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Students' Attitudes Towards School Subjects With A Special Focus On Physics: The Case Of Poland

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This work presents the results of research on over 5,000 students aged 14–15 that focuses on their attitudes towards school subjects with special regard to physics. It describes the mathematical relationships between an interest in physics and students' school grades, their plans to choose a profession in which knowledge in physics is needed, an opinion on the usefulness of physics for society and an assessment of the usefulness of the most important formulas from the school curriculum. The average declared interest in school physics, the assessment of its social usefulness and the willingness to choose a profession relating to physics were relatively low.

Of the 16 most important formulas taught in physics during the last three years of learning, only 3 formulas were considered useful by the students. The work also presents the ranking of the persons in the history of physics with the greatest impact on the fate of humanity, according to students.

Keywords: students' opinions, school subjects, interest in physics, usefulness of physics, physics formulas.

Introduction

Experts indicate negative correlations between a country's development index and students' attitudes toward science (Tytler and Osborne, 2011). While we need a more scientifically capable workforce and a scientifically literate society, unfortunately, the percentage of students choosing scientific and technical studies in many countries around the world is low (Stokking, 2000; Oborne, Simon and Collins, 2003; Toplis, 2011).

For several decades now, young people around the world have recognized natural sciences as important to society, but they do not want to become scientists. The more economically developed the country is, the lesser the general perception of the usefulness of the natural sciences (Schreiner and Sjøberg, 2007). Natalie Angier, in her book entitled "The canon", refers

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to a study of over 800 British students aged 13–16, conducted in 2005, which proved that only 7% considered scientific work as interesting (Angier, 2006).

It is believed that one of the most important tasks of teachers is to make students interested in the subject they teach. The study of interest is particularly important in the case of subjects that are widely recognized as very difficult, such as physics, which is commonly regarded as one of the most difficult subjects to teach (Blasiak, Godlewska, Rosiek and Wcislo , 2012).

An interest in a particular subject is often regarded as a prognosis of success in various areas of life. This belief is one of the basic paradigms of modern didactics. The Cambridge Dictionary and English Oxford Dictionary define an interest as "the feeling of wanting to learn about something or of wanting to be involved with and to discover more about something" or "the feeling of wanting to know or learn about something or someone". The Collins English Dictionary states: "if you have an interest in something, you need to learn or hear more about it".

Students interests change over time, as new achievements of science and their numerous innovative applications appear. Interests change depending on the age of students, their gender, their social background and the economic development of the countries in which they live. They are also influenced by teaching programmes and methods as well as their life aspirations.

In early childhood, there are no major differences in the scientific interests between girls and boys. Significant differences appear later, and they deepen with age. At the end of high school, girls are mostly interested in biology and boys in physics and technology (Avan, Sarwar, Naz and Noreen, 2011; 2011; Baram-Tsarabi and Yarden, 2011; Dewitt, Archer and Osborne, 2014). Girls usually have less interest in physics than boys (Arandia, Zuza and Guisasola, 2016). This differs in some countries. There are reports that, for example, in Hong Kong, the age of students and their gender are not significant factors of interest in science (Cheung, 2107). Research conducted in Ethiopia shows that girls and boys exhibit different perceptions of the relevance of science in their lives. There, the teacher is the authority and the main source of information (Yazachew, 2013). In Pakistan, for example, there was a higher interest in science in girls than in boys (Anwer and Iqbal, 2012).

At higher stages of education, students tend to choose subjects that are related to their interests (Elsworth, Harvey-Beavis, Antiely and Fabris, 2010). Most often, attention is paid to students who are interested in the subject, and no attention is paid to students who are not interested in or even dislike the subject being taught. Our research conducted over the last 30 years shows that interest in physics is significantly lower compared to other school subjects, but also that the difference between the percentage of students declaring an interest in physics and the percentage of students who do not like physics is negative. This means that there are more students who do not like physics than those who do (Błasiak, 2011). Students who do not like physics have a negative impact on the achievement of the whole group. A majority of students who dislike physics most often think, for example, that there should be fewer hours of physics at school in the future than there are today. This may be because physics is generally considered a difficult subject (Ryan, 2016).

Our experience from over a dozen years ago indicated that at the beginning of the school course, interest in physics was very high and was often the largest among all school subjects. However, after a few months, it fell quite sharply to being at the lowest level of interest. From the research conducted on a sample of about 3,000 students, it was clear that the worst teaching results were in those classes in which teachers did not recognize the interests of their students. We often observed situations in which a dozen or so students declared an interest in physics in the initial phase of teaching, but the teacher recognized only a few of them. In those days, we had a relatively large number of pupils willing to study physics. Currently, this number is several times smaller (Błasiak, 2011; Blasiak, Godlewska, Rosiek and Wcislo 2012).

Physics is a distinctive area of human knowledge. Understood as a science, it brings tremendous achievements. In the iconic ranking made 40 years ago in the U.S. by M. Hart, in “The 100: A Ranking of the Most Influential Persons in History” (including prominent religious and political leaders, travellers, writers, poets, philosophers), there was a record number of physicists: Newton (2nd on the list), Einstein (10), Galileo (12), Faraday (23), Maxwell (24), Heisenberg (46), Rutherford (56), Planck (59), Röntgen (71), Fermi (76), Euler (77). Maria Skłodowska Curie was placed on a standby list alongside Archimedes, Leonardo da Vinci, Benjamin Franklin, and several other eminent scholars. Among the most influential figures in the history of the world, there are only two writers: Shakespeare and Homer (Hart, 1978). History “magistra vitae est”. Including the threads of the history of physics in the teaching process is conducive to increasing interest in this subject (Simmons, 2000; Balchin, 2003; Hong and Lin-Siegler, 2011). It is a paradox that physics as a school subject evokes poor student interest and that students do not want to be scientists in the future.

A study conducted among 14- to 17-year-old students indicates that enhancing student’s enjoyment and interest may result in more students studying science (Elsworth, 2010; Palmer, 2017). Investigating students’ attitudes toward science has been a substantive issue in the work of the science education research community over the last decades (Osborne et al., 2003; Cristidou, 2011; Krapp and Prenzel, 2011; Boe, Henriksen, Lyons and Schreiner , 2011; Potvin and Hasni, 2014).

Goals and Methods

Knowledge on pupil’s interest in the main teaching subjects is very helpful for any educational school system. It is especially important in the case of school subjects commonly considered to be very difficult and disliked. In this paper we tried to answer the following questions.

1) The first purpose of this research was to find an answer to the question about the level of interest in the school subjects being taught among girls and boys aged 14–15 years.
2) Based on our teaching experience and previous research, we suspected that one of the most disliked school subjects will be physics. We intended to examine the interest in this subject on a larger scale than had been done by the authors of previous works (Osborne et al., 2003; Oon and Subramaniam, 2011). We think that the distribution of students into only two categories (i.e. interested and not interested) is an excessive simplification of reality. After many previous experiments with similar studies, we decided to apply a wide scale to assess the intensity of interest that is, from a level of 0, meaning total lack of interest, to a level of 10, meaning maximum interest. Our second aim was to find an answer to the extent of student interest in physics using this relatively wide scale.
3) The next goals were, respectively, to measure the percent of students’ conviction about their plans in choosing a future profession in which physics would be useful and of their beliefs concerning the usefulness of physics for society, using the same new scale (0 to 10). Due to the fact that school grades are often the cause of students’ dissatisfaction, we decided additionally to find a connection between the assessment issued to students by their teacher and students’ own subjective assessment, i.e. self-evaluation.
4) Another question posed in the research was to find information on the students’ assess-

ment of the suitability of the most important physical formulas from the completed curriculum. With the help of the best physics teachers, we selected 16 formulas found in all school textbooks. We considered that the best teachers are those whose students achieved the greatest successes in the regional physics competitions organized by us for many years. The task of the respondents was to choose those formulas that they thought would be useful in their lives. Students could indicate any number of formulas.

5) To better understand the judgments of the surveyed students, we decided to get to know their views on the most important people in the history of physics. Our task was to find a ranking of those scientists who, in the opinion of the respondents, had the greatest impact on the development of physics.

For most of the issues mentioned above in research question #2 concerning interest in physics, we intended to compare the results for boys and girls. We hypothetically assumed that an interest in physics is essentially higher in boys than in girls.

The research was conducted in Poland in 2018. It involved 5048 students aged 14–15 years, completing a three-year middle school curriculum. There were 2501 girls and 2547 boys in the sample studied. The surveyed students completed an elementary physics course throughout the three-year teaching cycle (usually two hours per week for one year and one hour per week for two years). Before that, they had attended a six-year elementary school in which they had four hours of the subject per week for three years. About 20–25% of the content of the natural science curriculum was related to physics (Podstawa, 2011).

The selection of schools was not completely random, because we were not able to organize a randomized sample, mainly for economic and organizational reasons. In the research, we used the help of our post-graduate students who conducted surveys in over 100 schools in nine Polish regions. They covered 65% of the territory of Poland. Students answered the survey questions anonymously in the presence of their teacher, and their answers were later forwarded to the central computer bank.

The full text of the survey is presented in the appendix. The first question identified the gender of the respondents. The next three questions concerned respectively: the degree of the student's interest in physics, their plans to choose a profession requiring a knowledge of physics, and the degree of the usefulness of physics for society. In these three cases, the answers should be given on the same scale from 0 to 10.

In the fifth question, students had the opportunity to choose from 16 physics formulas that they thought would be useful in their future lives. These were physics formulas from their school curriculum, which concerned, for example, Newton's Second Law of Motion, kinetic energy, or potential energy in a gravitational field, etc.

In the sixth and last question, we asked students about their school grades and their self-assessment in physics (on a uniform scale from 0 to 10). The seventh question concerned the identification of the persons from the history of physics who had the greatest influence on its development. The eighth and ninth questions asked students to indicate their three most favorite and three least favorite school subjects.

Results

The results are presented by first discussing the emotional attitude of the students to selected school subjects. Table 1 shows the percentage of students who found the subject to be the most liked L (column II) and the least liked D (column III). In the last column, you can see the difference between the percentage of students who consider the subject to be the most liked and the percentage of students who passed it that consider it the most disliked.

Table 1. *Students' most liked and most disliked school subjects*

School Subjects	L [%] Most liked	D [%] Most disliked	Difference L-K [%]
Chemistry	17	33	-16
Physics	17	28	-11
History	17	24	-7
English language	27	28	-1
Geography	13	14	-1
Mathematics	32	33	-1
Music education	2	1	1
Polish language	25	24	1
Biology	20	19	1
Technical education	4	2	2
Religion	8	4	4
Informatics	13	3	10
Physical education	44	7	37

Figure 1 presents the average results of 5048 students' answers to question 2. On the horizontal axis, the acceptance level [from 0 to 10] of the following sentence is marked: "I'm interested in physics".

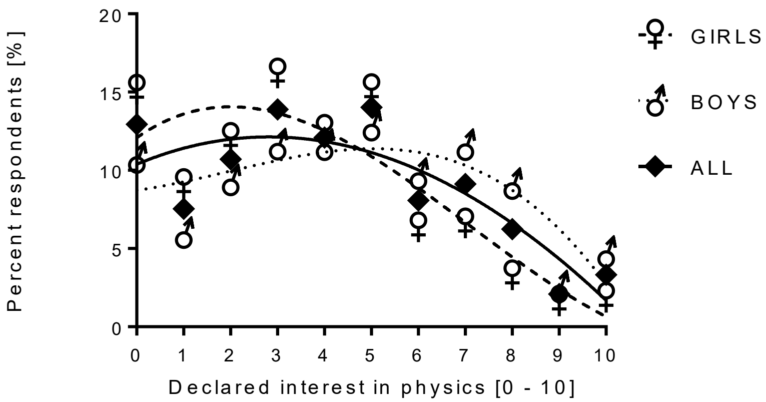

Figure 1. Percent of respondents who declared an interest in physics [scale 0–10]

The distribution is not Gaussian for p = 0.05. Only about 7% of girls and 17% of boys declared a relatively high interest in the subject (higher than 7) in the scale we adopted (from 0 to 10). The average values of declared interest for girls and boys were 3.5 and 4.5, respectively. The averages are significantly different (p <0.0001).

Different teachers were teaching the study group of over 5,000 students. Our more detailed analysis showed a large variation in the results depending on the teacher. For some teachers, the average declared interest was over 8 (on a scale from 0 to 10), while for others, it was less than 2.

Figure 2 presents the results of the answers to question 3. The horizontal axis presents the acceptance level [on the scale from 0 to 10] of the following sentence: "In the future, I plan to choose a profession in which physics will be needed".

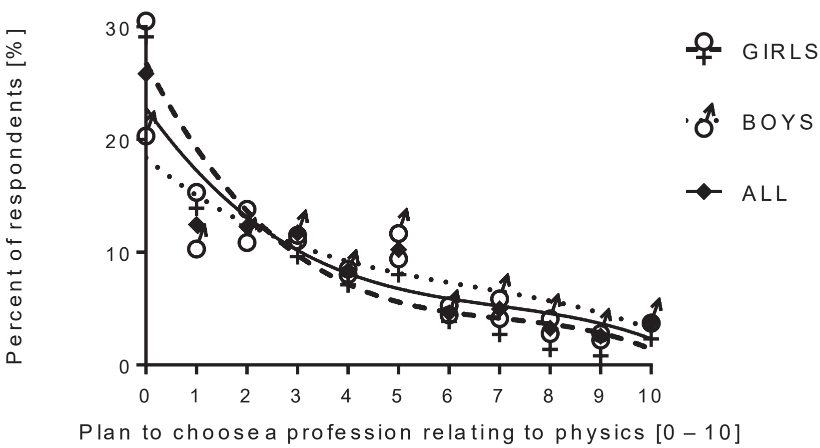

Figure 2. Percent of respondents planning to choose a profession relating to physics [scale 1–10]

Figure 3 presents the results of the answers to question 4. The horizontal axis presents the acceptance level [from 0 to 10] of the following sentence: “Physics is useful for society”.

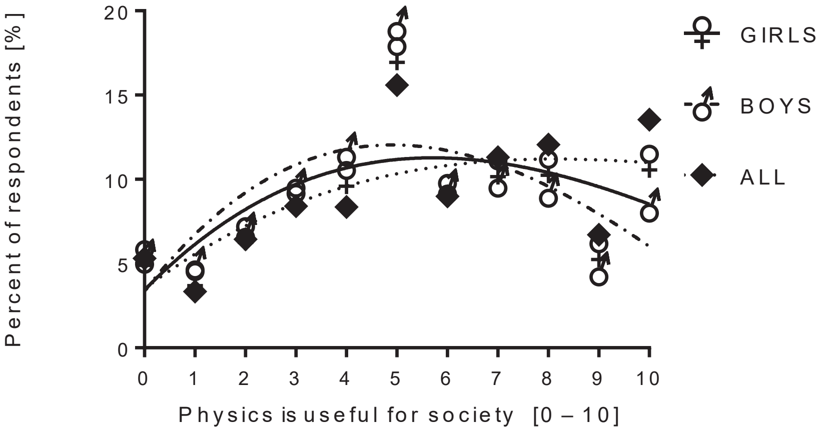

Figure 3. Percent of respondents who answered that physics is useful for society [0–1]

On Figures 1, 2 and 3, third-degree polynomials were fitted to the values of the obtained results. Such an approximation better reflects the mathematical description of the tested relations than a linear fitting.

Figure 4 shows the linear correlation between the level of acceptance of the declared usefulness of physics for society and plans to choose a profession in which physics will be useful, as well as the interest in physics among girls and boys.

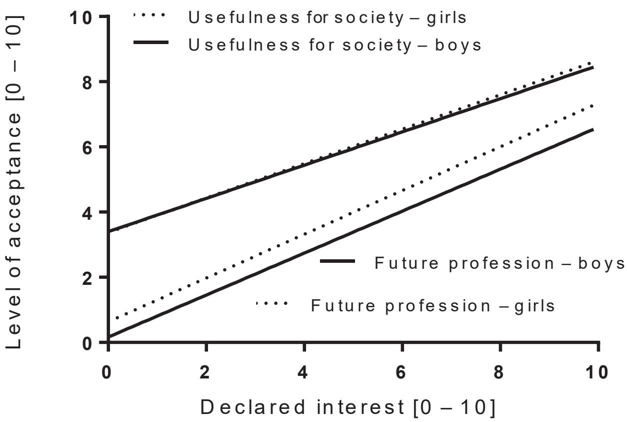

Figure 4. Correlation between an acceptance of the usefulness of physics for society and plans to choose a profession relating to physics, and declared interest in physics

Applying a linear regression, the level of acceptance of the importance of physics for society (A) depending on one’s interest (X) for girls could be described by the linear function

A (X) = 0.51 X + 3.40, and for boys A (X) = 0.52 X + 3.38. The corresponding Pearson correlation coefficients were: R = 0.47 for girls, and R = 0.54 for boys. The intention to choose a profession (P) in which physics would be useful: P (X) = 0.64 X + 0.17 for girls, and P (X) = 0.67 X + 0.63 for boys. In both cases, Pearson's correlation coefficients were equal to R = 0.63.

Appropriate approximations describing the relationship between the grade (M) in physics and the declared level of interest (X) were as follows. For girls M (X) = 0.22 X + 4.26, and for boys M (X) = 0.30 X + 3.12. The corresponding Pearson correlation coefficients were 0.27 and 0.39 for girls and boys, respectively. For all of the respondents, R2 = 0.3.

The average school grade among girls (on a scale of 0 to 10) was 5.0, and their average self-evaluation 5.7. For boys, the average grade was 4.5, and the average self-evaluation 5.3. The differences between averages were statistically significant at p = 0.01. The Pearson correlation coefficient for the linear correlation was 0.64 for girls and 0.58 for boys.

Figure 5 shows how many formulas out of the 16 most important ones from the physics curriculum taught by teachers were considered useful by students in their future lives.

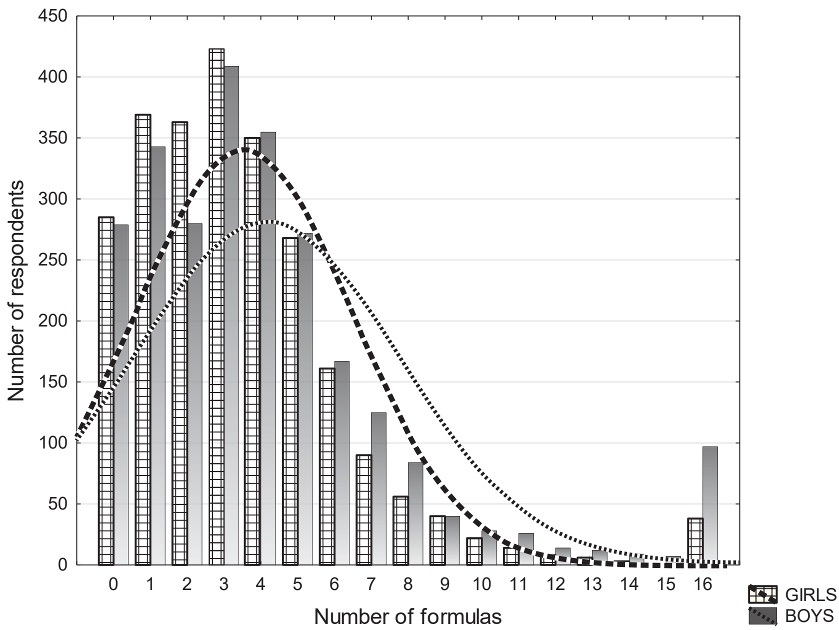

Figure 5. The number of respondents who considered a given formula to be useful

The average number of formulas considered useful, out of 16 to choose from, was low among the more than 5,000 student respondents. For girls, it was 3.5, and for boys it was 3.1. The difference is statistically significant (p <0.05).

The approximate linear dependency between the number of formulas (F) considered by students to be useful and their declared an interest in physics (X) was F (X) = 0.45 X + 2.10 for girls and F (X) = 0.42 X + 2.05 for boys.

In Figure 6, we present the names of those persons in the history of physics, whose achievements our students deem most important.

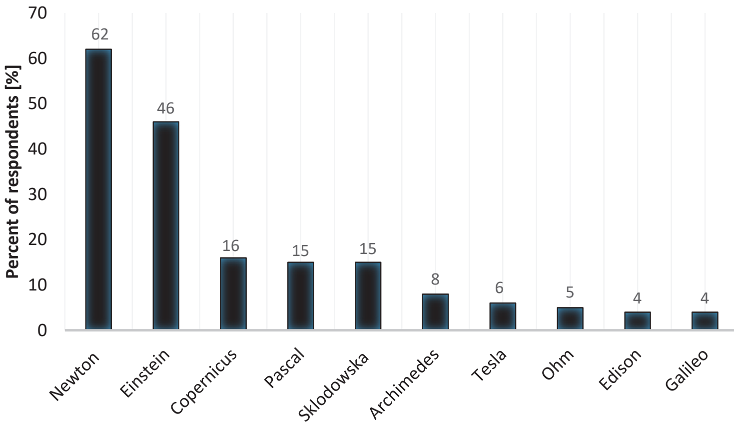

Figure 6. The most important physicists in the opinion of the respondents

Discussion

At the outset, we will refer to the emotional involvement of students with school subjects. Table 1 shows that the largest number of students considered physical education, mathematics and English to be their most liked subjects. The least liked subjects were chemistry, mathematics, physics and English. All those students who indicated the school subject as the most liked (positive engagement) and those who considered it the most disliked (negative involvement) deserve special attention because different didactic strategies must be used in working with them. The subjects with the greatest emotional involvement of students included: mathematics, physical education, English, chemistry, Polish, and physics.

We believe that in the full assessment of the students' mental attitudes to school subjects, it is also worth taking into account the difference between the percentage of students who like the subject and the percentage of students who do not like the subject. In this respect, physical education and computer science are in the best position, whereas chemistry and physics are in the worst.

We observed interesting results in the case of mathematics, with the largest polarization of extreme opinions among the students. The percentage of pupils who like mathematics the most is surprisingly high (32%), and it is almost the same as the percentage of students who do not like mathematics (33%). The smallest emotional involvement in school subjects was noted in the case of religion, technical education and music.

Similar research was conducted by us in 2008 in a group of over 1,000 high school students aged 16–19 years. At that time, the results also pointed to mathematics as the subject with the highest polarization of students' preferences. Most of the pupils indicated mathematics and biology as their favourite school subjects, and physics was considered the least-liked subject (Blasiak, 2011). Ten years ago, this group had a more favourable emotional relationship to biology, English and geography. Polarizations (i.e. the differences between the percentage of students who like the subject and those who dislike this subject) were smaller. However, it is difficult to make unambiguous conclusions because the groups differed in age, and the research was conducted at different times.

In the following, we will discuss the subject of physics, which in many countries of the world is often the most disliked school subject. It turned out that in the studied area of Poland (inhabited by 65% of its citizens), students' interest in this subject is relatively low: on average, less than 40% of the scale we selected. Our hypothesis that boys' interest is significantly higher than girls' interest has been strongly confirmed.

The determination of students regarding the choice of profession (measured on a scale from 0 to 10) in which physics will be useful is presented in Figure 2. With a very high probability of more than 90%, only 2% and 3% of girls and boys, respectively, plan to choose a profession relating to physics. Approximately 70% of girls and 55% boys express a deep reluctance (at levels 0, 1, 2 and 3 on a scale of 0 to 10) to choose such a profession . Of course, these declarations should be treated as preliminary since the students had at least 3 years to make a final decision on a chosen field of study during the time the research was conducted. However, they were already at the stage of pre-electing their specialization at a later stage of education (e.g., humanities or mathematics and natural science).

The curves presented in Figure 3 on the acceptance of the importance of physics for society have a definitely different shape. They indicate the high level of students' beliefs in the usefulness of physics to society. A high belief in the usefulness of physics (6, 7, 8, 9 and 10 on a scale from 0 to 10) was declared by about 65% of girls and 70% of boys. All that remains is to hope that these values will not deteriorate with further education.

Figure 1 and especially Figure 2 show the characteristic phenomenon of the so-called central tendency. The percentage of students' responses is clearly higher in relation to the fitted curve.

An additional quantitative result of this part of our research was the determination of the mathematical functions describing the relationships between: 1) the student's willingness to choose a profession relating to physics and interest in physics P(X); 2) the level of students' acceptance of the importance of physics for society and their interest in physics A(X). The scales chosen suggested that the simplest models describing the reality could be "linear": P(X) = A (X) = X, i.e. linear functions with the slope equal to 1 and intercept close to 0. The obtained results deviated significantly from this approximation. In case 1, the linear function adjusted to the data had a similar slope for girls and boys, which was 0.6. The intercept for boys was essentially larger compared to the girls. In case 2, the linear function adjusted to the experimental data had a slope of approximately 0.5 and an intercept of about 3. We hope that future research of this type for other school subjects will allow for the construction of better prognostic models.

The resolution of the dispute between supporters and opponents of a strong dependence between school grades in physics and students' interest in this subject M (X) was an important question investigated in the study. In the linear regression, the slopes of the respective functions were significantly less than one. They were 0.2 for girls and 0.3 for boys. It turns out that school grades do not depend on students' levels of interest. This result disproves the supporters of the theory that there is a strong dependence between school grades and students' levels of interest in subjects.

School grades are probably not the best measure of student achievement. Often, it significantly differs from students' self-evaluations. In our study, the Pearson linear correlation coefficient between the school grade issued by the teacher and the students' self-evaluation was approximately $R = 0.6$. For low school grades, self-evaluations were significantly higher, and for the highest school grades, they were slightly lower. From a didactic and educational point of view, considerable discrepancies between grading and self-evaluation are unfavourable, especially in the case of low school grades.

Physics is an experimental science that continually uses a mathematical description of the relationship between physical quantities. There are many relationships and dependencies expressed in the form of the so-called formulas. These formulas for some students can be examples of the mathematical beauty of physics, while for others they are a reason for discouragement within this subject. The appropriate distribution showing the percentage of students who found a certain number of formulas to be useful is shown in Figure 5. The most frequently chosen formulas were those defining speed, mechanical work and the relationship between force, mass and acceleration in Newton's law, whereas the least frequently chosen was the second law of thermodynamics.

It is worth noting the seemingly irrelevant detail shown in Figure 5 on the right side of the histogram. Approximately 6 percent of students (2 percent of girls and 4 percent of boys) considered all the formulas to be useful in life. Perhaps some future outstanding scientists are within this small group of students.

The situations described above are very unfavourable. There is a chance that this may improve later in the school education process. This is suggested by our complementary research conducted in a group of about 50 students aged 16–17 years who have undergone the next stage of education in upper secondary school. In this age group, average students chose (from the same set of 16 models) an average of 6 formulas as useful. The best students, laureates of local physics contests, chose 10 formulas (Kazubowski, 2016).

Each person has their own vision of the most important people in the world of science. It depends on the type and levels of education. Our respondents could not yet have a sufficiently broad picture of achievements in physics. However, it is worth analysing their judgments at this stage of teaching, because the first ideas we create are usually very long-lasting. In Figure 6 we can see the names of those figures in the history of physics, whose achievements our students deem most important. The first two surnames, Newton and Einstein, are almost always in all rankings, regardless of education and location in the world. The rest is debatable. The position of Nicolaus Copernicus and Marie Skłodowska Curie is probably the result of the location of the tested sample on the world map.

Edison's position is surprising because he was an outstanding inventor but not a physicist. We noticed that in the former capital of the country in which the research was conducted, three of the most beautiful buildings there have the following names: Newton, Galileo and Edison. Perhaps this led to the students confusing inventors with scientists. Natalie Ungier (a winner of the Pulitzer Prize) wrote that British students aged 13–16 years who took part in a study conducted in 2005, also mentioned the name of Christopher Columbus in addition to the names of Einstein and Newton when answering a similar question (Angier, 2007).

Conclusion and Limitations

The results of this part of our research concerning students' opinions on the usefulness of physics for society and their plans for choosing a science-related profession coincide with the results of Schreiner and Sjogerg's research conducted in many countries around the world about 10 years ago. Physics is one of the most disliked school subjects throughout the world as well as in Poland. Nonetheless, young people recognize and value its usefulness to society. This gives hope that future generations will appreciate those who decide to work in the field of the natural sciences after all.

The use of an unusual, multistage rating scale of interest allowed us to determine three functional relationships: the relationship between the assessment of physics' usefulness and interest in the subject, the relationship between the desire to choose a profession in which physics will be useful and interest in the subject, and the relationship between the number of formulas considered useful in life and interest in the subject. Studying such relationships at different levels of education at different times can be helpful in improving teaching programmes and methods.

In the case of mathematics, chemistry and physics, we noted a large polarization of students' emotional attitudes to these subjects. A large percentage of students classified them as most-liked subjects, but a significant part of the students also classified them as least-liked subjects. For the benefit of society, it is important that the number of students who find these subjects as their favourite is as high as possible and the number of students who find these subjects as least favourite is as low as possible. We need to improve the methods of working with students who are not interested in physics. We think that more research is needed on the methodology of working with students who do not like a given subject.

We have not been able to find experimental confirmation of the hypothesis that students regarded by teachers as good and very good in physics (highly graded) are definitely more interested in the subject than students achieving mediocre (lowly graded) results. It seems that school grades are not the best measure for student achievement. The interests declared by the students do not necessarily coincide with real interests, which is understood as special activities in a specific field. Further research should include other, more objective indicators of student interest.

Our sample registered a lower interest in physics among girls, which is similar to study results in other countries. We believe that further work is needed to increase girls' interest in the subject (Ceci,2 007) .

Since a positive attitude to the subject and interest in physics depend significantly on the teacher, special attention should be paid to the quality of teacher education, including the ability to individualise student work (Keller, Neumann and Fischer, 2016).

The surprisingly negative opinions of students about the usefulness of most mathematical relations between physical quantities, commonly referred to as formulas, that we registered gives a more critical outlook on the basics of teaching. It seems that we, teachers, are ineffective in showing the usefulness of mathematics in physics and other areas of human activity. A wise young individual will not learn what they think is unhelpful in life. It is, therefore, necessary to undertake work on scientific literacy in the field of mathematical education. We should consider which of the mathematical formulas should be removed from the physics curriculum, or we should consider how to change the teaching methodology so that students are convinced about the importance of physical formulas (Trumper, 2016). The profound social changes in the world are causing students to pay increasingly more attention to the practical usefulness of acquired knowledge (Kahneman, 2011).

We and many other researchers (Cleaves, 2005; Aschbacher, Li and Roth 2010; Woods-McConney, Oliver, McConney, Schibeci and Maor 2013) are deeply convinced that there is a need to conduct comprehensive research on the factors relating to student involvement in science and the methods used to induce and strengthen their interest.

Our research conclusions have some limitations because the research was conducted only in part of Poland (65 percent of its territory). The organization of the school system and curricula have also been changed. Therefore, it is worth extending this research to the entire country in the next years. It is also worth conducting similar surveys for other school subjects.

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Appendix

1. Gender of the respondent: Male, Female
2. Rate the truth of the sentence on the scale given below: **I'M INTERESTED IN PHYSICS**

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

3. Rate the truth of the sentence on the scale given below: **IN THE FUTURE, I PLAN TO CHOOSE A PROFESSION WHERE THE KNOWLEDGE OF PHYSICS WILL BE NEEDED**

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

4. Rate the truth of the sentence on the scale given below: **PHYSICS IS USEFUL FOR SOCIETY**

0	1	2	3	4	5	6	7	8	9	10

5. Mark the formulas learned in the physics class that **you think** <u>will be useful to you in your life</u>

1 $F = m * a$	2 $a = \frac{\Delta v}{\Delta t}$	3 $R_z = R_1 + R_2 + \cdots$	4 $s = \frac{at^2}{2}$
5 $E_p = m * g * h$	6 $v = \frac{\Delta s}{\Delta t}$	7 $W = F * s$	8 $T = \frac{1}{f}$
9 $E_k = \frac{mv^2}{2}$	10 $p = \frac{F_n}{S}$	11 $V_{śr} = \frac{s_{całkowita}}{t_{całkowity}}$	12 $\Delta E_w = W + Q$
13 $p = \frac{m}{V}$	14 $U = \frac{W}{q}$	15 $I = \frac{q}{t}$	16 $W = U * I * t$

6. In the previous semester, I achieved the following grade in physics:

   a) insufficient, + insufficient, sufficient, + sufficient, satisfactory, +satisfactory, good, +good, very good, +very good, excellent

7. Write down the names of people in the history of humankind who, **in your opinion**, had the greatest impact on the development of physics

   a) ....

8. Give the names of your 3 **most liked** school subjects

   a) ....

9. Give the names of your 3 **most disliked** school subjects

   a) ....

10. In my opinion (in my own self-evaluation) in the last semester I deserved the following grade in physics:

    a) insufficient, + insufficient, sufficient, + sufficient, satisfactory, +satisfactory, good, +good, very good, +very good, excellent