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WHAT DO SCIENTISTS DO? – INCREASING AWARENESS OF SOCIAL AND NETWORKING ASPECTS IN EVERYDAY ACTIVITIES OF SCIENTISTS

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ABSTRACT

Background: Unfortunately, despite many efforts, women are still underrepresented in most STEM (Science, Technology, Engineering, Mathematics) areas, particularly in physics. Changing the image of science and especially physics to be less masculine, less difficult and more social may be a promising way to attract more pupils and especially girls. One auspicious possibility to change the image of science is to clarify the actual wide range of activities of scientists in their everyday work life (the "nature of scientists", NoSt), including social and communicative aspects.

Purpose: In the current study, we aim to show if changes in pupils' views about NoSt can be increased by explicitly giving input about scientists' everyday activities before conducting experiments and if this changed image of physics will lead to higher career aspirations, especially for girls.

Sample/Setting: The sample consists of 48 pupils of the fifth grade (10-11 years old) of the German "Gymnasium" in Rhineland-Palatinate, Germany (24 pupils in treatment group (TG, 13 boys, 8 girls) and control group (CG, 12 boys, 11 girls). All pupils visited a university outreach lab with a 10-15 minute-long introduction followed by 135 minutes of experiments. During the introduction, the intervention (discussion about NoSt) took place for about 5 minutes. Pre-tests were conducted a day before, post-tests directly after the visit at the outreach lab.

Design Methods: In a quasi-experimental pre / post design, a questionnaire on NoSt was used (Cronbach's $\alpha = 0.75$) in addition to a question concerning future science career aspirations. As our sample was small, we used Mann-Whitney-U-tests for comparisons between and Wilcoxon-signed-rank-tests for comparisons within groups, and Cohen's *d* as effect size.

Results: Within groups, perception of social and networking aspects of NoSt increased for all subgroups except for girls in the CG ($p_{\text{male,TG}} = 0.013$, $d_{\text{male,TG}} = 1.90$; $p_{\text{female,TG}} = 0.011$, $d_{\text{female,TG}} = 4.00$; $p_{\text{male,CG}} = 0.022$, $d_{\text{male,CG}} = 1.76$). For career aspirations, the only significant effect is for boys of the TG ($p_{\text{male,TG}} = 0.038$, $d_{\text{male,TG}} = 1.40$). The girls of the TG show the highest increase, but also a growing standard error of the mean of career aspiration.

Conclusions/Implications for classroom practice and future research: The current study provides first evidence that just a discussion in class about scientists' everyday work can on one hand raise the awareness of social and networking aspects of NoSt, especially for girls, and on the other hand increase pupils' science career aspirations. We see encouraging evidence to recommend to outreach labs as well as to teachers doing lab work in class to include at least short discussions about scientists' everyday acitivites to provide pupils with a less stereotyped image of the nature of scientists.

Keywords: Gender, Nature of Science, Outreach labs

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1 INTRODUCTION

Unfortunately, despite many efforts, women are still underrepresented in most STEM (Science, Technology, Engineering, Mathematics) areas, particularly in physics. In the UK, in 2016, only 1.9 % of female pupils took physics A-level, compared to 6.5 % of male pupils, although the achievement in GCSE did not differ depending on gender [1]. Furthermore, women earned only 37 % of higher education science degrees in 2015/16 [2]. In Germany, the situation is hardly different. In Rhineland-Palatinate, in 2016/17, only 25 % of female pupils continue physics after 10th grade, compared to 51

% of male pupils [3]. In 2016, all over Germany, women earned only 15 % of bachelor's degrees, 17 % of master's degrees and 19 % of PhDs in physics [4].

There are two main problems arising out of this imbalance: On the one hand, modern societies miss out on a huge number of talented people, aggravating the shortfall of STEM graduates. This concerns governments and employers alike, as e.g. in the UK, the number of jobs requiring STEM skills is expected to rise at twice the rate of other occupations over the coming years [1]. Furthermore, there is a growing amount of evidence that diversity is positively associated with the performance of firms (see e.g. [5]). On the other hand, women miss out on well-paid job opportunities, that would have been a good match to their capabilities and interests.

2 RESEARCH BACKGROUND

2.1 Gender Differences and Stereotypes

According to several studies, the main reason why female pupils do not aspire physics careers is a lack of identification with the subject (see e.g. [6], [7]). The development of a "physics identity" is affected firstly by a personal and social sense of self, defined by characteristics that individuals hold to be self-defining (personal, e.g. "I am shy") and shared experiences and histories wirh certain groups (social, e.g. "I am a member of my family") [8]. Secondly, the physics identity is influenced by 4 physics-related perceptions: interest (desire to learn / understand), competence (belief in ability to understand content), performance (belief in ability to perform required tasks) and recognition (being recognized by others as a physics person) [8].

Numerous studies showed the image of physics to be rather undesirable (see e.g. [9], [10], [11]) and not compatible especially with girls' personal and social sense of self. For example, [12] found an "underpinning construction of science careers as 'clever'/'brainy', 'not nurturing' and 'geeky'" in opposition to girls' self-identification as "'normal', 'girly', 'caring' and 'active'", which rendered science aspirations largely "unthinkable" for girls. Other studies have shown that already children in elementary school are aware of math-related gender stereotypes [13] and associate science with masculinity [14], also increasing the misfit between girls' sense of self and physics identities.

Regarding physics-related perceptions, several studies found that female pupils are especially interested in communicative or social aspects in their prospective careers. So Wentorf et al. [15] found that 14- and 15-year-old girls were significantly more interested in scientist's activities like supervising students or collaborating with other scientists than boys. Those interests of girls' are often not met by the established image of science as consisting mostly of lonely lab work [8].

Competence, performance and recognition are closely related to pupils' self-efficacy beliefs [16], which have been repeatedly found to be relevant predictors of academic performance and persistance for many years [17]. After Sawtelle et al. [16], the sources of self-efficacy differ between men and women: While men's self-efficacy is influenced mostly by mastery experiences (i.e. successful, individual completion of a task), women's self-efficacy is affected most by vicarious learning experiences (i.e. observing someone else's success on a task). Emphasizing group work and other social aspects in the School Lab can hence contribute to close the gender-gap in self-efficacy [16] and subsequently promote girls' physics identities.

Given these findings, changing the image of science and especially physics to be less masculine, less difficult and more social may be a promising way to attract especially girls to career paths related to physics.

2.2 Nature of Scientists

One auspicious possibility to change the image of science is to clarify the actual wide range of activities of scientists in their everyday work life, including social and communicative aspects. Wentorf et al [15] introduced the construct "nature of scientists" (NoSt) as an addition to previous concepts of the "nature of science" (NoS) in the literature: In contrast to Lederman's [18] understanding of the genesis of scientific knowledge as being the core of NoS and extending the construct of the "nature of scientific inquiry" (NoSI), which focusses only on actual research activities of scientists [19], NoSt considers pupils' views about the image of scientists and their daily activities [15]. The associated test instrument emerged from Hollands RIASEC dimensions [20]. The RIASEC model is based on the assumption of six types of interest, which according to the model can be attributed to respective occupational groups.

To introduce a gender focus into the research of NoSt, we consider especially the RIASEC categories "social" and "networking" (a new characteristic that emerged in [21]). One reason for this is the known preference of female pupils toward social aspects in their prospective careers (see above). Another reason is that a Delphi study [22] concluded that "Cooperation and Collaboration" is an essential element of the nature of science. Participants considered it important that teaching stressed the social processes in science, as this aspect was "too often overlooked in school science" [22].

2.3 Outreach labs

A outreach lab is a science laboratory serving as an out-of-school learning place at instituions as universities, science centres etc. Classes of pupils undertake hands-on science projects at the outreach lab to learn new knowledge and to experience science in an authentic environment (e.g. getting in contact with actual scientists, using professional research equipment etc). Typical characteristics of outreach labs are "experiences of experimental methods, context-based cooperative learning, team work, exploring and problem-solving, and embodied experiences in a well-equipped environment" [23].

There have been several approaches to use outreach labs to teach nature of science aspects or to change the image of science subjects implicitly or explicitly (see e.g. [24], [25]). In the current study, we aim to show if changes in pupils' view about NoSt can be increased by explicitly giving input about scientists' everyday activities before conducting experiments.

2.4 Research Hypotheses

A outreach lab is a science laboratory serving as an out-of-school learning place. Classes of pupils undertake hands-on science projects at the outreach lab to learn new knowledge and to experience science in an authentic environment. Typical characteristics of outreach labs are “experiences of experimental methods, context-based cooperative learning, team work, exploring and problem-solving, and embodied experiences in a well-equipped environment” [23].

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(i) Pupils views about the nature of scientists (NoSt), especially about social and networking aspects, are changed more strongly with an explicit input about NoSt before conducting experiments, than without the input.

(ii) Changing in the views about social and networking aspects of NoSt leads to increased science career aspirations in physics, especially for girls.

3 METHODS AND DATA ANALYSIS

3.1 Intervention

The intervention took place during a visit of the outreach lab learning unit “Magnetism: Introduction to scientific methods”, were pupils conduct experiments in groups of two or three. This learning unit was developed as one of the outreach activites of the collabortive research centre *Spin+X* (SFB/TRR 173), which aims to improve high school education regarding spin and magnetism to increase the number of competent and motivated pupils choosing a career in spin research. In a first phase of the learning unit, pupils investigate the strength of an electromagnet as a function of current (see figure 1).

In a discussion in class, basic principles of magnetism are recapitulated and the experimental set up is explained. The electromagnet is placed underneath one end of a beam balance carrying an iron screw, which is attracted to the electromagnet if there is a current running thorugh the

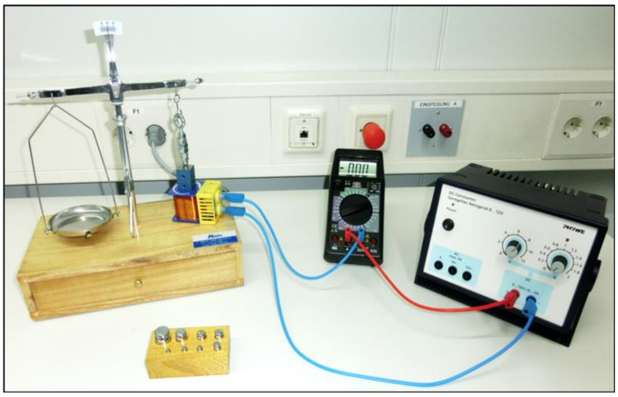

Fig. 1. Experimental set up.

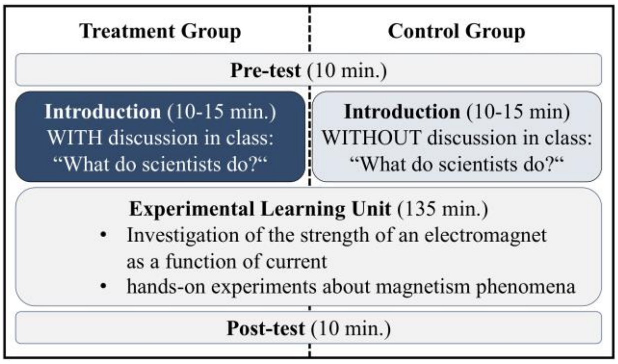

Fig. 2. Overview over the study.

coil. On the other end of the balance, pupils put different weights, until the gravitational force compensates the magnetic force. Pupils note the mass for different values of current, then they draw a diagram of their data using a spreadsheet software. Purpose of the experiment is not only to introduce pupils to electromagnetism, but also to introduce them scientific methods. Hence, there is a focus on writing a lab report while experimenting. In a second phase, pupils conduct hands-on experiments about magnetism phenomena: They play with a magnetically floating globe, they explore magnetic field lines by placing magnets on a tablet with iron filings, they build a miniature electric motor out of a battery, a screw, a magnet and some wire [26] and they built a Gaussian cannon [27]. This phase is more playful than the first one. Pupils are not required to write lab reports and do not work in fixed groups but explore the experiments as they like. In sum, both phases and the introduction last approximately 150 minutes.

In addition to this setting, the treatment group shortly discussed NoSt aspects in the introduction. Pupils were asked what they thought scientists at university would be doing in their everyday working life. If pupils did not mention it, the instructor told them that scientists teach students in lectures or seminars and help younger scientists with their work, that before scientists do an experiment, they read scientific literature and that when they got results, they publish them as papers or discuss them at conferences around the world.

3.2 Research Design

Pupils did a 10 minute pre-test the day before they visited the outreach lab (see figure 2). The pre-test consisted of a modified RIASEC+N instrument (see below) and an item regarding their science career aspirations. After the introduction with or without aspects of NoSt and the experiments, pupils did the same test again as post-test in the outreach lab.

3.3 Test Instrument

As test instrument for NoSt, we used a RIASEC+N survey [28]. As the original instrument was constructed for 14- to 15-year-old pupils, we adapted it to fifth graders, choosing an easier language and shortening the instrument to 16 items. Table 2 shows examples of our adaptation (translated from German language). Furthermore, we used one item to assess science career aspirations (“I would like to become a scientist later.”). All items were assessed using 6-point Likert scales from very rarely to very often (NoSt) respectively "not true at all" to "completely true" (science career aspirations). For conducting statistical analyses, the score of every item was transformed into a percentage, where 0 % meant the lowest and 100 % meant the highest frequency of the activity respectively affirmation of the statement. In the pre-test we additionally collected the following data: age, gender, last grade in science and maths. Grades in science and maths were collected to check for differences in prior knowledge between the groups.

Tab. 1. Sample.

	Treatment group	Control group
N	24	24
N(male)	13	12
N(female)	8	11
age	10.4 *years*	10.7 *years*

3.4 Sample

Our sample consisted of two fifth classes (N = 48, see table 1). Pupils were having additional science lessons once every other week. As for these lessons, the class was divided and taught monoeducatively, the girls and the boys of each class visited the outreach lab on different days.

4 RESULTS

Due to the different wording and decrease of numbers per scale after the adaptation of the original RIASEC+N survey [28], the original seven dimensions could not be reproduced in factor analysis and some of the scale reliabilites are very low (see table 2). As we are primarily interested in social and communicative aspects of NoSt, we used a new scale consisting of the items in the "social" and "networking" dimension. Those four items have an acceptable reliability of Cronbachs $\alpha = 0.75$ in the pre-test and Cronbachs $\alpha = 0.78$ in the post-test. As our sample was small, we used Mann-Whitney-U-tests for comparisons between and Wilcoxon-signed-rank-tests for comparisons within groups.

There was no significant effect between treatment (TG) and control group (CG) in the pre-test, neither for social and networking aspects of NoSt (SN), nor for science career aspirations (CA) or grades in science and maths.

There was a significant between groups effect for SN in the post-test ($z = 2.85$, $p = 0.004$, Cohen's $d = 0.90$), but no significant post-test effect between groups for CA. For SN, there were significant increases within both groups with a bigger effect in the TG ($z_{TG} = 3.57$, $p_{TG} < 0.001$, Cohen's $d_{TG} = 2.49$; $z_{CG} = 2.57$, $p_{CG} = 0.010$, Cohen's $d_{CG} = 1.27$). Furthermore, within the TG, there was a significant increase for CA ($z_{TG} = 2.17$, $p_{TG} = 0.030$, Cohen's $d_{TG} = 1.08$), while in the CG the increase was not significant (means see table 3).

Furthermore, we analyzed the data for boys and girls separately (see table 3 and figures 3 and 4). For the pre-test, there was a significant effect for SN for males ($z_{male} = 2.44$, $p_{male} = 0.014$, Cohen's $d_{male} = 1.12$), all other pre-test differences were not significant. In the post-test, there were no significant effects between groups, neither for SN, nor for CA, neither for girls, nor for boys. Within the groups, for SN, Wilcoxon-signed-rank-tests showed significant pre-post-increases for all subgroups except for girls in the CG ($z_{male,TG} = 2.48$, $p_{male,TG} = 0.013$, Cohen's $d_{male,TG} = 1.90$; $z_{female,TG} = 2.53$, $p_{female,TG} = 0.011$, Cohen's $d_{female,TG} = 4.00$; $z_{male,CG} = 2.29$, $p_{male,CG} = 0.022$, Cohen's

Tab. 2. Test instrument (all example items translated from German language).

Scale	Example items of adapted instrument	No. of items	Cronbach's α Pre test	Post test	Example items of original instrument [28]	No. of items	Cronbach's α
Introduction	*What do you think, which of these activities perform scientists frequently? Mark with a cross!*				*The regular everyday work of a scientist involves…*		
Realistic	*Performing experiments*	2	0.52	0.64	*Performing measurements*	6	0.73
Investigative	*Thinking about the results of experiments*	4	0.77	0.78	*Interpreting experimental data*	8	0.71
Artistic	*Thinking of new research ideas*	2	0.17	0.38	*Designing new research approaches*	7	0.74
Social	*Helping younger researchers with their work*	2	0.65	0.85	*Giving lectures and seminars for university students*	4	0.75
Enterprising	*Thinking about how much a research project will cost*	2	0.55	0.72	*Writing a financial plan for their research project*	3	0.90
Conventional	*Writing a lab report*	2	0.75	0.57	*Monitoring ongoing reactions or measurements*	7	0.77
Networking	*Working together with other scientists*	2	0.53	0.47	*Working together in interdisciplinary projects*	4	0.73

Table 3: means and standard errors

		social and networking aspects of NoSt			*science career aspirations*		
		N	**mean**	**std. error**	**N**	**mean**	**std. error**
TG	pre-test	21	65.2	3.88	21	42.9	5.90
	post-test	24	86.3	2.94	24	57.5	6.63
CG	pre-test	23	57.2	5.19	23	40.9	6.47
	post-test	24	72.5	3.76	23	46.1	6.82
TG, boys	pre-test	13	71.5	5.04	13	49.2	8.36
	post-test	13	87.3	3.87	13	60.0	7.16
TG, girls	pre-test	8	55.0	4.23	8	32.5	6.49

	post-test	8	86.3	5.57	8	50.0	14.64
CG, boys	pre-test	12	48.3	7.55	12	50.0	9.37
	post-test	12	72.1	6.23	11	54.6	8.57
CG, girls	pre-test	11	30.9	8.25	11	66.8	6.15
	post-test	11	40.0	11.12	11	73.2	4.92

$d_{male,CG}$ = 1.76). For CA, the only significant effect is for boys of the TG ($z_{male,TG}$ = 2.07, $p_{male,TG}$ = 0.038, Cohen's $d_{male,TG}$ = 1.40). The girls of the TG show the highest increase, but also an growing standard error.

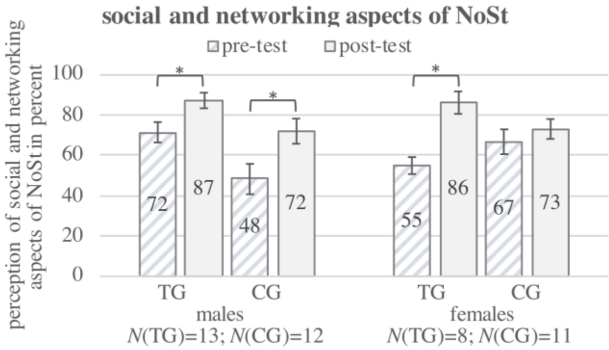

Fig. 3. Social and networking aspects of NoSt.

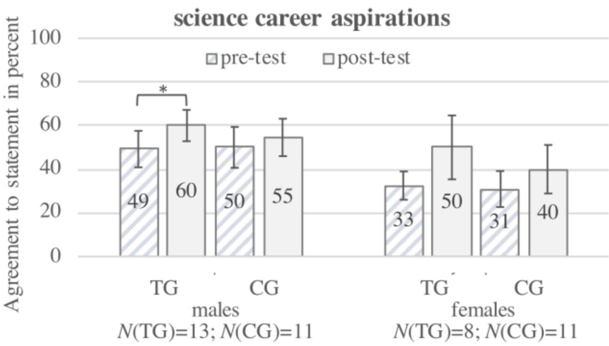

Fig. 4. Science career aspirations.

5 DISCUSSION AND CONCLUSIONS

5.1 Discussion

The four items that were adapted of the "social" and "networking" scale of the original RIASEC+N instrument [28] meet generally respected criteria for reliability with Cronbachs α above 0.7 (see e.g. [29]) for pre- and post-test.

In the pre-test, 20% of all children assessed the item "I would like to become a scientist later." as true or completely true. In comparison, [12] reported that under 17% of a sample of over 9000 10- and 11-year-olds aspired careers in science. Of those "science keen" pupils, 37 % were girls. There was an even bigger gender difference in the current study: only one girl was among the science keen pupils, compared to 8 boys. The studies are not completely comparable due to the different wording of items, but the trend of the findings of [12] could nevertheless be reproduced.

As expected, the discussion in class about scientists everyday work increased pupils' perception of social and networking aspects of NoSt. There was a significant, large effect in the post-test between the treatment group with, and the control group without such a discussion. This is not due to different predispositions, as there was no significant between groups effect in the pre-test. For boys as well as for girls of the treatment group, the pre-post-increase of the perception of social and networking aspects of NoSt was significant with large effect sizes.

Contradictory to our hypothesis, boys of the control group also showed a significant pre-post-increase of the perception of social and networking aspects of NoSt. Because of that, there ist no difference between the groups in the post test, although boys in the control group had a significantly smaller score in the pre-test. It appears that boys can infer from their own experimental activities that there is more to a scientists' work than actually performing the measurements. For girls, this seems not to be the case. Maybe, this is due to a higher unfamiliarity or novelty while experimenting. Several studies found that girls lack extracurricular activities in STEM and have less prior experience with experiments (see e.g. [30]). Too much pereived novelty is linked in the literature to poorer educational outcomes [31]. In this case, possibly novelty was preventing girls from perceiving social or networking aspects in their own experimental work. The discussion in class is therefore a meaningful possibility to extend the advantageous effects of a outreach lab visit to NoSt aspects, especially for girls.

Regarding science career aspirations, although the intervention was just a few minutes of discussion, there is a significant large pre-post-increase in the treatment group, while there is no significant effect in the control group. The pre-post increase is also significant for boys of the treatment group, but not for girls of the treatment group, although their increase exceeds the boys' increase. This is due to a growing standard error in the girls' group. Girls in the treatment group are more divers in their opinion towards science career aspirations in the post-test than before the intervention. It is apparently easier to raise science aspirations for boys than for girls, who despite of their new knowledge about social and networking aspects of scientists' everyday work struggle to integrate their developing female and science identities.

5.2 Conclusions, Limitations and Implications

The current study provides first evidence that just a discussion in class about scientists' everyday work can on one hand raise the awareness of social and networking aspects of NoSt, especially for girls, and on the other hand increase pupils' science career aspirations. Although the intervention was only a few minutes long, it had an effect on pupils. This is not uncommon: Another example for an effect of a few-minute-intervention is the efficiency of interactive lecture demonstrations (ILD) to provoke cognitive change [32]. In this intervention, students discuss their prediction and explanation of an observed demonstration experiment only for a few minutes. Despite the short intervention time, ILD proved to be effective in promoting students' conceptual change [32] with a medium effect.

The effect of the few-minute-intervention presented here might on itself not be tranferred into a long-term change of pupils' views, but as the intervention is very low-threshold, it can be included in almost every experimental activity in outreach labs or in school, producing a long-term effect by this repetition. This will be an interesting approach for further studies. As this was only a small sample, further studies are also necessary to confirm the presented result. Furthermore, examining different age groups would be an interesting approach, for example pupils shortly before graduation who have to make their decision for a field of study. Furthermore, in a longer or more intense intervention (e.g. a reflective discussion about the experience of social and networking aspects in their own experimental activities), even more girls might be persuaded toward scientific careers.

Nevertheless, we see encouraging evidence to recommend to outreach labs as well as to teachers doing lab work in class to include at least short discussions about scientists' everyday acitivites to provide pupils with a less stereotyped image of the nature of scientists. However, one has to keep in mind, that the goal of such interventions is an awareness rising rather than an increase of science career aspirations at any costs: All pupils should be able to make well-informed decisions about their future paths that are not clouded by stereotypes. Nevertheless, it is neither likely nor intended that more than a minority of pupils will actually turn toward scientific careers.

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REFERENCES

[1] Institute of Physics (2018). *Why not Physics?* Retrieved from https://www.iop.org/publications /iop/2018/file_71495.pdf

[2] Higher Education Statistics Agency (2018). *What are HE students' progression rates and qualifications?* Retrieved from https://www.hesa.ac.uk/data-and-analysis/students/outcomes

[3] Statistisches Landesamt Rheinland Pfalz (2017). *Statistische Berichte.* Retrieved from https://www.statistik.rlp.de/de/publikationen/statistische-berichte/

[4] Düchs, G. and Ingold G. (2016). Gut geparkt ist noch nicht studiert. *Physik Journal 15,* 28.

[5] Østergaard C., Timmermans B. and Kristinsson K. (2011). Does a different view create something new? *Research Policy 40,* 500.

[6] Kessels U. and Hannover B. (2004). Empfundene „Selbstnähe" als Mediator zwischen Fähigkeits-selbstkonzept und Leistungskurswahlintentionen. *Zeitschrift für Entwicklungspsychologie und Pädagogische Psychologie 36,* 130.

[7] Kessels U. (2005). Fitting into the stereotype: How gender-stereotyped perceptions of prototypic peers relate to liking for school subjects. *European Journal of Psychology of Education 20,* 309.

[8] Hazari Z., Sonnert G., Sadler P. and Shanahan M. (2010) Connecting High School Physics Experiences, Outcome Expectations, Physics Identity, and Physics Career Choice: A Gender Study. *Journal of Research in Science Teaching 47*, 978.

[9] Hannover B. and Kessels U. (2004) Why German school students don't like math and sciences. *Learning and Instruction 14,* 51.

[10] Wang M. and Degol J. (2013). Motivational Pathways to STEM Career Choices. *Developmental Review 33,* 304.

[11] Kessels U., Rau, M. and Hannover B. (2006). What goes well with physics? *British Journal of Educational Psychology 76,* 761.

[12] Archer L, DeWitt, J., Osborne, J., Dillon, J., Willis, B. and Wong, B. (2013). 'Not girly, not sexy, not glamorous': primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Socitey 21,* 171.,

[13] Steele J. (2003). Children's Gender Stereotypes About Math: The Role of Stereotype Stratification. *Journal of Applied Social Psychology 33,* 2587.

[14] Hughes G. (2001). Exploring the Availability of Student Scientist Identities within Curriculum Discourse. *Gender and Education 13,* 275.

[15] Wentorf W., Höffler, T. and Parchmann I. (2015). Schülerkonzepte über das Tätigkeitsspektrum von Naturwissenschaftlerinnen und Naturwissen-schaftlern. *Zeitschrift für Didaktik der Naturwissenschaften 21,* 207.

[16] Sawtelle V., Brewe E. and Kramer L. (2012) Exploring the Relationship Between Self-Efficacy and Retention in Introductory Physics. *Journal of Research in Science Teaching 49*, 1096.

[17] Multon K., Brown S. and Lent R. (1991) Relation of Self-Efficacy Beliefs to Academic Outcomes: A Meta-Analytic Investigation. *Journal of Counseling Psychology 38,* 30.

[18] Lederman, N. G. (2007). Nature of science: Past, present & future. In S. Abell & N. G. Lederman (Hrsg.), *Handbook of research on science education (S. 831–879). Mahwah: Erlbaum*.

[19] Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education*, *88*(4), 610–645.

[20] Holland J. (1963). Explorations of a theory of vocational choice and achievement. *Psychological Reports 12*, 547.

[21] Osborne J., Collins, S., Ratcliffe, M., Millar, R. and Duschl, R. (2003). What "ideas-about-science"

should be taught in school science? *Journal of Research in Science Teaching 40,* 692.

[22] Dierks P., Höffler T. and Parchmann I. (2014) Profiling interest of students in science: Learning in school and beyond. *Research in Science & Technological Education 32,* 97.

[23] Itzek-Greulich, H., Flunger, B., Vollmer, C., Nagengast, B., Rehm, M., Trautwein, U. (2015). Effects of a science center outreach lab on school students' achievement. *Learning and Instruction 38,* 43.

[24] Bergner N., Holz J. and Schroeder U. (2012). InfoSphere: an extracurricular learning environment for computer science. *Proceedings of the 7th Workshop in Primary and Secondary Computing Education,* 22.

[25] Birkholz J. and Elster D. (2016). Impact of reflective reviews on students' conceptions of Nature of Science Science. *Education Research: Engaging Learners for a Sustainable Future (Proceedings of ESERA 2015),* 855

[26] Schlichting H. and Ucke C. (2004). Der einfachste Elektromotor der Welt: Spielwiese. *Physik in unserer Zeit 35,* 272.

[27] Andersson Å., Karlsson C. and Hampus L. (2017) The Gaussian cannon. *Emergent Scientist 1,* 6.

[28] Stamer I., Pönicke H., Tirre F., Laherto A, Höffler T., Schwarzer S. and Parchmann I. (2019). Development & validation of scientific video vignettes to promote perception of authentic science in student laboratories. *Research in Science & Technological Education* , 528.

[29] Moosbrugger, H., & Kelava, A. (2008). Testtheorie und Fragebogenkonstruktion. Berlin, Heidelberg: Springer-Verlag.

[30] Brotman J. and Moore M. (2008). Girls and science. *Journal of Research in Science Teaching 45,* 971.

[31] Cors, R., Müller, A., Robin, N. and Kunz, P. (2017). Toward a more comprehensive framework for investigating novelty at out-of-school learning places for science and technology learning. *Progress in Science Education*.

[32] Zimrot, R. and Ashkenazi, G. (2007). Interactive lecture demonstrations: a tool for exploring and enhancing conceptual change. *Chemistry Education Research and Practise 8*, 197.