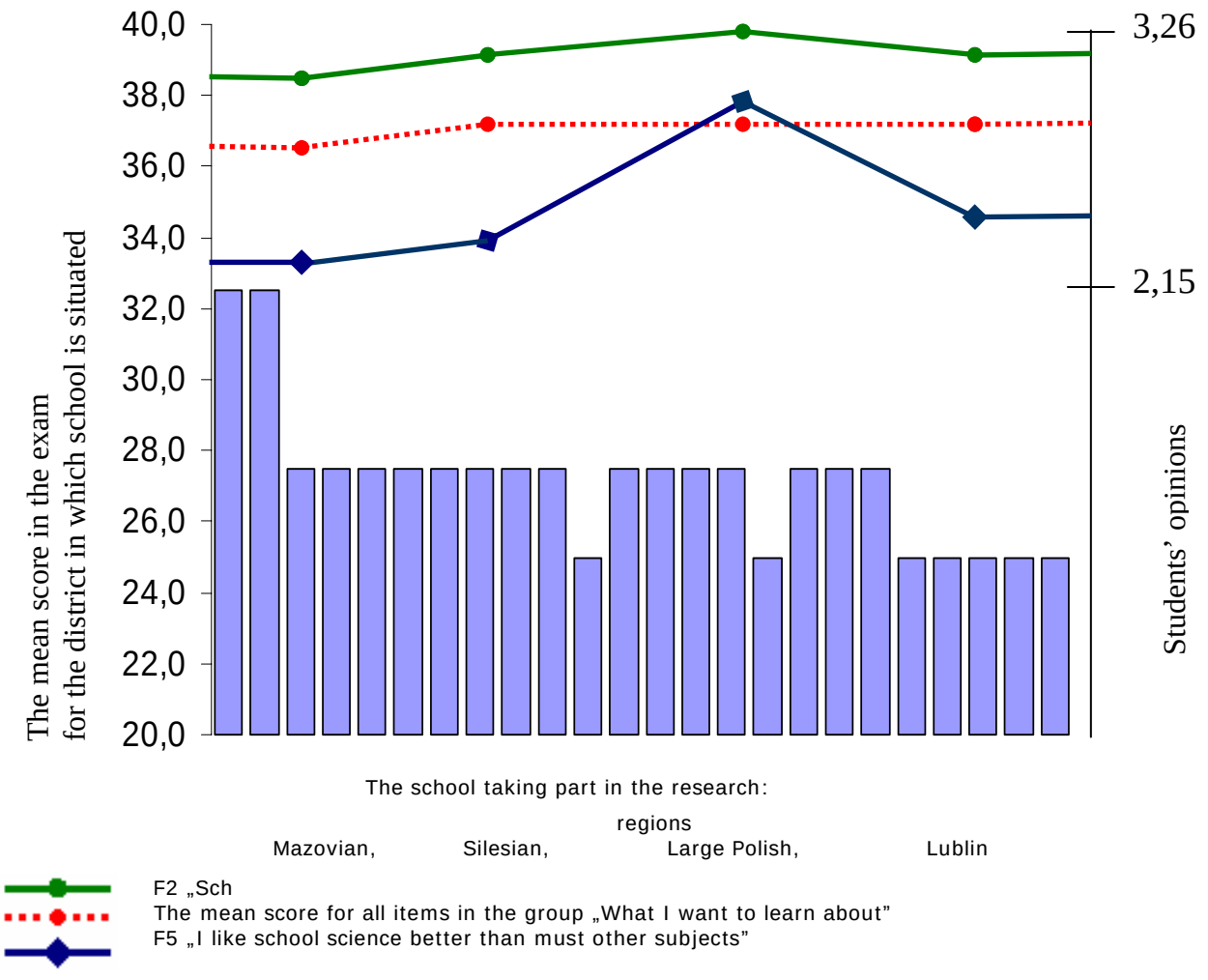
Pupils' small interest in the issues related to chemistry should not be surprising. Chemistry and physics are regarded by pupils to be boring and difficult. Reluctant pupils' attitude towards chemistry is caused by character of chemical knowledge that requires simultaneous reasoning from pupils on the macroscopic, microscopic and symbolic levels (Gabel 1999; Johnstone 1999). Another not less important reason is improper way of teaching chemistry consisting in paying too much attention to memorizing instead of understanding the acquired knowledge, obtaining skills for its application, particularly in reference to everyday life (Janiuk 2003).

Comparing the data obtained for boys and girls it can be stated that the differences in interest shown in a given problem are quite typical of both sexes though not as large as one should expect. For example referring to all items related to biology the average was 2.71 and 2.68 for girls and boys respectively. Greater differences are disclosed only in the case of specific items. This is the largest for items A8 "Heredity and how genes influence how we develop" whose levels of interest were 2.70 and 2.30 for girls and boys respectively. Close size differences in favor of girls also appear with items A38 "Eating disorders like anorexia or bulimia", A39 "The ability of lotions and creams to keep the skin young", A41 "Plastic surgery and cosmetic surgery" and A42 "How radiation from solariums and the sun might affect the skin" which should not be surprising taking their contents into account. For a change as can be predicted boys' interests are mainly related to the items connected with physics. Boys are evidently more interested in item A47 "How petrol and diesel engines work" (boys and girls 2.38 and 1.92 respectively) though at the same time it belongs to the group of items that are the least interested according to pupils (Table 4). Similarly to the above mentioned items which girls were more interested in, it should not be surprising either that the following items were more frequently pointed to as interesting by

boys, A31 “Explosive chemicals” A44 “Rockets, satellites and space travel” and A48 “How a nuclear power plant functions”.

Poland is the country where quite a large part of population, up to 38.5% lives in the village according to the statistical data from 2004. This is frequently due to considerably great difference in the lifestyle and access to education compared to urban population. It is evident when the answers related to the items in the group „My out of school experiences” are compared. The largest differences to the disadvantage of pupils living in villages are found for the items asking about performing such activities as using a mobile phone (H44), sending or receiving an SMS (H45), surfing the internet for information (H46) and sending or receiving e-mail (H50). However, pupils’ interest in science and technology do not depend on place of living. Greater differences are observed only for items A8 “Heredity and how genes influence how we develop”, A11 “How babies grow and mature” and A12 “Cloning of animals”, A18 “How radioactivity affects the human body”, A26 “Epidemics and diseases causing large losses of life”, E11 “What we know about HIV/AIDS and how to control it”, E31 “Biological and human aspects of abortion” and E32 “How gene technology can prevent diseases” which pupils living in towns are more interested in. However, pupils living in villages are more interested in items E35 “Risks and benefits of food additives” E36 “Why scientists sometimes disagree”, E37 “Famous scientists and their lives”, A38 “Big blunders and mistakes in research and inventions” E39 “How scientific ideas sometimes challenge religion, authority and tradition” and A40 “Invention and discoveries that have changes the world”. This is hard to indicate distinct dependences in this case, though pupils living in towns show greater interest in the issues connected with development of science and technology that can be explained by the fact that teachers pay more attention to them. Greater interest in sexual education may result from loose morals in towns. However, pupils of the same age in villages would like to know more about science and scientists but they agree to a lesser extent with the statement G1 “Science and technology are important for society”.

The results of external exams for the pupils leaving Junior Secondary School in the mathematics – science part are different for different regions of Poland. Therefore they were compared with the average result for all items in the group” What I want to learn about” for a given region and the result obtained for items F2 and F5 (Diagram 1)
Diagram 1.



As follows from the diagram pupils of schools in the regions where worse scores were achieved showed greater interest in learning the problems related to the teaching contents of science subjects compared to those in the regions where the scores were better. They also more frequently disclosed positive attitude to science, as follows from the dates related to

items F2 “School science is interesting” and F5 “I like school science better than most other subjects”. In this case convergence with the results of ROSE research comparing all participating countries is observed. Higher interest in science is shown by the pupils from the countries which achieved worse scores in the international research of achievements in science (e.g. PISA).

Discussion and implications for science education

The analysis of the research carried out in Poland within the project ROSE provided much interesting information about what students think about science at school which should be used for drawing conclusions about teaching science. The importance of the investigation of students’ attitudes towards science at school consists first of all in practical application of their results (Osborne, Simon and Collins 2003).

The basic conclusions of practical implication, which can be drawn from the research, result from the differences in pupils’ attitudes towards individual science subjects. It was found that pupils are most willing to learn biology, then geography and physics. However, they show the smallest interest in chemistry. Similar attitude to science subjects is observed in other countries in which the ROSE research was carried out (Jidesjö and Oscarsson 2006: Lavonen, Juuti, Uitto, Matthews 2005: Teppo and Rannikmäe 2004). This is also confirmed by other research (Gräber 1993: Osborne and Collins 2001), whereby there is a change in pupils’ opinion who not long ago considered physics as a difficult and of little interest subject (Whitfield 1980). It means that if opinions about chemistry are mostly responsible for a negative attitude towards science knowledge, then its improvement will depend largely on changes in teaching this subject. Science knowledge obtained by pupils should constitute the whole and individual subjects should play an equivalent role in it. It follows from the more and more common opinion that science teaching on the compulsory level should prepare students not only for the next level of science courses but also, if not first of all, for application of this knowledge in everyday life (Aikenhead, 2006). In such a case it is hard to imagine that its achievement would not involve a suitable level of chemical knowledge. However, it requires thoroughgoing changes in the aims and methods of chemistry teaching. Though some attempts have already been made, much effort and time is still needed to obtain positive results (Holman and Hunt 2002).

Moreover, it may be concluded that if it is possible to teach only the contents pupils want to learn. It is also of significant importance to find ways of teaching the issues pupils are not interested in and find them difficult but at the same time they are indispensable taking into account possibility of achieving all important goals associated with science teaching. Among the issues pupils pointed to as not interesting were “Atoms and molecules”. However, understanding chemistry even on its basic level is not possible without referring to the knowledge about matter structure (Harrison and Treagust 2002). This kind of chemical knowledge is also important taking into account other science subjects, like biology. Without knowledge about structure of chemical compounds, it is not possible to understand, even on a basic level, transfer of genetic information.
The research provides also information about teaching biology. As follows from the comparison of pupils’ attitudes towards individual issues included in this subject, botany is the least interesting for them. This is the section of biology that is traditionally considered to be of significant importance in teaching this subject. Yet it requires memorization of much information that is an additional burden for pupils’ memory and at the same time this section is neither very useful in everyday life nor necessary for getting acquainted with or understanding other sections of biology. Simultaneously, there are biology issues that pupils are interested in and find them very useful. This indicates evidently the direction of changes that should take place in biology.

It seems that the differences in the attitudes towards science shown by girls and boys are of smaller and smaller extent. As a matter of fact, they can still be observed in reference to specific issues. Therefore it is hard to draw practical conclusions based on it. Probably these differences will diminish in time, particularly in well-developed countries. Similarly, besides the evident conclusion about equalization of educational chances for pupils living in towns and villages, it is hard to point to specific activities concerning science teaching in both groups of pupils.

However, the regularity between level of achievement in science and interests towards school science and science in society is surprising. As follows from both the research carried out in Poland and that in all countries participating in the ROSE project. The groups of pupils achieving worse results in science exhibit more positive attitude towards school science and science in society. As the review of research shows this tendency is opposite for individual pupils (Osborne, Simon and Collins, 2003) which seems to be quite justifiable. Yet more profound analysis shows that these dependences are more complex, saying nothing about that what is, in this case, independent variable – attitude or achievement. Undoubtedly, determination of the factor, if such one exists, which causes the dependence observed in the research is of great practical significance.

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