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POLISH LOWER AND UPPER SECONDARY SCHOOL STUDENTS' CONCEPTIONS OF A SCIENTIST

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Abstract

There is an increasing problem of a much smaller number of students in natural sciences or mathematics in Poland. The number of students is decreasing so dramatically that some courses are closed. Therefore, it becomes very important to look for the possible causes. The starting point for these considerations is the study on the image of a scientist. The image of a scientist and the factors that shape it have been the subject of research in various countries around the world for more than fifty years. The aim of the present research was to determine what the image of a scientist according to Polish students is. Additionally, the impact of the students' age (in the range of 13-19 years old) on this image was analysed. The study involved 938 students of lower and upper secondary public schools from all over the country chosen randomly. The research was based on a questionnaire which was anonymous and community-based. The main questions were preceded by an enquiry about the respondent's personal information such as gender, age, type of school they attend, and school locality. These data were needed for the analysis of such factors as, for example, the effect of gender. The obtained results showed that the image of a scientist according to Polish students is quite similar to the stereotype adopted by students from other countries. Contrary to some earlier reports, Polish students usually presented a scientist as a young person and paid more attention to personal safety equipment like a lab coat, gloves and goggles. It should be noted that this stereotype is quite archaic and is not associated with a real vision of a scientist. This lack of awareness may have an impact on shortage of students in the structure of science studies.
Key words: *Draw-A-Scientist Test (DAST), images of a scientist, stereotype of a scientist.*

Introduction

The image of a scientist is shaped in students' minds by many different factors and may significantly influence the perception of science by school students (Schibeci, 2006, p.15) and determine the choice of career (Mead & Métraux, 1957, p.389). The research carried out in the scope of the image of a scientist shows the considerable influence of the cultural background (Sjøberg, 2002, Farland-Smith, 2009, p.36) and the development within a given country (Sjøberg, 2002). Milford and Tippett (2012, p.759) claim the students' attitude to science is determined by their experiences in school. Other research shows that the image of a scientist among students is affected by teachers, textbooks (Türkmen, 2008, p.59), type of school (public or private) (Medina-Jerez, Middleton, Orihuela-Rabaza, 2011, p.665). Some authors indicate that the students are strongly influenced by the image seen at home, in comics, and particularly on television programs and films (Long, Boiarsky &Thayer, 2001, p.265, Steinke et al., 2007, p.56).

The image of scientists and the factors that shape it have been the subject of research in different countries throughout the world for more than fifty years. During that period, several types of tests have been developed and the research methodology has expanded proportionately (Finson, 2002). The first type of a study carried out on a large scale in the United States was the

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description test - its participants were asked to write about their perception of scientists (Mead & Métraux, 1957, p.385). The purpose of this study was to obtain the information on the attitudes the high-school students hold as a group of people toward science and scientists in general and when they think about themselves as becoming scientists or as married to a scientist.

Another instrument that is still generally applied is the Draw-A-Scientist Test (DAST). Actually, the DAST is commonly called the test, but in fact it is a questionnaire. Respondents' task is just to draw a scientist (Chambers, 1983). It can be used separately or as a part of complex tools, for example, the SAS questionnaire (Sjøberg, 2002, pp.104-117), which has been used in a large project entitled 'Science and Scientists: The SAS-study'. The study involved several parts:

- 'Scientists as persons' - a questionnaire filled in by students who evaluate the traits and characteristics of persons working within the field of physics or engineering and biology or medicine,
- 'Out of school experiences: What I have done' – an inventory of 80 activities that may have bearing on the learning of science at school or at home together with the frequency of those activities,
- 'Things to learn about' - an inventory of possible topics that the students would like to learn about,
- 'Important for a future job' - the students are invited to judge which aspects are important for their future work,
- 'Science in action' - giving an opinion about the characteristic features of science, how it is perceived,
- 'Scientists at work' - the students do the DAST and are asked to add something in writing: 'Write some words about what you think scientists do and what issues they work on'.
- 'Me as a scientist' - a short essay prepared by the students who put themselves in the position of being a scientist and describe what subject they would like to do research on. The students are free to choose whatever they find interesting or important.

The study, based on the description test conducted in the 1950s by Mead and Metraux (1957, p.384) among 35,000 US high school students gave the stereotypical image of a scientist. Students viewed a scientist as a white middle-aged male, wearing a white lab coat and prescription glasses, who works in a laboratory surrounded by different flasks, vials and test tubes.

Further analyses of the image of a scientist were undertaken on the basis of a drawing-based method - the DAST. The first DAST studies were conducted during the years 1966-1977 in schools located in Canada, the United States, and Australia (Chambers, 1983, p.258). The subjects were 4807 children aged from five to eleven (from kindergarten to grade five at primary school) and the majority were from grades two and three. The drawings were analysed to find out whether previously determined characteristic elements of a scientist were present: (1) lab coat (usually white), (2) glasses, (3), beard, moustache, (4) laboratory equipment, (5) books or other symbols of knowledge, (6) items related to new technology, inventions, (7) captions of the „eureka!" type (Finson, Beaver, Cramond, 1995, p.196). The comparison of the students' age with the analysis of drawings revealed that the vast majority of the youngest students (kindergarten, first grade) did not include any of the above-mentioned indicators in their works. They began to be incorporated by the second grade students who statistically drew two elements viewed as stereotypical. It was also found that the drawings made by the older students resembled the stereotypical image of a scientist as analysed above - fifth grade students included three, sometimes even four types of those indicators. Moreover, the studies showed that not only age influences the number of stereotypical elements appearing in the students' drawings (Krause, 1977, p.10). There was a clear relationship between the accuracy of drawings and the students' economic situation (Chambers, 1983, p.261).

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The studies based on the DAST are still quite widespread and various aspects that may influence the image of a scientist are investigated. One of the most popular elements is the gender analysis of drawn scientist often in respect to gender of drawing a person. Many studies demonstrated that a scientist has been perceived mainly as a man and not a woman (Chambers, 1983, p.261; Manzoli, Castelfranchi, Gouthier, Cannata, 2006, p.10; Barman, 1997, p.21; Türkmen, 2008, p.59; Sjøberg, 2002, p.89; Huber & Burton, 1995, p.374). This view is still up to date. Moreover, it is very rare that a boy, when asked to draw a scientist presents such a figure as a woman, and only a small number of girls create the image of a woman scientist. Some researchers have noticed also the relationship between the content of the drawings and the students' gender. For example, Kind (1996) indicates that almost only boys prepare drawings that may be considered as science-fiction (6% of boys and 1% of girls). Boys also have a greater tendency to draw pictures of cruel and gruesome scientists (11% of boys and 2% of girls).

The research shows that the majority of students draw a scientist in a laboratory (Chambers, 1983, p.258) surrounded by laboratory glassware (Milford & Tippett, 2012, p.753). It may result from the fact that students find it the simplest to draw (Türkmen, 2008, p.57; Newton & Newton, 1998, p.1146). This thesis is not consistent with the fact that laboratory environment is strongly influenced by a cultural background. For example, US students (the majority of whom live in detached houses) often drew laboratories in the basement, whereas Chinese students (living in multi-storey apartments) did not produce even one such a drawing (Narayan, Park, Peker, 2009, p.48). Instead, Chinese students included in their drawings of laboratories the 'place for rest' that is typical in their culture, which was not done by US students (Farland-Smith, 2009, p.34).

Another factor that has an effect on the perception of a scientist by students is an earlier experience connected with science. It was found that students with bad memories and a negative image of a scientist are much less likely to perceive the sciences as interesting and to follow scientific careers in the future (Milford & Tippett, 2012, p.759). Extensive research aimed at answering such questions as 'How is a scientist perceived?' and 'What is a child's attitude to science?' was carried out within the framework of the project 'Science and Scientist: The SAS-study' (Sjøberg, 2002). The scope of the study was very broad - the project involved 21 countries throughout the world and a total of 9,300 students answered the questionnaire. The results show that child's approach to scientists and science is greatly affected by the development of the country in which the child lives. Students from highly developed countries known for progress in science often present scientists in a negative light - mad, careless, responsible for environmental pollution, performing dangerous experiments on animals, constructing nuclear bombs. Children from poorer countries illustrate a scientist as a noble and wise figure trying to save the world and helping people in need.

The aim of the research was to determine what the image of a scientist according to Polish students is. Additionally, the impact of students' age, in the range of 13-19 years old, on the image was analysed.

Methodology of Research

General Background of Research

Thus, so far Polish students' conception of a scientist was unknown. There are only results of a study concerning the citizens' perception of the scientist's attributes (Panasiuk; 1998, p.88) obtained within the research focused on stereotypes of different jobs. The leading attributes of Polish scientists listed by the respondents in the research dated 1980 were as follows: glasses (7.1%) and absent-mindedness (6.5%), and ten years later they were glasses (11.0%) and books (10.6%), which was found during the analogous study.

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Polish student population and society is quite homogeneous. Almost all students are white Caucasian and 92.2% of them are Catholics (GUS, 2014). Education is compulsory in primary (classes 1-6, age 7-12) and lower secondary schools (classes 7-9, age 13-16). Students can continue education voluntarily in upper secondary schools (classes 10-12 or 10-13 in technical vocational schools, age 16-19(20) respectively). The vast majority of the student population attend public schools in the local district. In lower secondary schools percentage number of male and female students is almost equal - 52% of boys (GUS, 2014). At upper secondary school level this proportion is changed and depends on the type of school. In general and non-technical vocational upper secondary schools domination of female students is noticeable - 38% of boys, but in technical schools this proportion is opposite - 60% of boys. Teaching in Polish schools is dominated by lecturing methods with elements of problem-based learning, but this approach is being changed. The latest reform of core curriculum introduced in 2009, defined new general objectives of education, graduates' key competences and made using inquiry-based methods (IBL – Inquiry Based Learning) obligatory (Act of the Polish Parliament, 2008). So far, changes in legislations do not have an effect on the methods used by teachers (Bernard, Migdał-Mikuli, Ciura, 2014), and the level of implementation of IBL (Bernard et al., 2013, p.52).

Sample Selection

The research was based on a questionnaire which was anonymous and community-based (Krosnick & Presser, 2010, pp.294-298; Sztumski, 2010, pp.170-180). The main questions were preceded by an enquiry about the respondent's personal information such as gender, age, type of school they attend, and school locality. These data were needed for the analysis of such factors as, for example, the effects of gender.

The study involved 938 students of lower and upper secondary public schools from all over the country chosen randomly. Questionnaires which did not include complete data were excluded from the analysis. The final research group equalled n = 781, of which boys = 269, and girls = 512, including 350 lower secondary school students and 431 upper secondary school students. The variations in responders' gender structure were caused by gender disproportion in the upper secondary schools. Moreover, it was noticed that the male respondents' answer sheets were more often incomplete.

Instrument and Procedures

The main element of the questionnaire was the DAST drawing, which was modified by adding a one-sentence description of the drawing: 'The drawing shows ...', so that the drawing was more understandable for an analysing person.

The DAST analysis started with the selection of characteristics whose frequency of occurrence was to be counted. For this purpose 50 works were randomly chosen, and drawings were described with characteristic features. Obtained characteristics were listed and compared with the DAST checklist (Finson et al., 1995, p.196). Obtained features covered all DAST checklist features (lab coat, eye glasses, facial growth of hair, symbols of research, symbols of knowledge, technology), and included several additional scientists' attributes. Obtained features were used as a new check-list and a base for drawings' transcription. All the drawings were coded by one trained person. The relativity of the interpretation of drawings was analysed by the test of intra-scorer (intra-judge) and inter-scorer (inter-judge) reliability (Toğrol, 2013, p.291). For this purpose, 40 randomly selected works were coded a second time by the main coding person and a third time by an independent researcher without experience in this particular transcription. The results were compared and the correlation coefficients were calculated. The correspondence between coding and re-coding equalled 0.95, $p < 0.001$, and between cod-

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ing and independent coding 0.85, $p < 0.001$. These results indicate fairly high inter-scorer and intra-scorer reliabilities, similar to the reliability studies found in earlier research conducted by Schibeci and Sorensen (1983, p.17) or Toğrol (2013, p.291).

Results of Research

Table 1 shows the features of a typical scientist according to Polish students. The results show that the scientist according to the statistics is a young person wearing corrective glasses and having wild hair. Unfortunately, it was not possible to determine the age of the person in each drawing.

Table 1. Analysis of drawings-frequency of personal indicators.

Indicators	Frequency [%]		
	Total	Lower secondary school	Upper secondary school
Young	53.4	56.3	51.0
Eyeglasses	34.7	38.9	31.3
Crazy hair	28.3	27.7	28.8
Old	15.5	15.4	15.5
Lab goggles	10.0	10.0	10.0
Facial hair	9.9	11.7	8.4
Bald	8.6	9.4	7.9

The subjects drew scientists with numerous attributes, the numbers of which are presented in Table 2. The prevailing attribute included laboratory containers. They were usually placed on a table together with books, notes, and other equipment. The elements of personal protection were also often observed, that is a lab coat and laboratory goggles which noticeably differ from corrective eyeglasses. Examples of drawings are presented in Figures 1-4. Drawings were chosen to show the variety in the perception of the image of the scientist by the students, most of them depart from stereotypical image.

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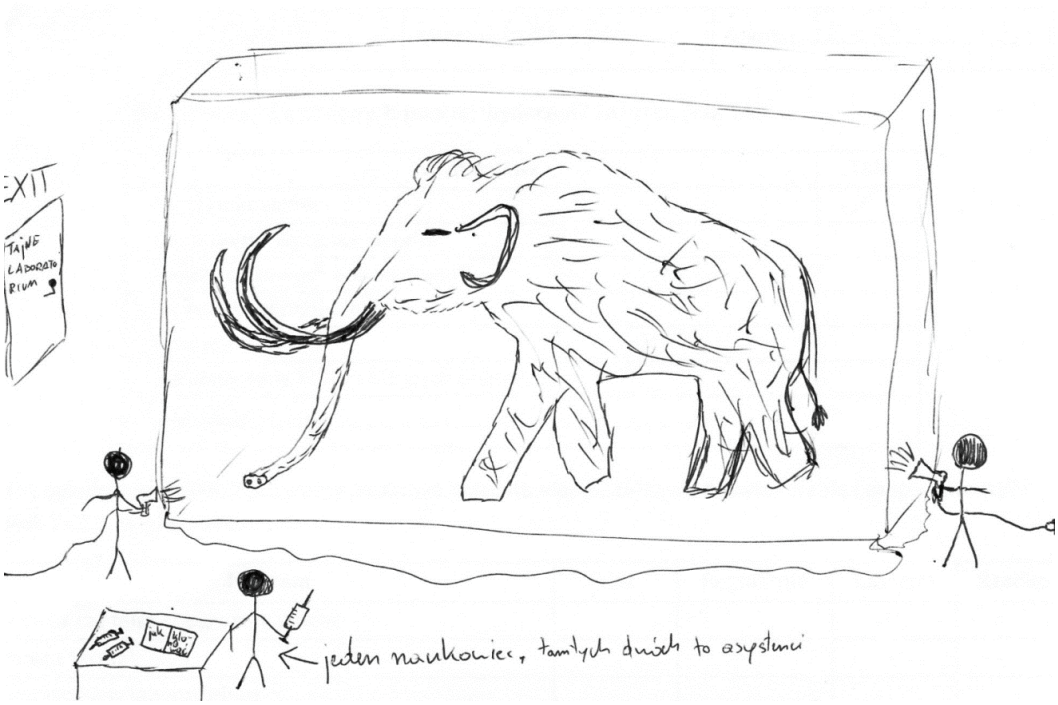

Figure 1: Drawing made by a male respondent, age 18. Author's description: The figure shows the mammoth, which scientists have found in Northern Asia. It is in a block of ice, so they try to defrost it and then clone.

Figure 2: Drawing by a female respondent, age 18. Author's description: Thinking scientist.

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Figure 3: Drawing by a male respondent, age 17. Author's description: A scientist working outdoors.

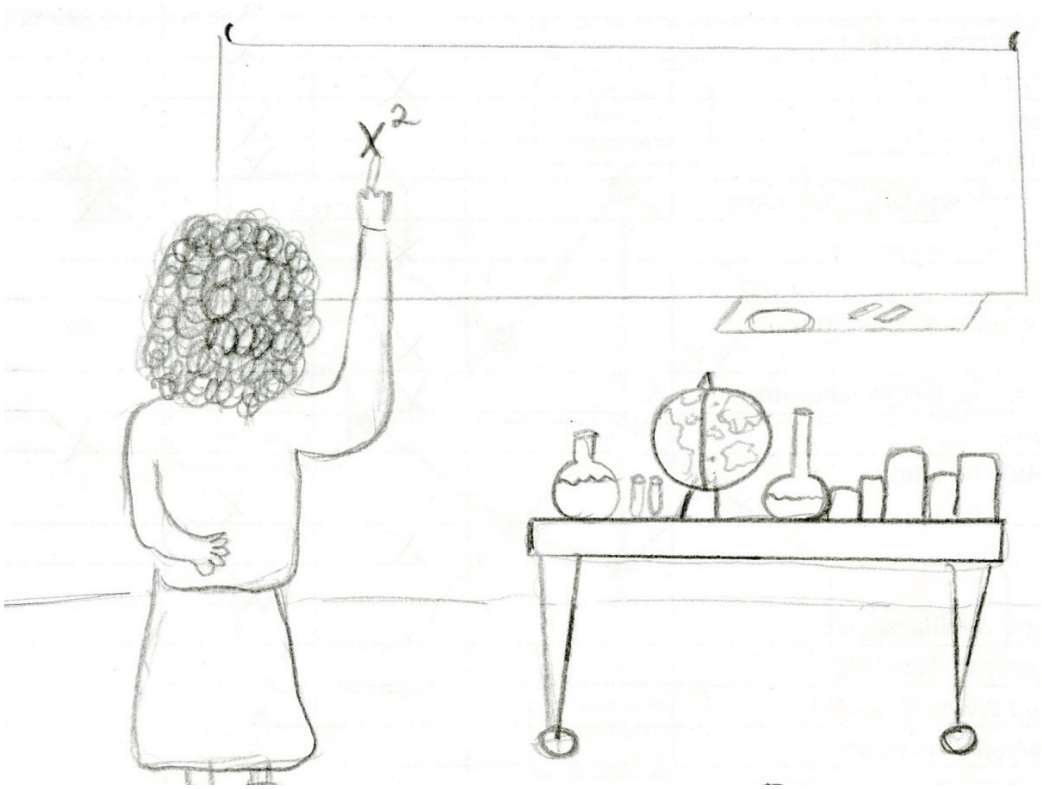

Figure 4: Drawing by a female respondent, age 15. Author's description: A lecturer at university.

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Table 2. Analysis of drawings - frequency of scientist's attributes.

Indicator	Frequency [%]		
	Total	Lower secondary school	Upper secondary school
Basic lab glass	81.8	80.0	83.3
Table	68.5	76.0	62.4
Lab Coat	46.9	43.1	49.9
Books	15.5	11.7	18.6
Blackboard	14.6	14.6	14.6
Notes	11.3	10.0	12.3
Equations	11.0	12.0	10.2
Computer	7.4	8.3	6.7
Microscope	5.9	5.1	6.5
Animal	3.2	4.9	1.9
Plant	2.0	2.9	1.4
Chalk	1.7	2.3	1.2
Loupe	1.3	0.9	1.6
Pointer	1.0	0.9	1.2
Syringe	0.5	0.3	0.7

The objects presented in the drawings and the one-sentence description of the drawing made it possible to assign an area of science to a drawn scientist in a large number of cases (Table 3). The description resulted in associating laboratory glassware in the majority of cases with the profession of a chemist which greatly prevailed. It may be surprising that the presentation of a scientist as being a specialist in the humanities was more frequent than that of a medicine doctor.

Table 3. Analysis of drawings-frequency of profession.

Indicators	Frequency [%]		
	Total	Lower secondary school	Upper secondary school
Chemistry	64.0	65.7	62.6
Biology	2.0	2.9	1.4
Physics	0.9	1.1	0.7
Pharmacy	0.9	0.6	1.2
Mathematics	0.6	0.9	0.5
Humanistic	0.3	0.6	0.0
Medicine doctor	0.1	0.3	0.0
No indicator	31.2	27.9	33.6

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The next analysed element was the gender of the drawn person (Table 4) and analysis in relation to the respondent's gender (Table 5). Despite the fact that nowadays research is usually carried out by teams of researchers, the drawings mostly show one individual person. In the instances of drawings showing a group of people, it was usually impossible to identify the gender due to the low number of details in each figure. The category of 'No indicator/other' included the drawings of persons without features determining their gender.

Table 4. Analysis of drawings-frequency of gender.

Indicators	Frequency [%]		
	Total	Lower secondary school	Upper secondary school
Woman	7.8	6.6	8.8
Man	88.6	89.1	88.2
Group of people	2.8	3.1	2.6
No indicator/other	0.8	1.2	0.4

Table 5. Analysis of drawings-frequency of gender in relation to the respondent's gender.

Gender of a respondent	Indicators	Frequency [%]		
		Total	Lower secondary school	Upper secondary school
Woman	Woman	11.5	11.2	11.7
	Man	85.0	85.4	84.7
	Group of people	2.0	2.0	2.0
	No indicator/other	1.6	1.5	0.0
Man	Woman	0.7	0.0	1.6
	Man	95.5	94.5	96.8
	Group of people	4.5	4.8	4.0
	No indicator/other	0.00	0.0	0.0

Discussion

After summarising the obtained results, it is possible to present the image of a typical scientist. According to Polish students, both at lower and upper secondary school level, typical scientist is a young male wearing corrective glasses and having crazy hair. He usually wears a lab coat and works with chemistry. Therefore, he is surrounded by simple laboratory glassware placed on a table, along with books and notes. Another frequent element of the surroundings is a blackboard.

Differences in the perception of the scientist by the students of lower and upper secondary schools are subtle. Noticeable changes occur in four areas. With students' age, there is a clear decrease in indicating a desk and animals as attributes of a scientist in favor of the use of books and wearing a lab coat. This is probably due to increased awareness of the value of referring to the literature (books) and the location of a scientist in a lab, not in a classroom (table). A similar trend was noticed by Fung (2002, pp.207-208). It can also be noticed that a similar number of features is represented in the drawings made by the Polish students from lower (age 13-16) and upper (age 16-19) secondary school. There is no maintenance of the observed trend

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of increasing the number of elements in the drawings made by lower secondary school students in comparison to the students of the kindergarten, and at primary school level (Özel, 2012, p.3191). The research by Leblebicioglu, Metin, Yardimci & Cetin (2011, p.171) shows that the perception of a scientist by the students changes, due to the influence of such factors as laboratory classes or direct contacts with the representatives of the world of science.

The produced image of a scientist is quite similar to the stereotype described by Mead, Metraux (1957, p.385); Chambres (1983, p.257); Turkmen (2008, pp.56-57); Milford & Tippett (2012, p.757); and Toğrol (2013, p.295). The similarity to the stereotype and lack of changes over time is not a surprising element in view of the research by Matthews and Davies (1999, pp.82-84) who compared the results of their studies carried out in 1993 and 1999 and found that the students examined in 1999 produced even more stereotypical images of scientists than earlier. A feature that makes the obtained results different is the scientist's age. Drawings of Polish students usually present a scientist with the characteristics of a young person while the other research indicates a middle-aged or even older person. This change coincides with the observations by Toğrol (2013, p.293) and Turkmen (2008, p.60) who noticed that the figure of an evil old scientist is replaced with a younger smiling one. It is also noticeable that the number of drawings showing the scientists with facial hair is relatively small.

A lab coat, which is a prevailing feature in almost all available results, is also a dominant element in the drawings prepared by Polish students. Yet, it needs to be emphasised, that as many as 47% of students' drawings are of a scientist wearing a lab coat and such a result is more than twice as high as the result of the research in Turkey (Toğrol, 2013, p.293) over a similar period of time. In addition, it appears to be significant that the students pay more attention to other personal safety equipment like gloves and goggles.

Many conducted studies demonstrate that a scientist has always been and still is perceived mainly as a man and not a woman (Chambers, 1983, p.261; Fort & Varney, 1989, pp.11-12; Barman, 1997, p.21; Sjøberg, 2002, pp.93-94; Manzoli et al., 2006, p.10; Türkmen, 2008, p.57). It is very rare that a boy, when being asked to draw a scientist, draws a woman. The research carried out among the US and Chinese students (Farland-Smith, 2009, p.27) reveals that 56% of US girl students drew a woman scientist while in China this was made only by 38% of girl students. In the same study, only 6% of boy students from China and 14% of boy students from the US drew a scientist as a woman. Moreover, only 2% of US girl students and 1% of US boy students included in the same drawing both a woman and a man, and there was not even one such case among the drawings prepared in China. Polish students are somewhere in between the above-mentioned results. About 11% of girl students and less than 1% of boy students drew a woman scientist. According to Gardner (1980, pp.49-53) students' mental schema is affected by cultural models to which students are exposed. At this point, it should be emphasised that the word 'scientist' in the Polish language is a masculine noun and there is no feminine equivalent, an analogous problem is shown in relation to the Turkish language Akcay (2011, p.10). What is also interesting is that the instructions for the task were written in the singular, but in spite of that, boy students drew a group of persons conducting the research statistically twice more frequently than girl students (boys: 4.5%, girls: 2.0%). Unfortunately, in most cases the level of detail in the drawings showing a group of scientists was too low to determine the gender. Comparing the results between the two groups is a noticeable increase in the number of women indicated as a scientist. This is indicated by the fact that increases with age, not only the girls seeing themselves as scientists, but also the number of male students embodies a person a scientist with a woman. Quite different results were obtained by Fung (2002, p.210), who studied the image of a scientist in Hong Kong. The results indicated that with increasing students' age the number of students indicating a woman scientist decreased. The reason in this case, however, may be cultural differences, as in Asian countries the role of women is significantly different from the role of women in Europe.

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On 'masculine image of science' already in 1985, shows Kelly. Reason for such an image as indicated by Steinke et al. (2007, p.58) may be the influence of the media. About 28% of respondents drew scientists with a crazy hairstyle. Such a high level of association of a man of science with madness may be influenced by the media (Jane, Fleer & Gipps, 2007, p.14) which are abundant in the programmes popularising such a stereotype.

Conclusions

The study shows that the image of a scientist (indicated at the beginning of Discussion) is being developed with the students' age. During the growth of a student the image of the scientist based on a school teacher is replaced by a person working in an academic or industrial laboratory. It seems to be important in this process to show the students how scientists and their work environment really look like. Personal contact with science representatives during school lectures or visits in laboratories can also raise the students' awareness of gender equality in the field of science. It may enable more students to see themselves as scientists in the future and engage their interest in science subjects. Some of those features may be completed by implementation of Inquiry Based Learning in school, which is being promoted by European Commission, and obligatory included into the curricula of many EU countries. Perhaps, a greater awareness of the researcher's work will contribute to a greater interest in science studies and careers in science.

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