WHAT IS HAPPENING TO SCIENCE SUBJECTS IN PUBLIC EDUCATION? – UNIVERSITY STUDENTS' OPINION ABOUT TEACHING SCIENCE

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Abstract

The devaluation of science literacy is not today's problem. In several countries expenditure spent on education has grown, numerous thorough and long-term reforms have been introduced, however, with little success or positive effect. In our search based on this, we aimed to analyse students' attitudes towards science subjects in public and higher education from different aspects. In our present paper we try to focus on the results based on the students of University of Debrecen who filled out self-completed questionnaires. The questionnaire includes a module of subject preferences, several question blocks on methodology and the use of various school equipment as well as questions about the attitudes of teachers and students' learning habits and motivation to learn. From the answers it becomes evident that the main methodological tools of teaching science subjects include uninteresting subject contents, lectures and explanations as well as sketches drawn up on the board. It is a controversial data that rank numbers related to either subject preferences or their usefulness and variedness does not show attachment with the fact whether a student is majoring in natural science at present.

Keywords: scientific attitudes, sciences, learning motivation, teaching methods.

1 INTRODUCTION

Knowing the world around us, possessing the necessary knowledge that can be used in everyday practical life is extremely important for all people. Providing this knowledge for the society is primarily the responsibility of schools. In the past fifty years different methods and means have been used to raise the standards of teaching natural sciences and their prestige, too. In several countries expenditure spent on education has grown, numerous thorough and long-term reforms have been introduced, however, with little success or positive effect ([1], [2]). Unfortunately, academic knowledge is still typical of education in general and even more of science subjects. When teaching science, as Osborne points out ([3], [4]), we try to give a young child a one thousand- piece puzzle and hope that they will have a holistic picture of the pieces, instead of providing them only the simplified 100 piece version, which would be much more effective. This way pupils could have a solid base for the teaching-learning process.

So we expect our students to acquire a large amount of lexical knowledge, not leaving them enough time for understanding and applying what they have learnt.

PISA surveys carried out every three years by OECD measure students' knowledge of science subjects and their way of thinking. These surveys pointed out that it is not enough to measure and analyse students' level of knowledge related to each subject but the affective, personality factors that may influence pupils' efficiency must be focused on as well. This has also been underpinned by the decade-long experience which is verified by both Hungarian ([5]), and international surveys (e.g. TIMSS, PISA), concluding that attitudes towards science are declining throughout school years ([6]).

The number of students who are interested in a field of science is relatively small. At the same time there are those who are less talented in science subjects and therefore show less interest, the "silent majority", who only thrive to "survive" these subjects ([7]). Science education, however, in case it would like to succeed, should concentrate on this majority of students. Vosniadou and Ioannides ([10]) also underlined the fact that there is a dichotomy of quantity and quality in education, which is an existing problem. Because of the huge amount of curriculum and the decreasing time devoted to it, there is less and less opportunity for experiments, problem-solving tasks and exercises that need practical knowledge. Without these, all the science subjects tend to become more academic, distance from students and a proper science attitude cannot be formed.

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In our research we attempted to find out the main reasons for decreasing science attitudes even at an international level, with the help of university students who filled out our questionnaire. Those studying in higher education have a complex vision of what is happening in public education as they have finished their secondary school studies, but are still young enough to remember back and based on their memories and experiences their responds give a thorough picture of science education going on in Hungary. From the questionnaire based survey, carried out at the University of Debrecen, we may learn what students think about teaching science in public education, what they experienced while learning these subjects in elementary and secondary education and what memories they have about their teachers, the applied teaching-learning methods and toolkit and we can come to a conclusion regarding the reasons why increasingly, students turn away from science subjects in secondary education.

2 SCIENCE EDUCATION AND LITERACY

We may have encountered the term "science literacy" first in the study written by Hurd, American entomologist, who meant some kind of general knowledge by the term which is relevant for even those who are not interested in science. This is essential because there are relatively few students at schools who take interest in any of the science subjects. The number of those who are not interested is much higher. Learning for these students is not a value, they try to get through these subjects by working out different "survival strategies" ([10]). Osborne ([4]) highlighted the different needs of two target populations: 1.) those who want to go on to higher education and show interest and 2.) those who do not. The present education system, however, with its applied methods and toolkit is not able to achieve the goal in case of either population. It is quite evident that in our globalised world everyone needs some science knowledge to be able to understand the challenges of the rapidly changing technology and different environmental issues.

Science literacy has been approached in different ways so far but the precise definition to be given still awaits ([9], [11], [12], [13], [14], [15], [16], [17]). The most frequently quoted interpretation is provided by Bybee ([12]), who said that the main goal of teaching science subjects was to convey science literacy to every student. The science concept of the OECD-PISA program builds upon Bybee's ([12]) literacy interpretation which includes the application of science knowledge in everyday practical life, the system of reflective arithmetic operations, recognizing, understanding and using scientific rules as well as the ability of bringing decisions about the world of nature. By possessing this science knowledge we will be able to understand and handle problems of everyday life, recognize the consequences of our decisions, understand more complex correlations and apply the knowledge we have acquired ([18]). In 2006 the PISA surveys focused on science competences. Along with this, a complex definition of science literacy was given as well and the analytical parts oriented on this were extended with attitudes related to science and technical-type of questions. It was crucial because turning away from sciences and the massive decline of attitudes towards them is an international phenomenon. Instead of forming basic scientific attitudes at schools, by conveying an overburdened curriculum and giving strict tests on it, we only bring up little scientists. We deprive students of gaining experiences and as a result they will be unable to interpret more specific, abstract materials and the related explanations properly. As a result of this students tend to move away from science subjects because they find them far too scientific and they cannot link the acquired knowledge to everyday situations ([20]).

With the extension of the empirical surveys it has become evident that knowledge does not equal with the possession of certain skills. Assessing specific factual knowledge can only be relevant if we pay attention to analysing these skills as well as the affective and personality factors.

3 ATTITUDES TOWARDS SCIENCE SUBJECTS

Among affective factors that influence student achievement surveys which examine students' attitude are of exceptional importance. Attitude is not an innate trait but an attribute formed by different stimuli which result in either a positive or negative approach to objects, persons, ideas or ideologies. Attitude is one of the central concepts of social psychology, which has developed from a simple, one-dimensional interpretation to a complex, multi-dimensional idea by today ([21]). Subject attitude surveys provide a lot of information beyond specific subject preferences. From the results it may be concluded what tertiary majors are popular at certain ages, which subjects must be taught with other methods or require different toolkit and which changes or reforms have not lead to a positive result.

Due to diverse interpretations, subject attitude surveys both in national ([22], [23], [24], [25], [5]), and international literatures (TIMSS and PISA surveys [26], [27]) go back to several decades.

The low popularity of science subjects is well presented by the ROSE project *(Relevance of Science Education),* which examined 15-year old students' attitude to and preference of science subjects in more than 40 countries. The tests in every participating country showed that science subjects are at the end of the preference list ([27]).

Another example for the decline of the popularity of science subjects at an international level is the change in the rate of those who were admitted to science-technology university trainings and those who graduated in the end ([2]). From the 15 countries tested, only in Turkey, Australia and Belgium did the number of students taken up science majors grow more than by 2%. If we take a look at the number of graduates we may conclude that there was only a growth in the number of students gaining a science degree in Canada and Finland, while there was a dramatic fall among these graduates in Poland, Denmark, the Netherlands and Germany.

Subject attitude surveys also revealed that students' approach to each subject got worsen throughout the years spent at school and this is especially true in case of science subjects ([29], [18], [6], [30]). The knowledge students acquire at school, however, cannot be applied in after-school situations and thus science knowledge remains so called inert knowledge ([31], [32]), which include certain separated skills that students possess but are unable to apply.

PISA tests also measure the emotional, non-cognitive factors of students' attitude to learning and try to find correlations between these factors and the level of students' output. Regarding learning attitude, Hungarian students do not believe in their own skills and underestimate their mastered knowledge ([33]). In each attitude survey from all science subjects, physics has ranked a constant bad position in the preference list ([34], [18], [35]). The correlation between the preference of subjects and success has been examined recently. In case of biology and geography Orosz ([24]) has revealed the strongest relation between the grade of the subject concerned and its preference among all science subjects. At the same time, in another survey it was proven that even those students refuse these subjects significantly who achieve good results ([5]).

Csaba Csíkos ([5]) underlined the facts that in attitude tests the differences between subjects are significant, compared to each other. The reasons for students' negative attitude in case of permanently and highly refused subjects must be found out, which may refer to methodological or as a result of this other career choice problems. In our survey with the help of university students' questionnaires we tried to find the main reasons for the refusal of science subjects, paying special attention to those teachers' personality who teach sciences and also the methods and toolkits used by them.

4 THE PURPOSE AND QUESTIONS OF THE SURVEY

We have been carrying out our survey within the frame of OTKA project number K-105262, entitled "Innovative, interdisciplinary approach of science subject pedagogical researches". This has been going on since May 2014 as a part of a research on students' learning and subject attitudes in public and higher education. In this study from the complex project we would like to present the primary results of a questionnaire survey carried out among the students of the University of Debrecen, whose purpose is to identify university students 'opinion who have a more complex vision of higher education and through this we may have a picture of teaching science in public education, the main features of the teaching-learning process, the preference of science subjects and the causes of the decline of science subject and learning attitudes.

The questions of our survey presented in this study were the following:

1. Where are science subjects ranked (including mathematics) in the preference list of subjects?
2. Is there a significant difference between the rate of preference and the gender of the responding students as well as the type of higher education training?
3. What correlations can be revealed between students' attitudes to sciences and teachers' personality, the methods they use and the toolkit available?

5 THE SAMPLE AND METHOD OF THE SURVEY

In our present survey, we try to show the primary results of self-completed questionnaires filled out by students of University of Debrecen (N= 348 capita). Our query is not complete, it shows data worked up until submission of paper. Table 1 shows the distribution of responding students' sex and types of their higher education trainings. By students in non-science trainings we mean arts and musician students.

Table 1. Distribution of responding students' sex and types of their higher education trainings.

	Science training	**Non-science training**	**Total**
Male	53	50	103
Female	140	155	295
Total	**193**	**205**	**398**

The toolkit used in our survey has been developed throughout a 1,5 –year long research process that include strings of pilot tests. Our main tool was the questionnaire which is suitable for descriptive, exploring purposes and with its use we may gain plenty of information in the area examined in no time. The compiled questionnaire includes 26 questions, each group of questions, the elements examined within them and the reliability (Cronbach-alpha) of every field are presented in Table2.

Table 1. Question categories of the survey,
elements examined and the Cronbach-alpha of each group.

Question categories	**Elements examined**	**Cronbach-alpha**
Variables	sex, features of training, type of settlement with elementary school, type of settlement with secondary school, maintainer of secondary school, parents' qualification, occupation, secondary school results	-
Methods	teaching methods, learning management, ICT, homework	0,902
School devices	traditional and ICT devices, demonstrational and student experiments, drafts	0,901
Preference rank	preference of each subject,	0,717
Learning drives	internal and external motivators, personal attitudes	0,916
Teacher behaviour, personal traits	professional expertise, behavioural culture, helpfulness, personal traits	0,831

The most frequently used question in the questionnaire was the Likert-scale question with 5 ranks, as in Hungary the 5-scale grading system is in use so students can more easily adapt to it and this type of scale is more appropriate for complex correlations between results. It must be emphasized that in the survey we rated mathematics to science subjects, this way with the questions dealing with science subjects we asked not only about biology, physics, geography and chemistry but also mathematics. Therefore, our results show the university students' (University of Debrecen) rating of the public school position of these five subjects. Our results were analysed with the SPSS, version 22 statistical programme.

6 RESULTS AND THEIR EVALUATION

To answer the question which position science subjects take in the preference list of subjects and whether there is a significant difference between the rate of preference and the sex of the responding students as well as the types of higher education training, we used the SPSS 22 program.

Table 3 shows the average rates of subject preferences based on students' answers by their sex and the type of higher education trainings.

Table 3. The average values of subject preferences summarized by students' sex and the types of higher education trainings (notation: green indicates the most preferred, red indicates the least preferred subjects; rates indicated with * are significant).

Subjects	Type of higher education training		Sex		Total
	Non-science trainings	Science trainings	Female	Male	
art	3,86	3,69	3,83*	3,59	3,77
biology	3,58	4,23*	3,94	3,78	3,91
chemistry	3,04	3,45	3,20	3,47	3,25
English	4,28	4,02	4,23*	3,82	4,14
ethics	3,39	2,82	3,00	3,43	3,10
geography	3,33	3,51*	3,30	3,83	3,42
German	3,67*	3,34	3,70	2,85	3,50
history	4,32*	3,67	3,98	4,03	3,99
Hungarian grammar	4,03*	3,36	3,78	3,38	3,68
Hungarian literature	4,45*	3,67	4,16*	3,68	4,05
informatics	3,52	3,38	3,36	3,70	3,45
mathematics	3,01	3,82*	3,44	3,39	3,42
music	3,46	3,13	3,26	3,45	3,29
other foreign language	3,80	3,34	3,48	3,71	3,52
physics	2,51	2,97	2,70	2,94*	2,75

From the average values it is evident that science subjects (except biology) take the last places in the preference list of all subjects (A<3,5), including ethics and music as less preferred skill subjects. At the same time biology, based on students' answers, is the fourth most preferred subject (A=3,91), outpaced by English (A=4,14), literature (A=4,05) and history (A=3,99) . The reason for this may be the fact that in Hungary a foreign language (mostly English), Hungarian literature and history are mandatory maturation exam subjects. The reason for biology being so highly preferred can be that 50% of the students filling out the questionnaire were biology teachers or were taking part in biology pre-service teacher training. Taking this aspect into consideration, our sample must be refined. In the subject rank physics has the worst position because in none of the dimension examined has it reached grade 3. What is even more aggregating is that the preference rank of physics is significantly lower than the rate of chemistry (R=0,217; p<0,01). Comparing males and females, it can also be concluded that women more significantly dislike physics (p=0,002; t=1,504) than men. Geography is more preferred by men while it is rather refused by women. It is chemistry that is at the end of women's preference list while in case of men it is mathematics. Biology is the fourth most preferred subject with both genders .It must be noted, however, that there is a dramatic difference between the responding men and women (p=0,000). Comparing the answers of students taking part in science and non-science training (musicians, arts) the difference is conspicuous. For those in non-science training the four least preferred subjects are all science subjects (physics, mathematics, chemistry, geography), where physics is the last one in the rank, dramatically falling behind compared to mathematics, which outpaces it (R=0,413; p<0,01). For those in science training the most preferred subject is biology, which is significantly more preferred by them compared to non-science students (p=0,049; t=6,189), and also mathematics belongs to the dominantly more preferred subjects(p=0,027;

t=5,993). Science students mainly refuse ethics, physics and music and physics also get to the end of the preference list among these students compared to music (R=0,180; p<0,05). From the five examined subjects physics is in the worst position. To the question, what correlations can be revealed between students' attitude to sciences and the teacher's personality, their teaching methods and the toolkit available, we ran the rank correlation test in the SPSS program and this way we determined the Spearman rho value of the correlation. In order to interpret the results properly we must present the frequency of each teaching-learning method and tool, their appearance in lessons, which will show the position of science subjects in the Hungarian education system (Table 4).

Table 4. The frequency average of applied teaching-learning methods and toolkits on a 5-grade Likert-scale, highlighting the most frequent elements.

Methods	**biology**	**physics**	**geography**	**chemistry**	**mathematics**
Power point	2,63	1,80	2,22	1,74	1,30
Film	2,43	2,10	1,94	1,76	1,46
Problems solving on the class	2,39	3,35	1,98	3,15	4,47
expressing opinion	1,90	1,78	1,83	1,64	1,56
presentations	2,46	2,12	2,24	2,01	1,45
Pair-work	1,98	1,76	1,76	1,86	1,77
Group-work	2,21	2,00	1,98	1,98	1,93
Individual work	2,79	3,25	2,54	3,15	4,11
Writing home-work	2,70	3,51	2,47	3,38	4,54
Dictation	3,98	3,93	4,02	3,96	3,47
Explanation	4,46	4,44	4,29	4,49	4,69
Tools	**biology**	**physics**	**geography**	**chemistry**	**mathematics**
Board Sketches	3,97	3,74	3,74	4,15	4,53
Teachers' carried-out experiments	2,04	2,75	1,32	2,86	1,27
Students' carried-out experiments	1,72	1,82	1,48	2,00	1,17
Competition	2,19	1,93	1,97	2,14	2,36
Modell	2,54	2,60	1,90	2,50	1,75
non-ICT based tools	2,36	1,83	3,06	2,07	1,95
ICT-based tools	1,69	1,52	1,54	1,55	1,53
exercise book sketches	4,21	4,05	4,10	4,08	4,08

From the data of Table 4 it can be seen, based on students' answers, that in Hungary the most frequently used methods in case of all science subjects are dictation and explanation. Their frequency is the double of any other methods examined. In case of mathematics solving problems and individual work are also dominant. From the dominant tools we may mention board and exercise book sketches. To answer the question above, we highlight those seven methods (Table 5) and tools that significantly appear in case of science subjects and affect subject preference and attitude.

Table 5. Rank correlation values indicating the correlations between the preference of science subjects and applied methods and tools *(* : p ≤ 0,05; ** : p ≤ 0,01).*

Methods	**biology**	**physics**	**geography**	**chemistry**	**mathematics**
Power point	0,164**	0,133*	0,112*	0,134*	0,129*
Film	0,091	0,141**	0,162**	0,262**	0,056
Problem-solving	0,103	0,166**	0,170**	0,149**	0,161**
Expressing Opinion	0,149**	0,179**	0,089	0,129*	0,067
Presentations	0,134*	0,185**	0,098	0,138**	0,142**
Pair-work	0,191**	0,155**	0,174**	0,125*	0,056
Group-work	0,174**	0,113*	0,120*	0,191**	0,009
Tools	**biology**	**physics**	**geography**	**chemistry**	**mathematics**
Board Sketches	0,207**	0,156**	0,104*	0,177**	0,143**
Experiments carried-out by teachers	0,210**	0,154**	0,144**	0,051	0,054
Experiments carried-out by students	0,209**	0,079	0,021	0,238**	0,002
Competition	0,281**	0,216**	0,027	0,413**	0,229**
Modell	0,197**	0,142**	0,151**	0,003	0,109**
Non-ICT based tools	0,181**	0,116*	0,131*	0,134*	0,183**
ICT based tools	0,169**	0,005	0,022	0,196**	0,036

From Table 5 it can be seen that the most frequently used methods (dictation, explanation) have no positive impact on the preference of science subjects, thus they dropped out of our rank correlation table. What is more, dictation has a significantly negative influence on subject attitude ($R=0,125$; $p<0,05$). The frequency of their application raises a serious problem. There is a weak correlation between the methods and tools indicated in Table 5 and the preference of each science subject. It may be seen that from the methods and tools in the questionnaire those became highlighted which make it possible for students to start thinking, and they can become active participants of the teaching-learning process. Among the methods the most dominant ones are expressing opinion, presentations, pair and group work, which indicate that students love to share their ideas with their teachers and mates and also enjoy collaborating in tasks. In case of each science subject, board sketches are preferred, which contribute to the better understanding of abstract ideas, correlations, processes. This is also enhanced by ICT and non-ICT based tools. The ICT and ICT based tools (PPT, film) contribute to improving the preference of science subjects, however not exclusively, what is more, the non-IT based tools and methods are more numerous and their impact on subject preference is more significant. Experiments made by teachers and students also enhance the preference of these subjects, however, it must noted that based on students' answers the frequency of experiments in lessons do not reach value 2 on the 5-grade Likert-scale. Not even chemistry and physics are exceptions, despite the fact that the frequency of teacher's demonstration experiments is larger (chemistry $A=2,85$; physics $A=2,73$), however these values are not satisfactory either as the subject contents of physics and chemistry provide the most opportunities for experiments. The frequency of student experiments in case of both subjects is extremely low. According to the rank correlation tests experiments have a significant impact on subject preference in case of each subject (except for mathematics, where because of the subject content this variable is not relevant), it is only chemistry where the rank correlation value of teacher's demonstration experiments is not significant, however, that of student's experiments is. The reason for this may be that in case of chemistry, experiments are considered compulsory, it strengthens positive experiences if students can carry out experiments either individually or in pairs. The correlation between competitions and subject preference is hard to interpret as competitions are only relevant with more motivated students who show interest in any of these subjects. This is proved by the fact that among respondents the frequency of competitions related to science subjects is low (A<2), and only those with good academic results in science subjects said that they took part in a competition related to one of these subjects (p<0,05).

The McKinsey reports also highlight ([1]) the strong relation between the teacher's personality and the subject preference as well as the achievement in the given subject. From Table 6 we highlighted those teacher's behavioural patterns and personality factors that have a significant impact (p<0,01) on subject preference and students' subject attitude in case of each subject science according to the rank correlation test

Table 6. Rank correlation values indicating relation between the preference of science subjects and teacher's behavioural patterns and personality factors.

Teacher's behavioral patterns	biology	physics	geography	chemistry	mathematics
He/she explains well	0,268**	0,342**	0,358**	0,166**	**0,456****
Able to raise students' interest	0,303**	0,359**	**0,427****	0,306**	**0,491****
Patient	0,187**	0,238**	0,270**	0,197**	0,283**
Helpful	0,277**	0,251**	0,241**	0,238**	0,351**
Fair	0,224**	0,199**	0,290**	0,162**	0,366**
He/she uses different tools	0,149**	0,185**	0,105**	0,154**	0,170**
Professionally well prepared	0,182**	0,172**	0,216**	0,125**	0,317**

Teachers who are able to make students love their subject based on these can be described with the following features: patient, helpful, fair , professionally well prepared and explains well, their pedagogical toolkits are varied, that is they use different tools and are able to raise students' interest in the subject material. Along with the string significance values based on the Spearman rho values the "explains well" and "can raise interest" features may be emphasized, where the correlation is weak with strong significance, as opposed to geography and mathematics which show a correlation of medium strength.

In our survey we examined the teaching-learning in teacher-student system of relations. From the results those primary methodological and personality traits were outlined that have a dominant impact on preference of science subjects. The most frequently used methods and tools most probably play an important part in these subjects' being more and more refused and their decreasing preference at international level, too.

7 SUMMARY

The decline of science subject preference has been a serious problem in many countries for a long time. Several projects have been carried out to increase the popularity of these subjects, however, none of them have managed to bring a dramatic breakthrough. As long as the writers of curricula and requirement systems as well as schools cannot step away from requiring academic level, factual knowledge, probably the situation will not get any better. To reach this, however, a complete change of approach is required from policy makers, students and teachers, the question is only in what aspect and how.

In our survey using a self-completed questionnaire we asked the opinion of students of University of Debrecen, what they think about teaching science subjects in public education, their memories and experiences related to this.

As university students, they have a complex vision of what is happening in public education as they just have finished their secondary school studies so they can recall their memories. With the help of these data we may have a better understanding of the main factors that influence the preference of science subjects. In our questionnaire we highlighted those factors that have a significant impact on the teaching-learning process, its output and teacher-student relations (teachers' methodological culture, tools applied by them, teacher's personality factors and behavioural patterns).

Our results with respect to the preference of subjects, underpinned the results of earlier surveys. From our survey it turned out that in Hungary the number of methods and tools that have a positive effect on the preference of science subjects is rather low. Instead those methods dominate that have a negative impact (e.g. dictation, giving tests on subject contents which were not explained properly). As far as teachers' methods and toolkits are concerned, those teachers are able to make students love their subject who have a varied spectrum of methods and tools. IT devices are not the only options but they have an important part in making these subjects more popular. The non-IT based tools are essential, too because they can be touched by students or they may be models that students can make by themselves. Science subjects cannot lack teacher's explanation, which must be complex and exact, in order to have a better understanding of abstract definitions, correlations. Explanations must also include board drafts that present the main ideas of the subject content visually as well. The good teacher is helpful, patient and fair in evaluation. He does not dictate the subject material but raising and keeping up interest, explains it and does not assess understanding by testing lexical knowledge but by giving problem solving tasks which force students to recognize different correlations. Apart from policy and decision making levels, the key is in the teachers' hands. At the end of the questionnaire we asked students in open questions what they would suggest teachers should do in order to make science subjects more popular and lovable.

One of these opinions is close to their empirical results of our research, so it can be citated here as the closing thought of our study:

"More experiments and presentations should be used which can present interesting, thought-provoking phenomena. I never listened in class only when it came to experiments or the teacher brought in a model. This way it was much easier to understand what we were supposed to learn…" (Teacher of history-geography)

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