JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

REVISITING STUDENTS' PERCEPTIONS OF RESEARCH SCIENTISTS – OUTCOMES OF AN INDIRECT DRAW-A-SCIENTIST TEST (InDAST)

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Abstract. *What is the image of research scientists in students' minds? Studies in this area have been underway for more than fifty years and suggest that scientists are perceived as bespectacled men in lab coats, working alone in rooms full of basic lab glassware. This image has been derived mainly from the analysis of drawings, known as the Draw-A-Scientist Test (DAST). However, DAST instructions are based on the word, "scientists", the meaning of which seems too narrow for today's world and not reflecting the wide range of STEM-based research careers. Moreover, the instructions can predetermine the number and gender of people in the picture. For this reason, a new tool has been developed which provides an indirect analysis – the Indirect Draw-A-Scientist Test (InDAST). The new instrument was used in an experiment with secondary-school students (n = 851), and the resulting image of the scientist was compared with an earlier experiment that employed the original DAST instructions. The results showed that the basic attributes, appearance, and workplace of scientists are similar in both studies, but the new procedure disproved the theory that scientists are perceived as men working alone and that female students do not see themselves as scientists.*

Keywords: *drawings analysis, gender and science, image of scientists, scientist stereotype, STEM careers.*

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Introduction

The current market demand for STEM (Science, Technology, Engineering and Mathematics) graduates in many countries exceeds the number of students interested in these fields (Bernard, Migdał-Mikuli, & Ciura, 2014; Barmby, Kind, & Jones, 2008). Therefore, it is no surprise that actions are being taken to encourage students to take up those subjects and that research is in progress to determine the factors that are putting students off science studies. One major factor shown to have an impact on the perception of science is the image of the scientist. The manner in which students perceive scientists and their work can influence their attitudes towards school subjects (Schibeci, 2006), their choices of university courses (Kahle, 1988) and their professional careers (O'Brien, Martinez-Pons & Kopala, 1999; Farland, 2003). For these reasons, intensive research of the image of the scientists has been conducted all over the world for many years.

Theoretical Background

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 this period, several types of tests have been developed, and the research methodology has expanded proportionately (Finson, 2002). The first type of research conducted on a large scale in the United States was the description test, in which participants were asked to write an essay about their perceptions of scientists (Mead & Métraux, 1957) or answer questionnaires (Beardslee & O'Down, 1961). Further research on the image of scientists was dominated by drawings analyses. This approach was developed by Chambers (1983), and the instrument was called the Draw-A-Scientist Test (DAST). This instrument is commonly called a test, but in fact, it is a questionnaire, in which part of the respondents' task is to draw a scientist.

The research based on description tests and DAST analyses came up with the stereotypical image of the scientist in the students' minds. Students viewed a scientist as a white middle-aged male wearing a white lab coat and prescription glasses, working in a laboratory surrounded by various flasks, vials, and test tubes. In the following years, analyses of the drawings became more detailed, and the images of the scientist and his/her working environment were characterized. Distinct characteristic features of the scientist emerged: (1) lab coat (usually white), (2) glasses, (3), beard or moustache, (4) laboratory equipment, (5) books or other symbols of knowledge, (6) items related to new technology and inventions, and (7) captions of the "eureka!" type (Finson, Beaver & Cramond, 1995). This image still prevails.

Other research focused on the correlation between the students' age and the image of the scientist. Analyses of drawings revealed that the vast majority of the youngest students (kindergarten, first grade) did not include any of the abovementioned indicators in their drawings. They began to be incorporated by second-grade students who, on average, drew two features viewed as stereotypical. It was also found that the drawings made by older students more closely resembled the stereotypical image of the scientist as analysed above – fifth-grade students included three, sometimes even four, examples of those indicators (Fung, 2002).

Further research described the successive parameters which affected the perception of the scientist in the minds of students, e.g., their cultural background (Sjøberg, 2002, Farland-Smith, 2009; Narayan, Park, Peker, & Suh, 2013). A comparative study carried out among the US and Chinese students (Farland-Smith, 2009) showed that a greater proportion of Chinese students held stereotypical and traditional images of scientists, and the American students had a broader image of scientists. It was also noticed that US students (the majority of whom lived in detached houses) often drew laboratories in basements, whereas Chinese students (living in multi-storey apartments) did not produce even one such drawing (Narayan, Park & Peker, 2009). Instead, in their drawings of laboratories, Chinese students included 'places for rest', which are typical in their culture and are not included by US students (Farland-Smith, 2009). Another factor can be the stage of development within a given country (Sjøberg, 2002). Children from poorer countries presented the scientist as a noble and wise figure trying to save the world and helping people in need, whereas students from highly developed countries often presented scientists in a negative light – mad, careless, responsible for environmental pollution, performing dangerous experiments on animals, constructing nuclear bombs. Other research shows that the image of the scientist among students is affected by teachers, textbooks (Türkmen, 2008) and the type of school (public or private) (Medina-Jerez, Middleton, & Orihuela-Rabaza, 2011). Several authors indicate that the students are strongly influenced by the images seen at home, in comics, and particularly on television programmes and in movies (Gardner, 1980; Long, Boiarsky & Thayer, 2001; Steinke et al., 2007).

Another area of research is the gender analysis of the drawn scientists, very often in respect to the gender of the person drawing the picture. Much research has demonstrated that the scientist has been perceived mainly as a man and not as a woman (Chambers, 1983; Barman, 1997; Türkmen, 2008; Sjøberg, 2002; Huber & Burton, 1995). 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 draw a picture of a female scientist. Research on drawings in terms of gender can also focus on other correlations. For example, Kind (1996) and Tan, Jocz & Zhai (2015) indicate that boys more often draw unrealistic pictures that can be considered as science-fiction. Boys also have a greater tendency to draw pictures of cruel and brutal scientists (Krause, 1977; Türkmen, 2008).

Limitations of DAST

It would thus seem that the issue has already been thoroughly addressed and that the image of scientists among students is well known and exhaustively described with all of its shaping factors. The problem, however, is the impact of the research tool on the findings. The instructions for DAST, "Draw a scientist", have certain limitations which become greater on translation into other languages. To begin with, students are asked to draw a single person; accordingly, we should not be surprised that their drawings rarely depict groups. In addition, while the word "scientist" is gender-neutral in English, in other languages, such as Polish or Turkish, it is a masculine noun (Dudek & Bernard, 2015; Akcay, 2011) with no feminine equivalent. The image of scientists as men working alone in labs can thus be largely induced by the instructions of the test. It does not necessarily need to reflect the actual perception of scientists or the attitudes of girls towards a scientific career. Those are technical difficulties with the tool. The other aspect of limitation is the meaning of the word "scientist". It seems too narrow for today's world, and does not reflect the wide variety of science-related careers that are available and related to the research. Considering all those limitations, it can be concluded that there is a need for new tools that can inform us how students perceive science, the research process, researchers and their professions.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Modifications to DAST

In the last 20 years the original DAST has undergone various modifications. For instance, Matthews (1996) conducted research in which he instructed students to draw two scientists and subsequently supply a short description of their drawings. The experiment was carried out in English; therefore, the instructions did not suggest any particular gender. Most students drew a mixed-gender group of two scientists. Importantly, drawings of two men represented around 20% of all analysed drawings, while two women appeared in only 6% of the pictures, drawn only by girls.

DAST is often supplemented with descriptive elements, such as in the abovementioned research. This facilitates the interpretation of drawings and provides additional information on the scientist's occupation (Dudek & Bernard, 2015) or activities (Aguilar, Rosas, Zavaleta & Romo-Vázquez, 2014). The description can take the form of a short comment or a more elaborate and structured statement (Farland-Smith, Finson, Boone & Yale, 2014). Some of the most complex approaches integrate many distinct measurement tools and methods. Such an approach was used by Sjøberg (2002), in a large project entitled 'Science and Scientists: The SAS-study'. In this research, the DAST test is used as part of a tool called the SAS questionnaire. It is divided into several parts, in which students describe scientists as people, their out-of-school experiences, things they like to learn about, and what is important for their future job, then give an opinion on the characteristic features of science, write a short essay in which the students put themselves in the position of being a scientist and, finally, draw a scientist.

There were also attempts to avoid using instructions based on the word "scientist". Christidou, Hatzinikita & Samaras (2010) asked students: "Please draw a researcher". They received drawings depicting a wide range of STEM-related specializations, such as researchers in biomedical sciences, engineers, earth science specialists, astronomers, and space science specialists. Unfortunately, those results did not reflect the ideas of regular students, since the research was undertaken during a science event: "Researchers night" and participants drew what they had just seen.

Research Question and Aim of the Research

This research addresses the question, *"What is secondary-school students' image of people conducting scientific research"*. Using the word "scientist" is deliberately avoided, first of all to avoid suggesting the number or gender of the persons to be drawn, and second, to release the full potential of research-based professions and activities that can be depicted. To this end, the classic DAST is modified to facilitate an indirect analysis. The questionnaire contains the following instructions: "Imagine how scientific research is conducted. Present what you see in a drawing. Add a short description below." The tool has been called the Indirect Draw-a-Scientist Test (InDAST). The aim of the research is to assess the influence of changing the instructions on the images of a scientist obtained and to test the entrenched DAST-based theory, which holds that scientists are perceived as men working alone and female students are less likely than their male peers to see themselves in the scientist role. For that reason, the InDAST results have been compared to those of the classic DAST research by Dudek & Bernard (2015).

Methodology of Research

Background of the Research

The perception of scientists among Polish students was studied in the 2013/2014 school year (Dudek & Bernard, 2015) using the classic DAST questionnaire. The results did not differ significantly from those observed in other countries. According to Polish students at both the lower and upper-secondary-school levels, a typical scientist was a young male wearing corrective glasses with crazy hair. The scientist usually wore a lab coat and worked in chemistry. Consequently, he was surrounded by simple laboratory glassware placed on a table, along with books and notes. Another frequent element in the surroundings was a blackboard.

It needs to be noted that the Polish student population and society as a whole is quite homogenous. Almost all students are white Caucasian, and 92% of them are Catholics (GUS, 2014). Education is compulsory in primary (grades 1-6, age 7-12) and lower-secondary schools (grades 7-9, age 13-16). Students can continue education voluntarily in upper-secondary schools (grades 10-12 or grades 10-13 in technical vocational schools, age 16-19(20), respectively). The vast majority of students attend public schools in their local districts. In lower-secondary schools, the percentage of male and female students is almost equal – 52% boys (GUS, 2014). At the upper-secondary-school level, this proportion is different and depends on the type of school. In general, and non-technical vocational upper-secondary schools, the domination of female students is noticeable – only 38% are boys. However, in technical schools, this proportion is the opposite – 60% are boys. Teaching in Polish schools is dominated by lecturing methods with elements of problem-based learning, but this approach is changing. The latest reform of the core curriculum, introduced in 2009, defined new general objectives of education, graduates' key competences, and advised using inquiry as one of the leading methods (Act of the Polish Parliament, 2008). So far, changes in legislation have not had much effect on the methods used by teachers and the level of implementation of Inquiry-Based Learning (Bernard, Maciejowska, Krzeczkowska & Odrowąż, 2015; Bernard et al., 2012).

The InDAST-based experiment was conducted during the 2014/2015 school year. No significant changes had been introduced to the curriculum or expected learning outcomes in Polish schools between the DAST and InDAST research. In both cases, questionnaires were sent to the randomly selected lower- and upper-secondary public schools all over the country. No school was in both groups. Survey materials were sent to schools, rather than to specific teachers, and were to be completed in a manner freely chosen by the school. Therefore, it could be assumed that they reached teachers of a range of subjects and students completed the survey materials both during classes and as part of their homework assignments.

Research Tools

Both questionnaires used a single A4 page. The main element in the DAST questionnaire was a drawing with the original instruction – "Draw a scientist", but supplemented with the one-sentence description "The drawing shows..." so that the drawing was more understandable for the analysing person. InDAST used a similar layout and the corresponding instructions were "Imagine how scientific research is performed. Present what you see in a drawing. Add a short description below." The questionnaires were anonymous and community-based (Krosnick & Presser, 2010). The main questions were preceded by questions about the respondent's personal information such as gender, age, type of school they attended, and school location. These data were needed for the analysis of such factors as the effects of gender.

Participants

The DAST and InDAST research involved 938 participants each. Questionnaires which did not include complete data were excluded from the analysis. The final research group sizes and their characteristics are presented in Table 1.

Table 1. Number and characteristics of respondents in the DAST & InDAST research groups.

Respondents	DAST	InDAST
N	781	851
Women	512	512
Men	269	339
Lower-secondary	350	300
Upper-secondary	431	551

Data Collection and Analysis

The student questionnaires were subjected to qualitative and quantitative analyses. Coding was used as a process of organizing and sorting data. At the first stage of the DAST, qualitative analysis of completed questionnaires was performed. For this purpose, fifty responses were randomly chosen, and features associated with the drawings were characterised. The derived characteristics were listed and compared with the DAST checklist (Finson et al., 1995). These derived features covered all the DAST checklist features (lab coat, glasses, facial hair, symbols of research, symbols of knowledge, and technology), and included several additional scientists' attributes. The obtained characteristics created a new checklist which was used for the drawings' transcriptions. To this end, a list of codes was created that covered the identified characteristic features of the responses. Then students' answers

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

were coded into an Excel spreadsheet using a 0/1 coding system (1 – indicates the presence of a feature and 0 – indicates the absence of a feature). At the next stage, percentage frequencies of the answers were calculated.

In the InDAST case, completed questionnaires were divided into two groups: 1 – those which featured human figures, and 2 – those which did not. The first group was analysed to determine the students' perception of scientists; the second provided a broader insight into perception of conducting scientific research process. Table 2 shows the number of respondents in the two sections.

Table 2. Features of InDAST drawings.

Respondents	InDAST drawings		
	All	With persons (group 1)	Without persons (group 2)
N	851	640	211
Women	512	337	175
Men	339	263	76
Lower-secondary	300	228	72
Upper-secondary	551	412	139

As in the DAST experiment, fifty drawings from each InDAST group were randomly selected for qualitative analysis. The characteristic features of the drawings which depicted people overlapped with the DAST checklist. The features noted in the pictures without people (group 2), were largely similar to those observed in the DAST experiment, but also included several items which had not been previously recorded (see Table 10).

In both experiments, all drawings were coded by one trained and experienced person. The reliability of the data was checked using the intra-rater and inter-rater tests (Gwet, 2014). For this purpose, forty randomly selected questionnaires from each group were coded a second time by the main coding person and a third time by an independent researcher without experience in that particular type of transcription. The results were compared and the correlation coefficients were determined to be 0.95, $p<.001$ for DAST and 0.90, $p<.001$ for InDAST, and between the coding and independent coding 0.85, $p<.001$ for DAST, and 0.80 $p<.001$ for InDAST.

Even though the InDAST research was completed second, and the coding and recoding personnel were more experienced than for the DAST research, the reliabilities for InDAST were lower. On the other hand, the values reached for the intra-rater and inter-rater were fairly high, similar to the reliability shown in the previous research by Schibeci and Sorensen (1983) or Toğrol (2013).

Results of Research

Table 3 shows the typical features obtained using both methods. In general, the findings of InDAST overlap with the results of the reference group, as well as similar research conducted in other countries, and confirms that scientists tend to be perceived as young people in lab coats. In addition, the InDAST group features fewer drawings of older people. Individuals are less frequently depicted as bald, or as having facial hair and do not generally have crazy hairdos, which makes them conform to the image of the crazy scientist. The percentage of drawings with bespectacled scientists continues to be high, but the glasses tend to be lab goggles, rather than prescription glasses.

Table 3. Analysis of the drawings – the frequency of personal indicators.

Feature	Frequency [%]	
	DAST	InDAST
Young	53.4	43.9
Lab Coat	46.9	45.0
Glasses	34.7	17.7
Crazy hair	28.3	8.0
Old	15.5	4.2
Lab goggles	10.0	22.8
Facial hair	9.9	4.8
Bald	8.6	3.0

Scientists are usually depicted in an indoor setting (lab), surrounded by basic glassware, notes, and a blackboard. The frequency of these elements was similar for both experiments. InDAST, however, stands apart in that its respondents more frequently depict more advanced technologies, showing a preference for computers and microscopes over books and equations on the blackboard. InDAST also features more attributes suggesting fields other than chemistry, such as animals, plants, and syringes.

Table 4. Analysis of the drawings – the frequency of the scientists' attributes.

Attribute	Frequency [%]	
	DAST	InDAST
Basic lab glass	81.8	82.2
Table	68.5	66.3
Books	15.5	7.7
Blackboard	14.6	11.1
Notes	11.3	15.2
Equations	11.0	7.5
Computers	7.4	14.5
Microscope	5.9	16.4
Animals	3.2	16.9
Plant	2.0	4.5
Chalk	1.7	1.4
Loupe	1.3	1.1
Pointer	1.0	0.8
Syringe	0.5	5.2

The objects depicted in the drawings and the one sentence descriptions of the drawings made it possible to assign an area of science to the portrayed scientist in a large number of cases (Table 5). In both experiments, the most frequent field was chemistry. However, in InDAST, chemistry's lead over the next-best-represented discipline was significantly reduced. The percentage of scientists working in biology, pharmacology, physics, or medicine was much higher in the indirect group. Drawings which depicted scientists dealing with mathematics or the humanities, however, again constituted a marginal fraction of a percent.

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ISSN 2538–7138 /Online/

Table 5. Analysis of the drawings – the frequency of the indicated scientific disciplines.

Scientific discipline	Frequency [%]	
	DAST	InDAST
Chemistry	64.0	55.5
Biology	2.0	17.5
Physics	0.9	4.7
Pharmacy	0.9	6.4
Mathematics	0.6	0.2
Humanistic	0.3	0.0
Medical doctor	0.1	2.0
No indicator	31.2	19.4

One of the primary objectives of InDAST was to test whether the image of the scientist as a man working alone, as obtained from DAST, corresponded to the actual perceptions of science and scientific research among students, or was implied by the phrasing of the instructions, these suggesting a singular person who is masculine. The results presented in Table 6 below indicated that drawings which featured human figures mostly depicted groups. The next most frequent were pictures of lone men, followed by the pictures of lone gender-neutral individuals. Lone women were the least common. It should be noted, however, that even when students were the least likely to draw lone female scientists, the frequency of such pictures was twice as high as in the reference DAST group.

Table 6. Analysis of drawings – the characteristics of the drawn persons.

Feature	Frequency [%]	
	DAST	InDAST
Lone woman	7.8	15.8
Lone man	88.6	30.3
Lone, no indicator/other	0.8	20.5
Group of people	2.8	33.0

A large number of groups drawn in the InDAST survey enabled a more detailed analysis. Table 7 showed the relevant frequency of the genders. Unfortunately, the drawings were often not very detailed, and, consequently, no gender could be identified in as many as 41% of the cases (see examples at Figure 1). Among the remaining drawings, a significant majority depicted mixed-gender groups; the percentage of all-male groups was half that of mixed-gender groups and all-female groups accounted for a quarter the mixed-gender groups.

Table 7. Analysis of the drawings – genders in groups of people.

Feature	Frequency [%]
	InDAST
Group of women	8.4
Group of men	16.4
Mixed group	34.0
Group no indicator/other	40.9

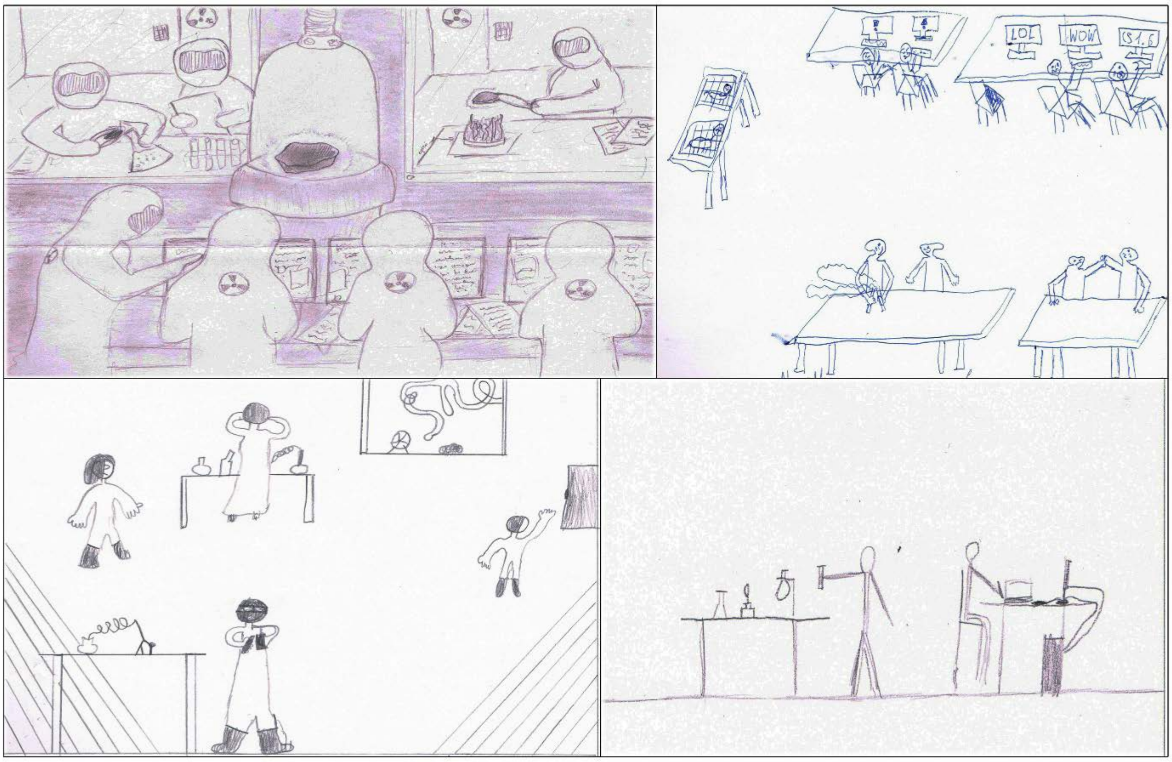

Figure 1: Examples of drawings – groups of scientists with no gender indicator.

The results were further analysed in terms of the students' gender (Table 8 and Table 9). Girls were equally likely to draw female scientists and male scientists. In the case of boys, however, drawings of male scientists were approximately four times as frequent as those of female scientists. For both genders, the percentage of women in the pictures was still considerably higher than in the DAST survey. It should also be noted that both boys and girls drew groups of people in more than 30% of the cases. Drawings without any gender indicators were also significantly more frequent than in DAST and were twice as high for male respondents as for their female peers.

Table 8. Analysis of the drawings – frequency of scientist' gender in relation to the respondent's gender.

Gender of the respondent	Indicators	Frequency [%]	
		DAST	InDAST
Woman	Woman (lone or in group)	11.5	41.6
	Man (lone or in group)	85.0	48.5
	Group of people	2.0	30.8
	No indicator/other	1.6	24.1
Man	Woman (lone or in group)	0.7	11.4
	Man (lone or in group)	95.5	43.3
	Group of people	4.5	36.1
	No indicator/other	0.0	46.8

Because of the number of drawings which depicted groups of people in InDAST, it was possible to analyse the pictures in terms of their author's gender – Table 9. Girls tended to draw a lone man almost as often as boys did, but lone women were considerably more frequent in pictures drawn by girls (see exemplary drawings at Figure

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

2). Girls were also considerably more likely to opt for a mixed team of scientists. Conversely, drawings by boys, regardless of whether they featured a lone person or a group, were more likely to have no gender indicators at all.

Table 9. Analysis of drawings – frequency of gender in relation to the respondent's gender.

Feature	Gender of respondent	
	Women frequency [%]	Men frequency [%]
Lone woman	22.6	6.8
Lone man	30.2	32.7
Lone no indicator/other	16.4	27.5
Group of women	4.3	0.4
Group of men	3.8	8.0
Mixed group	15.4	4.8
Group no indicator/other	7.4	19.9

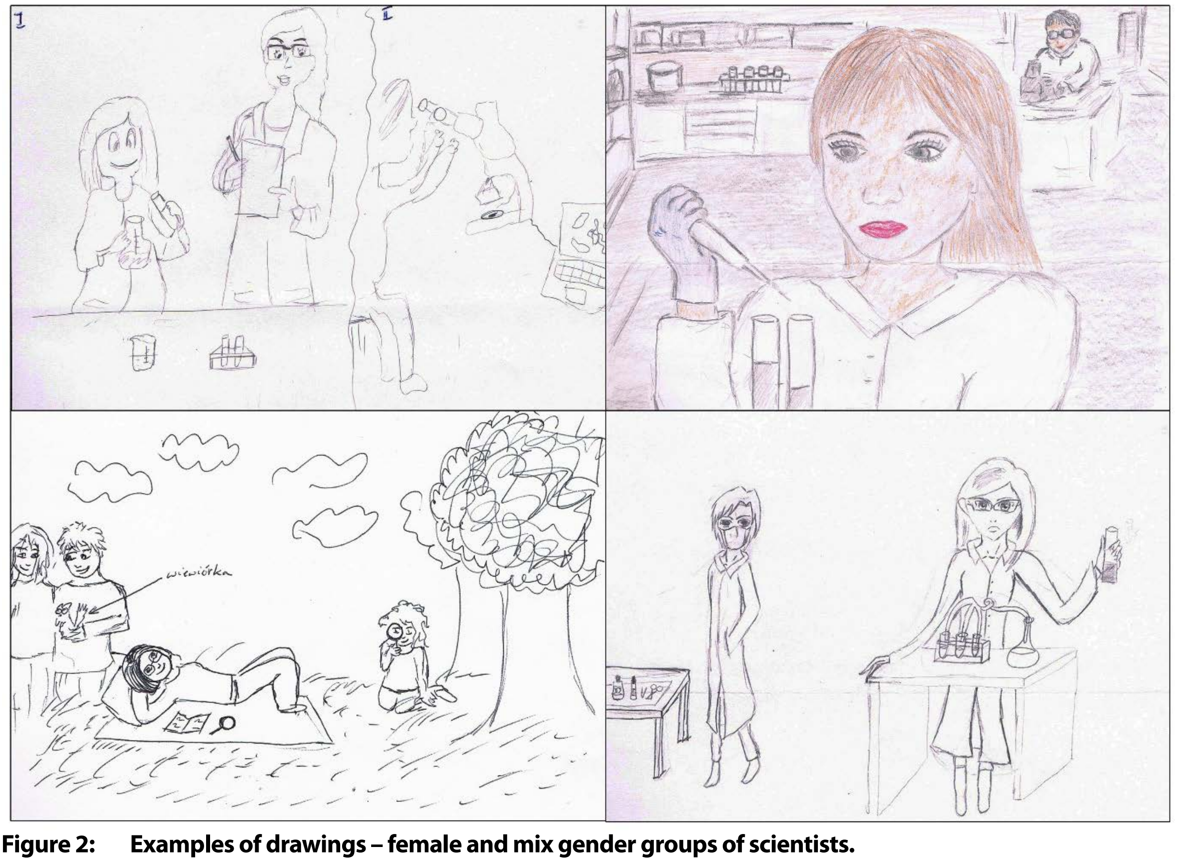

Figure 2: Examples of drawings – female and mix gender groups of scientists.

Drawings without a human figure were also analysed and the feature checklist proved to be partially different. Table 10 listed elements identified in at least 1.0% of the questionnaires. It could be noted that these drawings mostly showed rooms and equipment highly similar to those in the pictures with human figures. Additionally, they were also more likely to feature elements such as signs of radioactivity or DNA symbols. Some drawings included an explosion or a hand (often giant) which was performing various activities (examples at Figure 3). Others depicted the research procedure in a pictorial, descriptive, or symbolic form, often as a decision-making/logical template (examples at Figure 4).

Journal of Baltic Science Education, Vol. 16, No. 4, 2017
ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 10. Analysis of the drawings – frequency of features on drawings without persons.

Feature	InDAST
Basic lab glass	75.8
Table	34.1
Procedure diagram	22.3
Burner	21.3
Animals	16.6
Microscope	12.8
Computers	12.3
Hand	8.5
Notes	8.1
Explosion	6.2
Syringe	6.2
Loupe	4.7
Blackboard	4.7
Books	3.8
Radioactivity sign	2.8
Equations	2.8
DNA helix	2.4
Plant	1.9

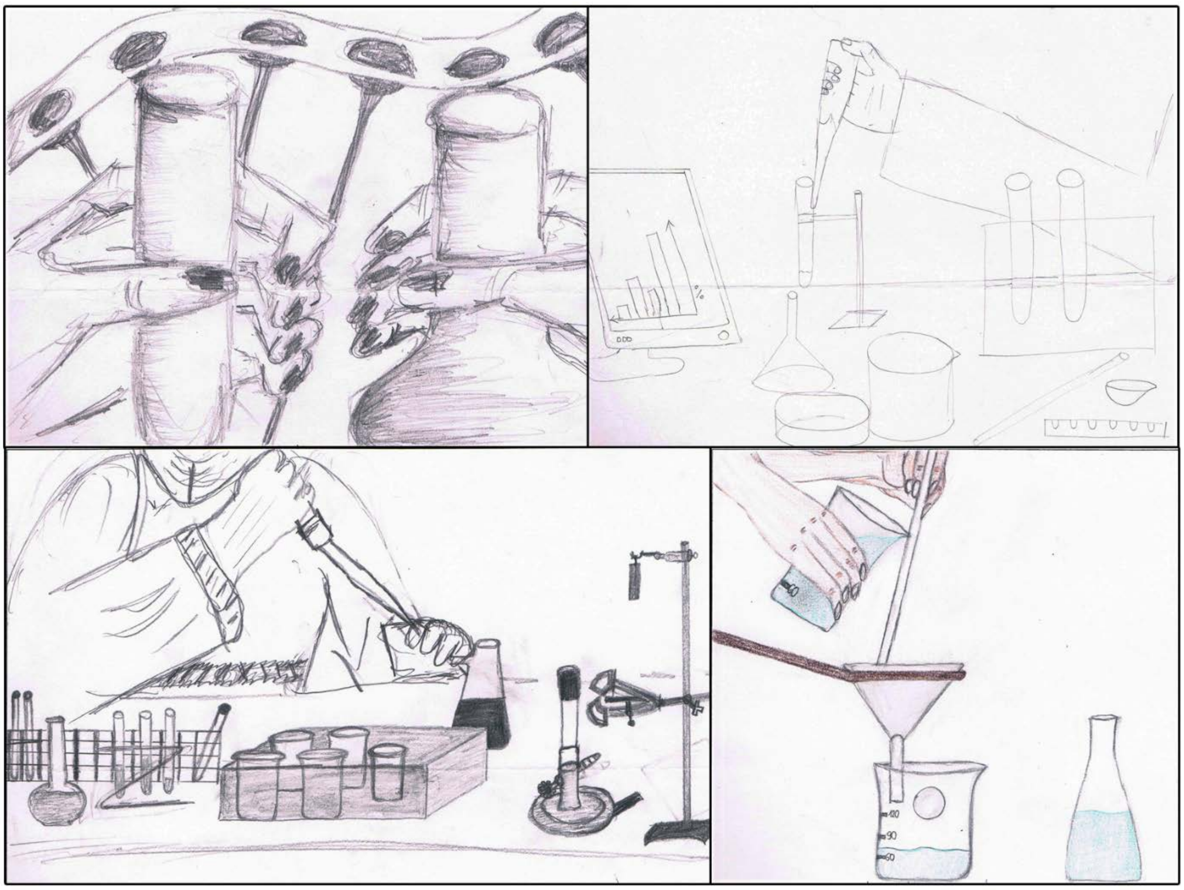

Figure 3: Examples of drawings – hands performing various activities.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

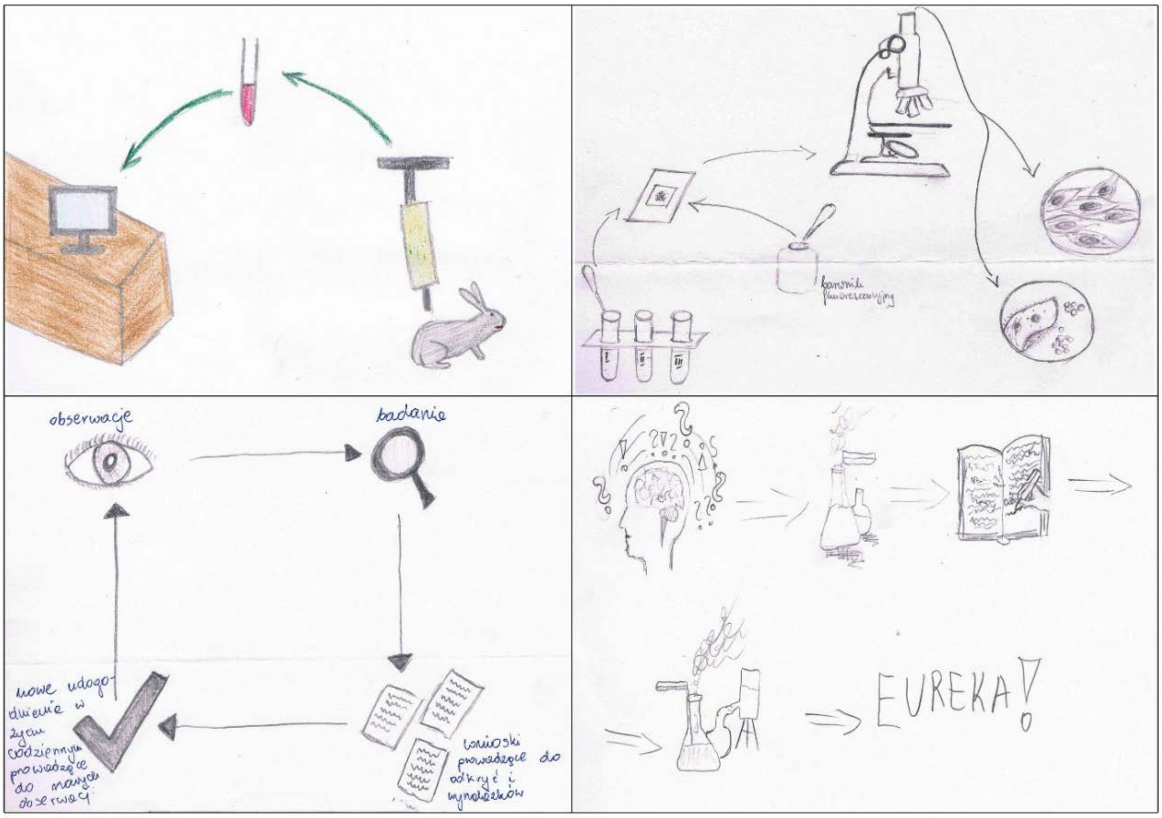

Figure 4. Examples of drawings – research procedures.

Discussion

The aim of the research was to develop a tool to determine the students' perception of people conducting scientific research that would not be based on the word "scientist" and did not suggest the number or gender of the persons to be presented. The results demonstrated that the wording used in the InDAST questionnaire and the method of analysis met the above requirements and was a useful alternative to the classic DAST.

The attributes of scientists and their working environment were similar in both groups. The number and character of presented characteristic features were typical for studied age group. Scientists were perceived as youngish bespectacled people in lab coats in rooms containing tables, basic lab glassware, and other, more advanced, equipment. The aim of the InDAST research was to test the theory that scientists were perceived as men working alone. The percentage of drawings that featured groups was approximately 3% in the reference DAST survey, it increased more than tenfold in the InDAST experiment. The analysis of depicted scientists, in terms of gender, painted an even more distinct picture. In the reference group, nearly 89% of the drawings depicted a male scientist compared to the low 30% observed in InDAST. The latter also featured more lone women (16%). The number of groups differed considerably, as well. In the reference study, it was too small to allow a detailed analysis. In InDAST, on the other hand, such pictures were quite common and, importantly, featured both single-gender and mixed-gender groups, a phenomenon rarely observed in the reference survey and in other similar research. An important group of the InDAST drawings also depicted human figures of no specific gender (21%). This could be because respondents did not attach great importance to gender but also because the InDAST drawings were much more complex and thus human figures tended to be sketched in much less detail. This explanation was supported by the analysis of drawings showing groups of scientists, which were often very elaborate and depicted many different elements in a schematic form. In these drawings, gender could not be identified in as many as 41% of the figures (Table 7). In addition, gender-neutral scientists were more likely to appear in the drawings made by male students. These seemed less precise overall. However, this was just an impression of the person who coded the pictures, since the parameter of "precision" had not been analysed. Furthermore, the analysis of gender suggested that girls tended to depict female scientists (alone or in groups) almost as often as boys drew male scientists. These findings were significantly at odds with the earlier DAST research (e.g. Finson et al., 1995). The reference survey and other similar experiments thus far showed that only a small percentage of female respondents drew female scientists. This was explained by the theory that girls did not see themselves as scientists (Chambers, 1983; Barman, 1997; Türkmen, 2008; Sjøberg, 2002; Huber & Burton, 1995, Medina-Jerez et al., 2011). The InDAST experiment disproved this theory. While the percentage of lone female scientists drawn by girls was lower than that of lone male scientists drawn by boys, girls were more likely to draw mixed-gender groups. This could be linked to a greater awareness of the issues of gender equality and rights among girls (Kelly, 1985; Long, Boiarsky & Thayer, 2001).

In previous research students from poorer countries presented the scientists as noble and wise figures, whereas students from highly developed countries more often presented scientists in a negative light. On images of Polish students none of the variants was dominating, both brutal scenes and world saving scientists were not frequent. Despite the rather neutral character of drawings, images of crazy scientists were present in both Polish studies. Moreover, a significant difference in frequencies between the classic DAST (28%) and InDAST (8%) was observed. There was a general trend over time that showed a decreasing number of drawings presenting mad scientists (Tan et al., 2015), but observed massive disproportion was rather an effect of the instructions. The InDAST guided respondents to depict real world situation – conducting research – and DAST did not suggest in what situation the scientist is to be drawn, so respondents could let their imagination run wild. However, the science fiction drawings, frequently drawn by students in other countries, were not present in both Polish studies.

Due to the one sentence descriptions of the drawings, it was possible to assign an area of science to the portrayed scientist in a large number of cases. The diversity of depicted professions was almost the same in both cases, but there was a difference in distribution between particular professions. In the InDAST research, the number of depictions of chemists was lower, and other professions were more common. Additionally, the percentage of drawings without profession indicators was much lower in the InDAST research. Once again it could be an effect of the instruction. As it was noticed, in the InDAST research, respondents were asked to present a meaningful situation – conducting research – and the DAST drawings often presented a man in lab coat just standing between laboratory glassware. Christidou, Hatzinikita, & Samaras (2010) pointed that DAST (and draw a researcher) results indicated that students were not familiar with the organization, specialization, possibilities, means, and achievements of modern research. Instead, they drew outdated and distorted clichés about science and technology from an earlier period. The InDAST results showed that students' ideas of research were more complex and that many of them were aware that conducting research required teamwork, and the process involved high technology. What might be disappointing is the range of professions presented. This might be caused by the students' lack of knowledge of the range of research-based STEM careers. Conversely, the InDAST instructions created an opportunity to present various professions but did not stimulate students to think deeper. They could present the first idea so the narrow spectrum of presented professions could result from the strongest and the most typical associations, not from a lack of awareness of available STEM careers.

Since the InDAST instructions did not explicitly require respondents to draw human figures, a number of pictures only featured a research lab or schematic representations of scientific procedures. Drawings without scientists did not differ significantly from those with human figures. They did, however, tend to include more advanced equipment. People were sometimes replaced by disembodied hands performing various activities. Drawings without human figures often featured warnings about threats (radioactivity) or explosions, i.e., elements which were not typically drawn together with scientists. It was not clear whether these pictures focus on the negative consequences of research and its uncontrollable outcomes, or rather the space in which dangerous processes were carried out and noxious substances used. A significant percentage (22%) of drawings without persons showed schematic representations of scientific procedures in a pictorial, descriptive, or symbolic form. These were not analysed, but the issue seemed to constitute an interesting subject for further research. In general, the variety of leading motifs was greater in the pictures without human figures than in those that depicted scientists at work.

Conclusions

The world around us and our lives are changing quickly in the 21st century, and science is not an exception. Extremely fast technological progress not only changes scientific research but also demands a large number of STEM graduates with diverse specialties. For that reason, it is important to create a positive image of science and people involved in research and to build students' awareness of STEM career diversity and offerings, which cannot

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

be achieved without research on current students' images of science and scientists. Research of this kind has a rich history, with many groups, relations, and shaping factors being studied and elaborated upon. Unfortunately, historically important tools, such as DAST, seems not to be sufficient and adequate for today's STEM-based world.

This article describes how the InDAST questionnaire facilitates research on the image of scientists in the students' minds when it is no longer plagued by the narrowness of word "scientist" and does not specify the number and the gender of the persons to be drawn. While there is a risk of obtaining pictures in which scientists are not present at all, other drawings allowed us to arrive at a clear image of scientists. Basic attributes, appearance, and the workplace of scientists are similar in both DAST and InDAST. What is shown, thanks to the new procedure, is that students possess a wider image of scientists and do not necessarily perceive person undertaking scientific research as men with crazy hair working alone and items within drawings, related to new technology, are more frequent when students draw a scientist in action – conducting research. Of particular importance is that the results also show that female students see women may be scientists. It seems that the current focus in science education, as indicated by the InDAST instrument, is that students are seeing science researchers in a wider orientation, more in keeping with members in society in general. This lends hope that current approaches to science education are allowing students to see scientific research as a meaningful career direction.

The major limitation of the presented research is the interpretation of students' intentions basing on drawings. Pictures, supplemented with short descriptions, create an opportunity to identify the profession of the people depicted, but we cannot be sure of the student intentions or their reasons. Therefore, a natural next step is suggested to use a mixed approach – the InDAST questionnaire combined with an interview – thus enabling students to explain their drawings and motives.

Acknowledgements

The authors would like to thank to Anonymous Reviewers for their constructive comments on the manuscript.

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Received: *March 13, 2017* Accepted: *June 22, 2017*

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