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CHOOSING AN ELECTIVE - WHAT IMPACT DO SCIENTIFIC PROFILE CLASSES HAVE?

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STRUCTURED ABSTRACT

Background: With 263,000 vacant jobs in the STEM sector, there is currently a shortage of specialists in Germany. Concurrently, schools report a decrease in scientific interest, particularly noticeable in lower secondary school (Grades 5 – 6), as many students choose to take non-scientific subjects. However, there are a few teaching models that can promote scientific interest and choice: Scientific profile classes (5^{th} – 7^{th} grade) are one possibility to compensate.

Purpose: Previous studies focus on choices made by high school students in 10^{th} grade. We aim to examine the effectiveness of a teaching model that contains profile classes. This will be assessed by investigating which elective students chose after 7^{th} grade, accompanied by exploring influencing factors, such us gender, grade, interest, ability-self-concept and motives for choice.

Sample/Setting: The sample consists of a total of 83 students in 7^{th} grade, where students either attended a scientific profile class or a regular class (n = 55, 29 male/25 female/1 non-binary; n = 28, 15 male/13 female, respectively) at two grammar schools in North Rhine-Westphalia, Germany.

Design Methods: At the end of 7^{th} grade, students answered a questionnaire including items on scientific interest, ability self-concept and motives for choosing an elective.

Results: There were no significant effects on elective choice between profile classes and regular classes ($\chi^2(1)=0.508$, p = 0.476) nor between genders ($\chi^2(1)=0.163$, p = 0.687). However, the factors utility value and ability self-concept have a significant influence on elective choice.

Conclusions/Implications for classroom practice and future research: This study provides the first attempt to identify what motivates secondary school students to choose an elective. Although we have determined a target group of students to promote science, our study concluded that science profile classes have no effect on elective choice. Future studies should further develop the curriculum and teaching method to effectively promote students' interests.

Keywords*: Electives, Profile Classes, Secondary School, Scientific Interest, Motives for Choice*

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1 INTRODUCTION

In Germany, there are currently 263,000 vacant jobs in the STEM (Science, Technology, Engineering, and Mathematics) industry (MINT-Herbstreport[1], 2019). One explanation could be an observable decline in scientific interest in students throughout their school career (Ferdinand, 2014). Interest in a subject becomes crucial when they are faced with the option of choosing electives or advanced courses, and much later when making career decisions (Hülsmann, 2015). Students begin thinking about their future at the age of 12 (Lindahl, 2003; Maltese & Tai, 2010): If they are less interested in science, they are less likely to choose a scientific career.
Currently, many teaching models do not exclusively aim to foster scientific interest and ultimately fail at assisting students when they transition to the job market. An intervention, such as vocational training, in Germany begins in middle school (Bundesministerium für Bildung und Forschung & Bundesministerium für Arbeit und Soziales, 2016). However, scientific interest is already very low by this point (Gebhard, Höttecke & Rehm, 2017), so it hardly encourages scientific career decisions.

Research indicates that, in addition to interest, students' choice of school courses is a decisive factor in their

[1] Scientists examine the scientific labour market twice a year

subsequent scientific career decisions. Recent studies focus on the advanced course choice in 11th and 12th grade high school students. However, students can already make initial decisions in the 7th grade when choosing an elective. This field of research has hardly been investigated so far. Depending on the school, a scientific profile can already be formed at this stage, which could also have an influence on a later scientific career. This study examines factors which influence elective choice in 7th grade.

2 RESEARCH BACKGROUND

2.1 Profile Classes

Profile classes offer a way for schools in Germany to develop a distinct profile. Schools have the opportunity to provide their students with individual support in various fields, such as music, languages or social sciences. In this study, scientific profile classes are examined (Schulte & Wegner, 2020). Prospective students are admitted to the profile classes based on interviews and the previous math and science grades. These classes are specifically intended to promote scientific interest and self-concept. Furthermore, they advocate students to continue science courses, which could later impact their career choice.

Implementing profile classes between 5th and 7th grade provides students with more time and flexibility, as it offers additional teaching time (1 extra lesson per week) as well as a wide range of extracurricular after-school support. It is mandatory to participate in scientific study groups and take part on numerous excursions, which has also been shown to trigger interest (Henriksen, Dillon & Ryder, 2014).

The scientific profile classes examined follow an alternative curriculum with context-oriented lessons and cover topics relevant to everyday life. The teaching material focuses on the scientific methods through observation, experimentation, and result comparison with discussions. Students can develop their own ideas, research questions and individually conduct experiments. This enabling them to choose topics in science class (Lindahl, 2003).

Teaching science in school is essential to maintain and promote interest, yet it is not always effective. Students often criticize the transmissive teaching as well as decontextualized and difficult topics, which subsequently have a negative effect on their interest and engagement with the subject (Lyons, 2006).

Recent research indicates that context-oriented teaching units are particularly beneficial to increase interest (Habig, Blankenburg, van Vorst, Fechner, Parchmann & Sumfleth, 2018).

2.2 Electives in Middle School

In Germany, educational policy is determined by each federal state. In North Rhine-Westphalia, the mandatory curriculum is supplemented by electives which start in 8th and continue until 9th grade. This is the initial opportunity for students to individualize their school profile and choose their specializations. Whereas students are used to having all subjects with the same classmates, the electives are arranged in courses mixing students from an entire grade and, therefore, breaking up the normal "class system". Student performance in electives is graded and credited for graduation (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen, n.d._a). At the school of this study, the following electives are offered: Spanish, biology/chemistry; mathematics/informatics; social sciences; theatre/media/performance and physics/technology. However, other schools may vary their electives depending on their educational resources or school profiles (e.g. bilingual history, biology/geography, and other foreign languages).

Further specialization occurs in the last two years of high school. Students are required to choose four "Abitur[2]"subjects to graduate: two advanced and two basic courses. Advanced courses are taught with more lessons per week and cover content in greater depth. Finally, students complete the "Abitur" with tests in their four selected subjects. Depending on which subjects were chosen, a scientific focus is possible (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen, n.d._b).

2.3 Scientific Interest

In scientific profile classes, the subject of interest is formed by the different teaching content in the subjects biology, chemistry and physics as well as extracurricular topics in the additional lessons.

Several studies indicate that scientific interest declines over the course of the school career (e.g. Gardner, 1987; Merzyn, 2008). The declining interest could possibly be explained by the theoretical and complex teaching of scientific knowledge. The inability to connect to science education starting from primary school on contributes to the loss of interest among students from 5th to 10th grade (Brüggemeyer, 2018).

It is accompanied by a decline in the continuation of science subjects during school, which is a global phenomenon that can be observed in Australia, Canada, Japan, and the EU (Lyons, 2006). According to Maltese and Tai (2010), students who are interested in scientific topics report that they were excited in early childhood. The authors state that scientific interest is already detected in primary school, or in the first years of lower secondary school. They explain that an origin of interest can be classified in three ways: intrinsic self-interest, school/education-based experience, and interest encouraged by a family member, with the first two having the most influence. Students who indicate at the beginning of their education that they aim to pursue a career in science, may change their minds during their school career. Therefore, schools play a decisive aspect in influencing interest in science, and should aspire to maintain and promote existing interest at an early stage.

Many studies on course selection focus on advanced course choice during the last few years of high school, which repeatedly has been demonstrated to correlate with interest (Abels, 2002; Merzyn, 2010; Pohlmann & Streblow, 2017). Hülsmann (2015) illustrated that the proba-

[2] Students take their "Abitur" examination in four subjects. However, during the final qualification phase between 11th and 12th/13th grade, students take between 11 and 13 subjects altogether. (Ministerium für Schule und Bildung des Landes Nordrhein-Westfalen,, n.d._c).

bility of choosing chemistry as a subject in upper secondary school increased if students participated in a science elective in lower secondary school. We infer that students choosing a science elective could have been impacted by participating in profile classes beforehand. If they are particularly interested in the natural sciences, it is more likely that they will choose a scientific elective and later on, an advanced science course. Ultimately, choosing an advanced science course is one factor towards pursuing a scientific career (Merzyn, 2010).

Students who choose to continue their school career in fields other than science are characterised by lower scientific competency and scientific interest. Both factors can be traced to negative experiences in science lessons throughout grades 5 and 6 and the perceived irrelevance of the content (Merzyn, 2010; Cleaves, 2005). Therefore, profile classes are intended to prevent negative experiences and instead promote interest, self-concept and competences in the sciences. Furthermore, personal attributes such as ability self-concept, grades and prospects of success also play an important role in course selection (Abels, 2002; Cleaves, 2005).

As there are few studies about the selection of science electives in relation to interest in secondary schools, our study aims to bridge this gap. Additionally, it examines whether a teaching model involving profile classes is effective at maintaining and fostering scientific interest, which is hoped to support the choice of continuing science subjects.

2.4 Research Hypotheses

This study examines whether profile classes promote scientific interest and explores motives that are decisive when choosing an elective:

(i) Which electives do students choose and are there differences between students in scientific profile and regular classes?
- Students in profile classes tend to choose a science elective (see e.g. Malteste & Tai, 2010; Hülsmann, 2015).

(ii) Which factors have an influence on choosing a science elective?
- Interest, ability self-concept and grades in biology, chemistry and physics have an influence on elective choice (see e.g. Hülsmann, 2015; Abels, 2002).

3 METHODS

The sample consisted of three 7th grade classes (n = 83) which were split by two profile classes and one regular class (n = 55 and 28, respectively). All students completed a questionnaire at the end of 7th grade. The instrument contained 32 closed items, using a 6-point rating scale from "strongly agree" to "strongly disagree" (scientific interest, motives for choice) and "very good" to "very bad" (ability self-concept), as well as one open item (see Tab. 1). Questionnaire scales are taken from already used and proven test instruments.

Items were divided into motives which *directly* influence choice, such as interest-enjoyment, attainment and utility, and *indirect* motives which are assumed to have an influence (scientific interest, ability self-concept and grades). The scale motives for choice was selected from Hülsmann's (2015) questionnaire.

Finally, students indicated which elective they chose. Additional data such as gender, age and grades in biology, chemistry and physics were collected.

Tab. 1. Test instrument scales: reference, number of items, an example item and Cronbach's alpha are given. The items were translated from German for the purpose of the publication.

	Scale (Reference)	No. of items	Item Example	Cronbach's α
Indirect motives	**Scientific Interest**[3] (Ferdinand, 2014; Schreiner & Sjøberg, 2004; Frey, 2009)	13	I enjoy studying scientific topics.	.95
	Ability Self-Concept (Hofman, Häußler & Lehrke, 1998)	7	According to my own assessment, my performance in the natural sciences is …	.94
Direct motives	**Motives for Choice (Hülsmann, 2015)**		I have chosen this specialty for the next two school years …	
	Interest-Enjoyment	3	… because I am interested in the elective and its topics.	.88
	Attainment value	2	… because it is important that I learn a lot about this subject.	.78
	Utility value	3	… because I expect that I will require knowledge in this area in the future.	.67
	Elective	1	Which elective did you choose?	-

[3] We performed an exploratory factor analysis. Variables were suitable (Bartlett test (Chi-square(78) = 837.59, p < .000; KMO = .930). A principal component analysis with varimax rotation indicates a single factor-solution that accounts for 64.5% of the variance.

4 RESULTS

To summarize our data, the electives biology/chemistry, mathematics/informatics and physics/technology were assigned as science electives and elective selection was analyzed as a dichotomous variable (yes/no). A chi-square test was conducted to explore differences in choosing an elective based on class type. All expected cell frequencies were greater than 5. There was no difference between chosen elective and class type or gender ($\chi^2(1)=.508$, $p=.476$; $\chi^2(1)=.163$, $p=.687$, respectively, see Fig. 1).

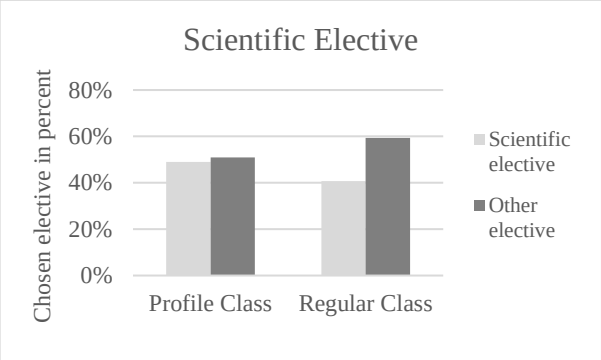

Fig. 1. Distribution of selected electives from students in regular (n=28) and profile classes (n=55).

Separate logistic regression analyses were calculated for direct and indirect motives to investigate influential factors for elective choice.

The model for direct motives ($\chi^2(2)$ =11,199, p =.004) and the z-test for the regression coefficient utility value are significant (Wald(1) =7,518, p =.006). (Nagelkerke R-Quadrat =.194, corresponds to a strong effect according to Cohen (1992), see Tab. 2).

Additionally, we examined the influence of the indirect motives such as scientific interest and ability self-concept using a logistic regression analysis

The model for indirect motives ($\chi^2(3)=12,868$, $p=.005$) and the z-test for the regression coefficient ability self-concept are significant (Wald(1)=4.455, $p=.035$). (Nagelkerke R-Quadrat =.171, corresponds to a strong effect according to Cohen (1992), see Tab. 2).

The factors utility value and self-ability concept are significant predictors of interest for future elective choice. Grades in biology, chemistry and physics, as well as interest-enjoyment and attainment value have no significant influence on elective choice.

Tab. 1. Logistic regression analyses predicting elective selection from direct (above) and indirect (below) factors.

Predictor	β	Wald χ^2	*p*	Odds Ratio
Interest-Enjoyment	.708	1.77	.184	2.03
Attainment value	-. 065	0.04	.848	.94
Utility value	.702	7.52	.006	2.02
Scientific Interest	-.051	0.02	.880	.951
Ability Self-Concept	.991	4.46	.035	2.69

Students in profile classes (M=3,59, SD=1,04) show a significantly higher scientific interest (t(81)=2,457, p=.016) than students of the regular class (M=2,96, SD=1,12). Furthermore profile class students have significantly better grades in chemistry (t(80)=-4,479, p=.000) and physics (t(80)=-3,595, p=.001). There is no significant difference in the subject biology.

5 DISCUSSION AND CONCLUSION

Profile classes are intended to build interest as they implement a curriculum with specifically designed context-oriented units. This provides flexibility while adapting to students' previous knowledge and interests. However, we found that attending the science profile class did not encourage students to choose a scientific elective more than those attending the regular class.

Both direct and indirect motives are assumed to influence elective choice. However, the factors utility value and ability self-concept were the only significant predictors (Cleaves, 2005). When students were asked about their reasons for choosing an elective, they justified their decision solely based on how useful they find the subject for their future. Utility-value has been shown to increase in importance with advanced courses (Hülsmann, 2015), and now this is seen in younger students in profile classes. We also observed an influence of self-concept on elective choice. This may be partially explained by perceived positive self-closeness, which is defined as the extent to which a person uses the elective to define themselves as well as their confidence in ability (Hannover & Kessels, 2004).

Interest in the elective and a general scientific interest did not seem to have a significant influence on the decision to choose an elective. In contrast to other studies, interest here does not significantly influence elective choice (e.g. Busch, 2016). Despite a comparatively higher level of interest, students in the profile class do not choose a scientific elective. One reason for this could be that new areas of electives like theatre or media were introduced in schools at the time of the survey. Many students chose these electives due to a novelty effect; those in the profile class may have preferred other electives because they had already acquired “sufficient” knowledge in science. In order to verify this assumption, interviews would have to be conducted with students to analyse reasons to choose or avoid certain electives.

Another influencing factor could be that students have to decide to attend a profile class at the beginning of high school. Therefore, it cannot be ruled out that there may also be students interested in science in the regular classes. These students might also choose science electives.

As attainment-value did not have an influence on elective choice, it seems that students do not mention the electives’ relevance for their own learning as a reason for elective choice. Finally, grades in biology, chemistry and physics had no influence on elective choice, which could indicate that students choose an elective regardless of subject performance. This aspect is supported by the fact that students in profile classes have significantly better grades in chemistry and physics.

To examine if grades have an influence, all grades would have to be recorded and analysed to look for correlations with their chosen elective.

These results illustrate necessary adaptations for the existing profile classes in this study. Vocational training (such as internships or inviting experts and scientists) should be offered earlier to provide students with the opportunity to be exposed to scientific professions, as students in 7th grade already make choices with their future career in mind (Lindahl, 2003; Lyons, 2006). This adaptation is supported by the items exploring construct utility value, which inquire the professional relevance of the area of elective. Although we did not see an impact of interest in our study, numerous studies show the importance of interest for a later scientific career (e.g. Hülsmann, 2015; Lyons, 2006; Henriksen, Dillon & Ryder, 2014; Abels, 2002). A school-related approach to improve profile classes would be to adjust the subject matter and improve context-oriented teaching units to benefit students on an individual level (van Vorst et al. 2015; Sennebogen, 2013).

Our study adds to the growing body of evidence that helps identify factors that encourage students to choose a scientific elective. Although profile classes are not yet ideal, we suggest further changes in the curriculum to promote scientific self-concept, a greater focus on student interest and starting vocational training earlier. If students are confident in their own abilities, students might choose another elective area. Furthermore, if students tend to be interested in all fields of science, they will choose more science courses. Ultimately, this could affect future career choices and hopefully might affect the shortage of STEM workers.

6 LIMITATIONS

One limitation of this study is the small sample size. Our results can only be interpreted in relation to the profile classes mentioned here and do not allow general conclusions to be drawn about the voting behavior of 7th graders. The control group only consists of one regular class; this must be enlarged in following studies to support our results. Subsequently, a cross-sectional study on elective choice in middle schools within all grammar schools in Nordrhein-Westfalen would be a useful approach to study elective choice in profile class students.

In order to obtain reliable scales, items that were used in the study by Hülsmann (2015) had to be excluded. Additionally, only a small number of variables are included in the calculation for attainment and utility value. In a subsequent survey, the questionnaire will be supplemented by further items.

Further studies should look at the extent to which profile classes already pursue context-oriented teaching, such as investigating teaching methods using video analysis or teacher and student interviews. We should also aim to increase our sample size, as it would be useful to survey groups at different schools for an entire year to exclude external influences, such as teaching styles, previous educational experiences and enrichment programmes. Additionally, most comparative studies look at students choosing advanced courses and not electives, therefore future studies should aim to look at studying elective selection, as career choices are already considered during lower secondary school (Lindahl, 2003 & Lyons, 2006). Based on Lindahl (2003), expanding the study by interviewing students about their decisions for elective choice would be also beneficial.

This study provides valuable information about choosing electives in profile class students and offers methods to promote scientifically interested students.

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