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REVIEW ARTICLE

The Image of Chemistry and a Stereotypical View on Chemists as Important Factors for a Chemistry-Related Career Choice of Students

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ABSTRACT

Scientists are often described as smart and logical thinkers but lacking in the so-called “soft skills.” Well-known TV series such as “The Big Bang Theory” and “Breaking Bad” have also shaped these stereotypical ideas in society. In the present study, a total of 1013 students in grades 8 and 11 were asked about factors that influenced a chemistry-related career choice. Since interest is considered an important factor influencing the career choice, the focus of this study was placed on images and stereotypes compared with academic self-concepts. The models calculated by multiple linear regressions showed significant differences in relation to grades but insignificant in terms of school type. A chemistry-related career choice of 11th grade students was based on the image of chemistry lessons and the distance between self-description and the view of a stereotypical chemical prototype whereas in grade 8 factors such as their grade in chemistry or factors of the academic self-concept also influenced this decision. The results point out the need to promote vocational orientation in chemistry lessons. It is particularly important that students have the opportunity to form a realistic image of chemists.

KEY WORDS: Career orientation in chemistry; stereotypes of chemists; image of chemistry; chemical prototype; prototype matching

INTRODUCTION

Smart, logically thinking but unromantic is how some students describe a physicist (Hannover and Kessels, 2002). In many cases, questions about students’ ideas of a physicist lead to an association of “The Big Bang Theory” character Sheldon Cooper. A highly gifted, but socially less capable, naive, and childish nerd who works as a post-doc in the field of theoretical physics and likes comics and railroads in his free time (Weitekamp, 2015, 2017). We, as scientists, know that is a rather stereotypical picture. The same picture has emerged a lot in the well-known draw a scientist test (Chambers, 1983; Finson, 2002). Sheldon Cooper is popular, but the question arises what impact does such a stereotype have on students’ career choice. Niedenthal et al. (1985) claimed an influence of stereotypes and images on a career choice in their concept of matching self-description and description of prototypes. The question is if there are the same stereotypes for chemists as tested for physicists and engineers (Hannover and Kessels, 2002) and if they influence a career choice in the field of chemistry?

LITERATURE REVIEW

Theories of Career Orientation and Current Research on Career Orientation in Context of Science with a Focus on Chemistry

There are several theories about career choice in general. One very popular theory is the interest-based theory by Holland (1959, 1997). In his RIASEC model, he names six different areas of interest, these are realistic, investigative, artistic, social, enterprising, and conventional. Holland assumes that a career choice is successful when the individual expression of interests and the interests assigned to a profession overlap. The theory by Holland provides the basis for economic tests to support career choice but does not take into account a possible – and probable – change of interests over time as well as the different phases of career choice, depending on age.

Holland’s model does not seem sufficiently suitable to describe students’ career choices and developmental psychological approaches are not considered. The career choice theory by Super (1980) as a “life span theory” offers more explanatory approach. The present study is based on the career choice theory by Gottfredson (1981, 1996, 2005). She combines Holland’s RIASEC model with the developmental psychology approach by Super and takes into account additional factors such as the influence of gender and gender roles or occupational images. In her approach, Gottfredson (1981) describes the path of finding a career. Based on one’s own personality and demographic aspects such as gender, social background, intelligence, personal interests and values, and the occupational images influenced for example by “sextype” or “prestige level,” a first selection of possible career preferences is done. In relation to the “perceptions of job accessibility,” a “range of acceptable occupational alternatives” then results from the individual preferences.

The final occupational aspiration is based on "stimuli to name one occupational title as a goal" (Gottfredson, 1981, p. 547). The process of career choice is thus characterized by circumscription, consisting of the limitation of the social space and the compromise between career aspiration and actually aspired and possible occupations (Gottfredson, 1996). The study of Helwig (2001) confirmed Gottfredson's theory in an impressive 10-year-long longitudinal study.

In the field of science, technology, engineering, and mathematics education (STEM), Simpkins et al. (2006) investigated the influence of interests, self-concepts, and grades in choosing special science courses during school. They found that self-concepts could have a higher amount of influence in course selection than the learners' values.

Some studies have already looked at factors influencing a chemistry-related career choice. From the multiplicity of factors, several particularly important factors can be identified. By analyzing the Program for International Student Assessment (PISA) data of 2006, Han (2017) found that especially environmental influences affect a chemistry-related career choice. He identified the STEM occupation of the parents, a general interest in science in the sense of enjoyment, the instrumental motivation to learn science and Science Literacy as important factors. Extensive studies point out the big influence of interest on a scientific career choice (Dierks et al., 2016; Höffler et al., 2019). In contrast to Holland, the cited authors add a seventh dimension "networking" to the RIASEC-model based on exploratory factor analysis. The new RIASEC+N-model now takes into account the interest in sharing and discussing knowledge (Dierks et al., 2016).

In the field of chemistry, some of the factors considered by Gottfredson have already been examined with regard to their influence on a chemistry-related career orientation especially in German-speaking countries. Bertels (2015) and Albertus (2015) found an influence of self-concept, motivational learning climate and self- and prototype description on a career orientation of students from *Hauptschule* and *Sekundarschule*[1]. They describe a high influence of satisfaction and chemistry-related self-concept as well as the distance between self-description and prototype and a lesser influence of self-description for students at the age of 15 and 16. Weßnigk and Euler (2011) were able to show the improvement of the image of chemistry education and science through an activity-oriented student internship in the student laboratory Baylab-Plastics.

The described career choice theories as well as the presented studies in the field of STEM and chemistry show an influence of self-concept and image variables. Some studies suggest an influence of the distance between self-description and prototype on the chemistry-related career orientation. Just a few studies have investigated the influence of these on a chemistry-related career choice, much less considered possible changes during schooling. In the study presented below, the different factors in a model are related to each other. In addition, the survey was conducted in different grades to achieve a broader overview over different age groups.

1 Secondary school in Germany and especially Northrhine-Westfalia (Germany) essentially consists of the school types Hauptschule, Realschule, Gymnasium and Gesamtschule. The aim of the highest degree at Gymnasium and comprehensive schools is the qualification for a university. Hauptschulen and secondary schools are more likely to prepare for an apprenticeship.

RESEARCH QUESTIONS

Based on the theoretical explanations, the following four research hypothesis were formulated:

(1) How do image factors such as the image of the subject or stereotypes have an impact on students' chemistry-related career choices?
(2) How is the image of chemistry described in comparison to chemistry lessons?
(3) How do the factors influencing a chemical-related career choice differ between grades 8 and 11?
(4) Which stereotypical ideas of scientists can also be found in the field of chemistry?

Methods

Focusing on the choice theory by Gottfredson, this study aimed at unveiling the connection between the academic self-concept and the occupational images of students (the image of chemistry or image of persons working in the field of chemistry). The influence of interest was not tested in this investigation. For the field of science education, this was investigated by Dierks et al. (2016) as well as by Blankenburg et al. (2016).

The constructs investigated in the presented study are shown in Table 1.

The SDQ III questionnaire by Marsh (1990) was used to assess the academic self-concept. Schwanzer et al. (2005) translated it into German. For reasons of test economy, not all constructs of the academic self-concept were used. Together with experts, the following items were selected as relevant: "Language," "Technical skills," "Intellectual skills," "Problem-Solving skills," and "Mathematical skills." For surveying the chemical self-concept, the item catalogue

"Mathematical skills" was adapted.

To ascertain the prestige of chemical professions, the prototype-matching concept by Niedenthal et al. (1985) was used. In the field of physics and engineering, Hannover and Kessels (2002, 2004) tested the relationship between self-description and prototype. The items used by the scientists were adapted for chemistry.

Describing the Sample

In 2015, a total of 1113 students of grades 8, 10, and 11 were surveyed at 14 different secondary schools in Siegen and Olpe (Germany)[3] using a paper-pencil-test. In addition to the

2 The reliability calculation is not intended for the catalog of questions and its evaluation and was therefore not calculated.

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Table 1: Constructs and items used in our own study

Concept	Items	Example-item (translated)	Reliability Cronbach Alpha
Demographic questions	Age Biological sex		---
Most recent grades	Chemistry Physics Biology Mathematics	"Please enter your last grade in the following subjects."	---
Academic self-concept SDQ III translated into German (Schwanzer et al., 2005)	Mathematical skills (Four items with three reversed items)	"I am good in mathematics" (seven-point Likert-scale from 1=totally disagree to 7=totally agree)	0.86
	Chemical skills (Four items)	Adopted Items from "Mathematical skills"	0.82
	Technical skills (four items with two reversed items)	"I am technically gifted."	0.74
	Intellectual Skills (4 items)	"I wish I was as intelligent as the others" (all items reversed)	0.77
	Problem-solving Skills (4 items with 3 reversed items)	"When it comes to solving problems, I'm good at combining ideas in ways that others haven't tried yet."	0.73
	General self-acceptance (Four items with two reversed items)	"All in all, I have a very positive picture of myself."	0.86
Image of Prototype (Hannover and Kessels, 2002)	Adjectives (14 items)	"Imagine a person working in the field of chemistry. Describe this person in the words below." Same adjectives as "Self-description" with seven-point Likert-scale from 1=totally disagree to 7=totally agree	---[2]
Self-description (Hannover and Kessels, 2002)	Adjectives (14 items)	"How would you describe yourself with the words below?" Adjectives with seven-point Likert-scale from 1=totally disagree to 7=totally agree	---[2]
Image of chemistry (Weßnigk, 2013)	Pairs of adjectives with semantic differential (nine items)	"How do you feel when you think about chemistry as science?" (pairs of adjectives with six point semantic differential)	0.89
Image of chemistry classes (Weßnigk, 2013)	Pairs of adjectives with semantic differential (nine items)	"How do you feel when you think about chemistry classes?" (pairs of adjectives with six-point semantic differential)	0.85

Reliability was also given where appropriate

questions presented in this paper, the 25-min survey also raised other questions on career orientation, the results of which will be not presented here.

The design of the study also takes into account the influence of chemistry lessons as the students are surveyed close to the beginning of chemistry education in grade 8 and at a later point in school at 11 (*Gesamtschule* and *Gymnasium*). Since *Realschule* ends after the tenth grade, only students of the grade 8 were surveyed here. A total of 105 pupils from *Realschule*, and 908 pupils from the *Gesamtschule* and *Gymnasium* were surveyed. As it is seen in Table 2, there are no noteworthy differences regarding sex. The average age in grade 8 is almost 14 years (M = 13.80, SD = 0.59) and 17 years in grade 11 (M = 17.08, SD = 0.70).

3 Realschulen end after grade 10 and prepare for professional training on the job. Some students at Gesamtschule also leave school after the 10th grade and start a professional training. At Gesamtschule and, of course, at the Gymnasium, students finish their education after grade 12 or 13, and may continue their education int the form of an academic education at univiersity.

Table 2: Description of sample

School type	Grade 8		Grade 11		Sum
	Male	Female	Male	Female	
Realschule	51	54	---[a]	---[a]	105
Gymnasium	153	182	124	135	594
Gesamtschule	94	108	40	72	314
Sum	298	344	164	207	1013

[a]Realschulen end after grade 10. Therefore, no data is available for grade 11

FINDINGS

This article focuses on the data of years 8 and 11 to have a clearly defined sample.

In addition to possible factors influencing a chemistry-related career choice, the current status of the career choice was also asked. When asked about their current career aspirations, 46.9% of students in grade 11 stated that they had no specific career aspirations yet. The number of these students is therefore as high as in grade 8 (44.3% with no specific career aspirations). In comparison to grade 8, in grade 11 more

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students can imagine taking a job in the field of STEM, but only 0.71% of the surveyed students aspire to a career in the field of chemistry.

To examine the influence on a chemical-related career choice of the concepts introduced above, a multiple linear regression was calculated for each grade. After excluding incomplete questionnaires (list-wise deletion of cases), a stepwise linear regression was carried out. In the calculated model for grade 8 (Table 3), the explanation of variance is 30.9% ($F(5,233) = 20.827$, $\rho = 0.000$).

In grade 8, the chemistry-related career choice is influenced by five significant factors: the four self-concepts "chemical skills," "problem solving," "general self-acceptance," and the "image of chemistry."

The calculated model of grade 11 (Table 4) has a variance explanation of 38.2% ($F(2,34) = 10.503$, $\rho = 0.000$). The model shows two factors influencing the statement "I can imagine doing something with chemistry later in my job": "image of chemistry" and "distance between Self-Description and Prototype."

In contrast to the model of chemistry-oriented career choice for the grade 8, only two factors could be found in the model for grade 11, which could be more associated with the image of subject and people working in the field of chemistry. As can be seen in the model, the narrower the gap between self-description and the view of a person working in the chemical field, the higher the agreement to a possible chemical career choice, and thus the more similar self-description and prototype are perceived. The calculated models suggest a closer look at the aspects of the academic self-concept that was investigated here (Table 4), the image of chemistry education, as well as the relationship between the students' self-description and description of their chemical prototype. Due to the particular relevance of choosing a career at the end of schooling, in the following, this article will focus on the influencing factors of a chemistry-related career choice in grade 11. Where possible, results from grade 8 students are included in the comparison.

Findings with Focus on Image of Chemistry and Chemistry Lessons

The image of chemistry classes and chemistry as science differed significantly in grades 8 and 11. Students described the image of chemistry as a science with more positive adjectives than their chemistry classes. Table 5 shows the results and the associated t-tests.

Table 3: Factors influencing the career choice ("I can imagine doing something with chemistry later in my job") in grade 8 with regard to a profession related to chemistry (Multiple Linear Regression)

Steps	Predictors	ΔR²	B	SE B	β	ρ
Step 1		0.23				
	Constant		−2.18	0.58		0.000
	Chemical skills		1.14	0.14	0.48	0.000
Step2		0.03				
	Constant		0.18	0.97		0.855
	Chemical skills		0.86	0.16	0.36	0.000
	Image chemistry lessons		−0.38	0.13	−0.21	0.003
Step 3		0.02				
	Constant		0.91	1.01		0.367
	Chemical skills		0.96	0.17	0.41	0.000
	Image chemistry lessons		−0.42	0.13	−0.22	0.001
	Problem solving		−0.22	0.70	−0.14	0.023
Step 4		0.02				
	Constant		1.35	1.01		0.183
	Chemical skills		0.79	0.18	0.33	0.000
	Image chemistry lessons		−0.47	0.13	−0.25	0.000
	Problem solving		−0.36	0.11	−0.23	0.001
	Intelligence		0.24	0.09	0.19	0.009
Step 5		0.01				
	Constant		1.79	1.03		0.083
	Chemical skills (self-concept)		−0.83	0.18	0.35	0.000
	Image chemistry lessons		−0.48	0.13	−0.26	0.000
	Problem solving (self-concept)		−0.35	0.11	−0.22	0.001
	Intelligence (self-concept)		0.31	0.10	0.25	0.001
	General self-acceptance (self-concept)		−0.18	0.09	−0.14	0.034

Total (N=529): R^2=0.31; $F(5,233)$=20.827, ρ=0.000

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In both grades, there was a significant difference between the description of chemistry lessons and chemistry as a science.

Table 4: Factors influencing the career choice ("I can imagine doing something with chemistry later in my job") in grade 11 with respect to a profession related to chemistry (Multiple Linear Regression with stepwise integration of variables)

Steps	Predictors	ΔR²	B	SE B	β	ρ
Step 1		0.28				
	Constant		7.53	1.05		0.000
	Image chemistry lessons		−1.17	0.31	−0.53	0.001
Step2		0.10				
	Constant		8.84	1.14		0.000
	Image chemistry lessons		−1.16	0.30	−0.53	0.000
	Distance self-description and prototype		−0.79	0.34	−0.32	0.026

Total (N=316): R^2=0.38; F (2,34)=10.503, ρ=0.000

Chemistry as a science was described with clearly more positively connoted adjectives.

The plot of the calculated mean values in Figure 1 also shows a more positive perception of chemistry in grade 11 compared to grade 8.

It becomes clear that chemistry lessons in grade 11 were perceived only slightly differently than in grade 8. In contrasts, students in grade 11 perceived chemistry as science significantly more positive than students in grade 8.

Findings with Focus on Self-Description in Comparison to Prototype-Description

Since the distance between self-description and prototype description becomes particularly important in the model of grade 11, this gives reason to take a closer the differences in self-description and description of the chemical prototype (Table 6).

Table 5: Mean values of the semantic differentials to describe chemistry as science and chemistry classes by students of grade 8 and 11

Pairs of adjectives	Grade 8				t (620)	ρ	Grade 11				t (359)	ρ
	Chemistry classes		Chemistry as science				Chemistry classes		Chemistry as science			
	M	SD	M	SD			M	SD	M	SD		
Important – Unimportant	3.33	1.38	2.58	1.49	12.51	0.000	3.39	1.40	1.79	1.22	20.19	0.000
Productive – Unproductive	3.13	1.27	2.64	1.29	8.66	0.000	3.36	1.31	2.06	1.13	16.82	0.000
Creative - Not creative	3.23	1.49	2.98	1.42	4.18	0.000	3.71	1.41	2.94	1.36	10.90	0.000
Dynamic – Static	3.50	1.19	3.16	1.27	5.84	0.000	3.63	1.27	2.85	1.27	10.73	0.000
Open – Closed	3.25	1.31	3.06	1.38	3.16	0.002	3.45	1.30	2.69	1.27	9.92	0.000
Progressive – Unprogressive	2.73	1.25	2.30	1.30	7.72	0.000	2.86	1.32	1.76	1.09	15.46	0.000
Innovative – Conservative	3.17	1.21	2.91	1.29	4.70	0.000	3.21	1.25	2.27	1.23	12.81	0.000
Active - Immobile	2.83	1.47	2.64	1.40	3.22	0.001	3.05	1.41	2.41	1.26	8.22	0.000
Open-minded – Clinging to existing	2.81	1.54	2.57	1.52	3.75	0.000	3.14	1.48	2.23	1.31	12.03	0.000

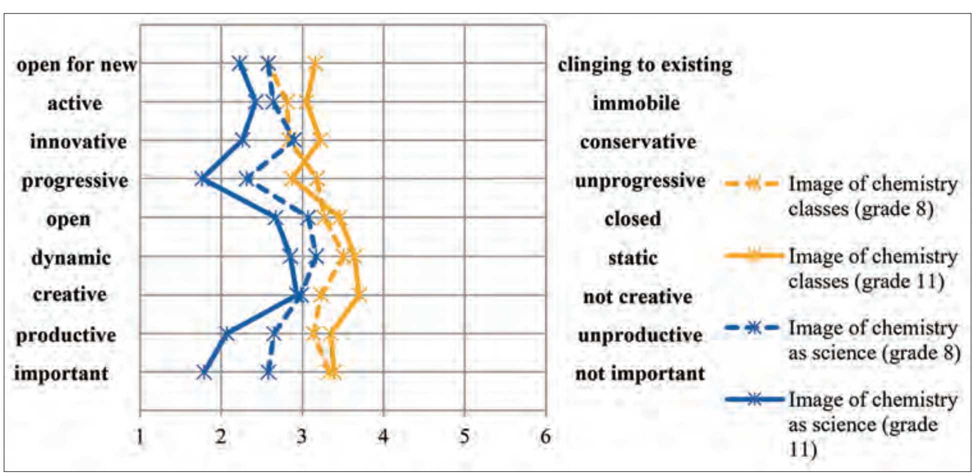

Figure 1: Comparison of the images of chemistry classes and chemistry as science among students in grade 8 and 11

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Table 6: Self-description and description of a prototype in the field of chemistry using adjectives (from 1=strongly disagree to 7=strongly agree)

Describing adjectives	Grade 8				t (608)	ρ	Grade 11				t (356)	ρ
	Self-description		Prototype				Self-description		Prototype			
	M	SD	M	SD			M	SD	M	SD		
Clever	5.01	1.33	6.01	1.35	−15.01	0.000	5.25	1.02	6.1	1.15	−12.04	0.000
Intelligent	5.05	1.33	6.07	1.27	−15.81	0.000	5.22	1.06	6.23	1.11	−13.92	0.000
Educated	4.9	1.34	5.99	1.34	−15.70	0.000	5.21	1.06	6.16	1.31	−12.96	0.000
Ambitious	5.28	1.61	5.72	1.44	−5.42	0.000	5.53	1.43	5.91	1.31	−4.27	0.000
Pompous	2.95	1.59	4.25	1.83	−14.89	0.000	2.74	1.46	4.2	1.86	−13.38	0.000
Nerdy	2.79	1.68	4.72	1.88	−20.82	0.000	2.93	1.67	5.05	1.71	−18.26	0.000
Sensitive	4.83	1.67	3.7	1.57	12.12	0.000	5.3	1.57	3.43	1.54	16.78	0.000
Romantic	4.2	1.78	3.1	1.68	12.02	0.000	4.38	1.75	2.78	1.51	13.86	0.000
Superior	4.36	1.63	4.9	1.67	−6.78	0.000	3.98	1.60	4.62	1.61	−6.11	0.000
Sentimental	4.33	1.62	3.42	1.63	10.57	0.000	4.4	1.74	2.97	1.40	12.68	0.000
Gentle	4.39	1.67	3.61	1.69	8.51	0.000	4.53	1.68	3.28	1.53	11.03	0.000
Softhearted	4.49	1.78	3.45	1.61	11.18	0.000	4.59	1.74	3.16	1.53	12.23	0.000
Delicate	4.65	1.63	3.81	1.77	9.19	0.000	4.83	1.69	3.81	1.74	8.51	0.000
Thinking straight	5.2	1.53	6.2	1.46	−12.96	0.000	5.36	1.40	6.44	1.16	−12.92	0.000

Table 7: Comparison of the image of chemistry lessons with the image of chemistry as science for students in grades 8 and 11

Describing adjectives	Comparison grade 8 and 11			
	Self-description		Prototype	
	t (991)	ρ	t (981)	ρ
Clever	−2.93	0.003	−1.06	0.289
Intelligent	−2.07	0.039	−1.97	0.049
Educated	−3.74	0.000	−2.08	0.038
Ambitious	−2.39	0.017	−2.07	0.039
Pompous	−2.00	0.046	0.36	0.717
Nerdy	−1.23	0.219	−2.71	0.007
Sensitive	−4.39	0.000	2.69	0.007
Romantic	−1.53	0.126	3.04	0.002
Superior	−4.39	0.000	2.52	0.012
Sentimental	−1.53	0.516	4.38	0.000
Gentle	−0.65	0.189	3.04	0.002
Softhearted	−1.31	0.386	2.70	0.007
Delicate	−0.87	0.099	0.01	0.989
Thinking straight	−1.57	0.116	−2.67	0.008

The results show a significant difference between the students' self-descriptions and the description of a prototype in the field of chemistry. Further, evaluations of the collected data show that there was almost no significant difference with regard to self-description and prototype description in comparison of grades 8 and 11 (Table 7).

DISCUSSION AND CONCLUSION

This study points out alarming results regarding the current career choice of students at the end of their schooling and highlights the need for increasing career orientation in schools. Almost half of all students surveyed in grade 11 had no concrete career aspirations yet. The Organization for Economic Co-operation and Development (OECD) stated that a career aspiration can be conducive to motivation and achievement in school (OECD, 2018). This supports the need for more career orientation in schools in general.

The number of those students who wanted to pursue a chemistry-related profession was very low, which was also shown by Haase and Pietzner (2016). In contrast to the study presented above, Haase and Pietzner found that 86% of their surveyed students of grades 7–10 had a specific career aspiration. The difference may be related to the unrepresentative composition of both studies. While in this survey only students of the region Siegen and Olpe in Germany were interviewed, Haase and Pietzner interviewed pupils of the Weser-Ems area in Germany. Since education in Germany is designed and regulated by each federal state, there may also be differences here (e.g., caused by different curricula or different focus in curricula). The number of students wishing to pursue a profession in the field of STEM subjects (24.5% of year 11 students in their study) was higher than the 15% reported in the PISA 2015 study (OECD, 2016). Stuckey et al. (2013) pointed out the importance of career orientation in chemistry education by defining a vocational dimension as one of three dimensions of relevant chemistry education. At present, career orientation in chemistry lessons seems to play a minor role, although it is anchored in the school curriculum.

The models described above highlight the large influence of the image of chemistry lessons as well as academic self-concepts such as "chemical skills," "problem solving ability," "general self-acceptance," and "intelligence" on the chemistry-related career choice in grade 8. The negative influences of the self-concepts "problem solving ability" as well as "general self-acceptance" were surprising and were not expected. One approach to understanding these findings could be the still

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diffuse influences at an early stage of career choice. To find out more about the negative influence of "general self-acceptance," the personality factors (BIG-5) of very science-interested students should be tested. These are "openness to experience," "conscientiousness," "extraversion," "agreeableness," and "neuroticism" (Roccas et al., 2002). It is already known from the field of computer science that good computer scientists have certain personality traits such as conscientiousness, openness, and introversion (Gnambs, 2015).

In contrast to grade 8, the chemistry-related career choice in the upper secondary school (grade 11) was influenced exclusively by images. It is remarkable that no academic self-concepts and especially not the chemical self-concept influences this career choice. Surprisingly, the image of chemistry as a science has no influence on the chemistry-related career choice either. Perhaps these findings mean that students who are interested in a chemical profession, which do not necessarily want to be active in the field of science but more in the chemical industry. In this study as well as in the STEM-Study by Acatech – Deutsche Akademie der Technikwissenschaften[4] (2015), students named scientific working methods last when they were asked about their future job (Spitzer, 2017).

The perception of chemists is a major factor in the chemistry-related choice of students. The results of the comparison between self-description and prototype description confirmed similar findings by Hannover and Kessels (2002) in the field of physics. From the students' point of view, this is a robust, rather negative picture of chemists over the surveyed school years. Thus, it seems reasonable to assume that the students were not introduced to people working in the field of chemistry and their work. Rather, they rely on stereotypes as represented in the media and communicated by society. With regard to the rather male stereotype of a scientist, Miller et al. (2018) already noticed positive changes in small children. On the one hand, we need to encourage teachers to share more information about occupations in their classroom and, on the other hand, enable them to counteract the stereotypical image of chemistry as science and the people who work in this field, for example, scientists usually being male, among other things. Contrary to this study's research hypotheses, the chemistry-related career choice in grade 8 was influenced not only by images but also by academic self-concepts. In an upper school level, however, only images played a role in the students' career choice. To confirm this presumption, a longitudinal examination is needed.

Concerning limitations, one has to keep in mind that the study described above is quantitative which makes it possible to calculate models that show important influence of image factors on a chemistry-related career choice. The way students characterize a chemist or chemistry as a science in detail cannot be described with the collected data, as this would require a qualitative study. An in-depth qualitative study could, however, provide information on other factors influencing a chemistry-related career choice, which might make it a future research goal. The explained variance of the calculated models suggests that chemistry-related career choice is also influenced by other factors, which are not taken into account in the presented study.

The findings in the present study support aspects of the career choice theory by Gottfredson, and it can be used to support the vocational process in schools (Gottfredson, 1996). The results of this study make clear that not only interests, like proclaimed in the RIASEC model of Holland, influenced vocational orientation. Especially at the end of school, a chemistry-related career choice is significantly influenced by factors such as the image of chemistry lessons and stereotypical perceptions of scientists. In addition, the lack of concrete career choices among grade 11 students highlights the need to strengthen vocational orientation in the context of school in general. With focus on a chemistry related career choice, the identified influencing factors underscore the necessity to strengthen the image of chemistry education and the people working in the chemical sector. Due to the very specific images, it makes more and more sense to expand chemistry classes with elements of career information and orientation. Due to the highly stereotypical mediation of the chemical or general academic profession by the media and society, this should include real-life contact with people in this area. This allows students to develop experience-based and more realistic prototypes. Projects and out-of-school laboratories such as the Baylab-Plastics (Weßnigk and Euler, 2011) or the self-designed environmental laboratory Chem-Trucking (Spitzer et al., 2015) can offer opportunities to gain real insights into the chemical industry and establish contacts with people working there.

ETHICAL STATEMENT

All procedures performed in this study were in accordance with the ethical standards of the Institutional and/or National Research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The participation in the survey was voluntarily with informed consent (consent of the school administrations as well as individual consent of the questioned students). The confidentiality and anonymity of the data were ensured throughout the collection and evaluation. Sufficiently large subgroups were also considered so it is not possible to draw any conclusions about individual persons.

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