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Research paper

The Big Six interests of STEM and non-STEM students inside and outside of teacher education

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ABSTRACT

Vocational interests are an important factor in the decision to become a teacher. Based on Holland's (1997) RIASEC model and large-scale data, the current study examines how far pre-service teachers (n = 2977) show different vocational interests in comparison to students not aspiring the teacher profession (n = 4766). Furthermore, it is investigated whether pre-service teachers in STEM and non-STEM fields differ regarding favorable interest constructs (e.g., person-environment fit). Pre-service teachers show higher Social and Enterprising interests than non-teaching students while within teacher education, especially males in STEM fields show unfavorable interest profiles. Conclusions are drawn regarding suitable support offers.

1. Introduction

Many countries face the problem that not enough people choose the career of a teacher (Burns & Darling-Hammond, 2014; Kearney, 2016; UNESCO Institute for Statistics, 2013). The lack of qualified teachers especially concerns the STEM fields (Kearney, 2016; Sutcher, Darling-Hammond, & Carver-Thomas, 2016). Suboptimal responses such as cancelling courses, increasing class sizes and raising teacher workloads endanger the quality of education in STEM subjects (Reinsfield & Lee, 2021; van Rooij, Fokkens-Bruinsma, & Goedhart, 2020) and can lead to the attrition of qualified teachers exacerbating the problem (Burns & Darling-Hammond, 2014; Stewart, 2012). Therefore, it is seen as crucial to investigate the career choice motives of potential and actual pre-service teachers in order to be able to recruit more applicants (Heinz, 2015).

So far, the career choice of teachers has widely been studied using the FIT-choice model (Watt & Richardson, 2007). This approach is based on an expectancy-value framework and focuses the *motivational* factors that influence the choice of a career as a teacher, e.g., 'altruistic'-type motivations, utilitarian motivations, intrinsic motivations and ability related beliefs (Watt & Richardson, 2012, p. 186f.). While studies applying the FIT-choice model have produced important results regarding the motivations, beliefs and perceptions pre-service teachers in different countries show regarding the teacher profession (e.g., Goller, Ursin, Vähäsantanen, Festner, & Harteis, 2019; Heinz, Keane, & Foley, 2017; Watt et al., 2012), we believe that the application of a person-environment fit (PE fit) approach with a focus on vocational interests can shed a new light on the career choice of pre-service teachers in general and can give new insights into the STEM teacher shortage in particular. Therefore, the current study uses Holland's (1997) RIASEC model, which focuses the fit with respect to profiles of vocational interests between persons and their work environments and states that vocational choice is driven by trait-like interests that people show and that are also descriptive of work environments (occupations).

Although there is no consensus about inherently favorable personality traits in the teacher literature, the Holland model tries to describe occupations including the teacher profession in terms of the interests that are characteristic of the work environment. Based on this approach, the current study claims that the teacher profession in the STEM fields can best be described by a combination of vocational interests that are hard to reconcile and that this characteristic can be an explanation for the STEM teacher shortage that

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has so far hardly been discussed (Köhler, Schmechtig, & Abele, 2019; Leon, Behrendt, & Nickolaus, 2018). To examine this assumption, the vocational interests of pre-service teachers of different STEM and non-STEM fields are analyzed. In order to reveal teacher-specific interests, vocational interest profiles of pre-service teachers are compared to vocational interest profiles of students who do not intend to become teachers (non-teaching students).

Previous studies that applied the RIASEC model to the teacher profession classified pre-service teachers into broad subject-related groups, such as math/science vs. arts/languages teachers (Kaub, Karbach, Spinath, & Brünken, 2016) or STEM vs. non-STEM teachers (Roloff Henoch, Klusmann, Lüdtke, & Trautwein, 2015). This classification can blur subject-specific interest differences and can lead to wrong conclusions regarding subject-specific teacher recruitment (see Heinz, 2015). Therefore, we are using data of a large-scale study that allows to distinguish STEM and non-STEM fields on a fine-grained level and to consider that not all STEM and non-STEM fields are equal with respect to their gender and interest distribution (Ertl & Hartmann, 2019; Su & Rounds, 2015). Since previous studies indicate strong gender differences with respect to the RIASEC interest dimensions (Morris, 2016; Su & Rounds, 2015; Su, Rounds, & Armstrong, 2009), the current investigation also considers the gender of the pre-service teachers and their non-teaching counterparts and thereby tries to provide a careful analysis of the interest structure of pre-service teachers in different STEM and non-STEM subjects.

2. Holland's model of vocational choice

The current study aims at analyzing the vocational interests of pre-service teachers (and non-teaching students). According to Holland (1997), vocational interests can be described by using six types of interests. These types are called Realistic, Investigative, Artistic, Social, Enterprising, and Conventional, and are commonly known as the RIASEC types or the Big Six interests (Larson, Rottinghaus, & Borgen, 2002).[1] The six RIASEC dimensions are supposed to encompass certain beliefs, values and interests regarding specific working activities. In more detail, the Realistic type prefers to work with tools and machines, the Investigative type likes to solve and think about complex problems, the Artistic type prefers creative and unstructured activities, the Social type is interested in social activities like teaching and helping other people, the Enterprising type strives for convincing and leading other people, and the Conventional type prefers repetitive and systematizing activities. Often, only the three dominant types out of the six RIASEC types are used to describe a person (see e.g. Tsabari, Tziner, & Meir, 2005): if a person resembles the Social type the most, followed by the Artistic type and the Enterprising type, the person is assigned the three-letter code SAE. According to Holland (1997), the RIASEC types are not only useful to describe persons but also and in the same manner, to describe work environments and jobs. For example, an SAE job comprises working activities that are associated with Social, Artistic and Enterprising interests. Holland (1997) assumes that people seek occupations that fit their interests, which in turn should lead to positive outcomes. So, if a SAE person takes an SAE job, the person fits the environment and is supposed to be satisfied and perform well. This person-job fit in the framework of Holland's (1997) theory is called *congruence*. The relationship between congruence and outcome variables such as performance could be confirmed by meta-analytic findings (Nye, Su, Rounds, & Drasgow, 2012, 2017). To measure congruence, the three-letter codes of persons and working environments can be compared, and fit indices can be calculated (Camp & Chartrand, 1992; Brown & Gore, 1994; Hartmann, 2018; Young, Tokar, & Subich, 1998). Despite those older measures ignoring the weaker dimensions of a profile there are more sophisticated methods such as the Euclidean distance index that fully accounts for the entire profile information (Tracey & Sodano, 2013).

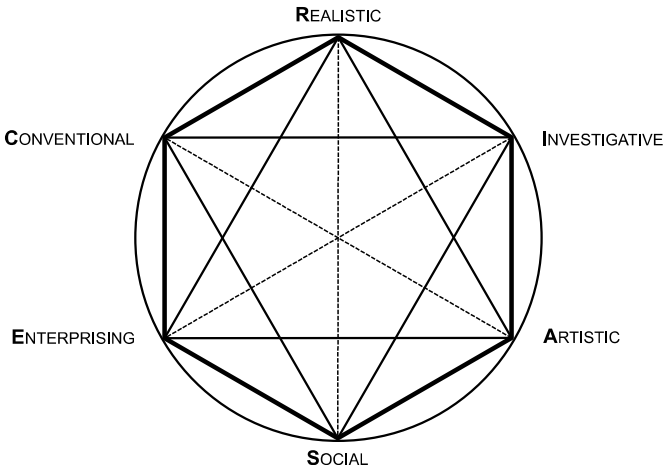

Fig. 1. Hexagonal structure of the Big Six (Hartmann, Heine, & Ertl, 2021, p. 730).

Another construct in the framework of Holland's (1997) theory that is of special relevance for the current investigation is called *consistency*. This construct is based on the assumption that the Big Six can be arranged hexagonally in a two-dimensional space with the distance between the dimensions reflecting their psychological similarity. That means, the Social type is more similar to the Enterprising type than to the Conventional type and dissimilar to the Realistic type (see Fig. 1). Research on this hexagonal assumption, also called the *calculus hypothesis*, has found evidence for both persons and working environments (Nagy, Trautwein, & Lüdtke, 2010; Tracey & Rounds, 1992, 1993).[2] Consistency is now the application of this hexagonal model to an individual profile and the extent to which the individual profile fits the postulated structure. This means that persons who show interests that are close together in the hexagon can be described as consistent and persons who show interests that are opposed in the hexagon are inconsistent. For example, if the dominant interest dimensions of a person are Social and Artistic, the person can be described as rather consistent, since these dimensions are adjacent in the hexagonal model and thus are similar, whereas a person would be described as inconsistent if the dominant interest dimensions would be Social and Realistic as they are opposite in the model and therefore dissimilar. In accordance with the calculus hypothesis, it is assumed that inconsistent interest profiles are less likely to occur than consistent profiles (Köhler et al., 2019; Leon et al., 2018). Since consistent persons are supposed to have a clearer vocational identity and do not have to handle contradictory interests, it is also postulated that consistency is positively related to favorable outcomes such as congruence, persistence and achievement (Eder & Bergmann, 2015;

[1] In the following, we use the terms 'Big Six interests' and 'vocational interests' synonymously.

[2] The structural validity of the RIASEC model can for example be tested using the randomization test of hypothesized order relations (Hubert & Arabie, 1987), which is based on a comparison of the intercorrelations of the six RIASEC dimensions in a sample. For example, according to the hexagonal structure, the correlation between R and I should be greater than the correlation between R and A and so on (see Fig. 1).

Holland, 1985; Tracey, Wille, Durr II, & De Fruyt, 2014) .[3]

3. The Big Six interests and the teacher profession

Holland's (1997) concepts of vocational interests, interest consistency and interest congruence have rarely been applied in research on the teacher career choice. In this context, two main topics have been focused so far, which are explained in more detail in the following sections. First, it has been analyzed which *environmental* interest profiles can most appropriately describe teacher education and the teacher profession. Here, different methods have been used and different aspects of the teacher profession have been focused (e.g. teaching domain). Second, it has been investigated which *individual* interests can actually be observed in samples of pre-service teachers and teachers, and how far their personal profiles fit to the environmental profiles of teaching.

3.1. Describing the teacher work environment using the RIASEC dimensions

The teaching profession is complex regarding its requirements and there can be hardly any consensus as to which personality traits of (pre-service) teachers are favorable per se. However, the PE fit model of Holland (1997) tries to provide an approximation of what RIASEC dimensions describe the teacher profession most accurately. Although, these descriptions are a simplification of the requirements of the teacher profession, they allow the comparison of individual interest profiles and environmental interest profiles and an estimation of person-environment fit (i.e., interest congruence). Previous studies indicate that the interests defined as most characteristic for the teacher-profession are valid since pre-service teachers showing these interests and being congruent are more satisfied with course contents and study conditions and are more confident that they can cope with stress caused by their studies (Kaub et al., 2012).

To estimate which vocational interest profiles most accurately represent a specific work environment such as the teacher profession, different Holland-based methods can be used (Rounds, Smith, Hubert, Lewis, & Rivkin, 1999). The most widespread is the *judgment method*, which has also been used to create the occupational interest profiles of the U.S. Occupational Information Network (O*NET), the most comprehensive occupation-related and up to date database (O*NET, 2020). Here, three trained judges were asked to make judgments on occupational units and to rate the appropriateness of each RIASEC dimension for each occupational unit. Rounds et al. (1999) report a high degree of reliability concerning the expert ratings and also give evidence regarding their external and structural validity (see also Rounds, Armstrong, Liao, Lewis, & Rivkin, 2008; Rounds, Su, Lewis, & Rivkin, 2013).

The RIASEC profiles regarding the teacher profession provided by the O*NET indicate that the Social dimension is the RIASEC dimension that is seen as most descriptive of the teacher profession.[4] This judgment is in line with other lists of occupational RIASEC profiles such as the Dictionary of Holland Occupational Codes (DHOC; Gottfredson & Holland, 1996), the General interest structure test (GIST; Bergmann & Eder, 2018) or the EXPLORIX test system (Joerin Fux, Stoll, Bergmann, Eder, & Hell, 2012).

Besides Social interests, the databases emphasize different aspects of the teacher profession when determining the most appropriate interest dimensions. In dependence of the career stage (teacher education vs. teacher profession), the school type and the teaching domain, they also consider Realistic, Investigative, Artistic, Enterprising and/or Conventional interests to be important. For example, the O*NET defines an SIR profile as being descriptive for chemistry teachers and an SAI profile for foreign language teachers.

Interest profiles of work environments that not only comprise of Social but also Realistic interests cause a dilemma as these two interest dimensions are opposite in the hexagon, indicating that they are contrary and hard to reconcile (see Fig. 1). The Social dimension is mostly seen as the RIASEC dimension that describes the teaching profession most appropriately. Teachers or pre-service teachers in Realistic domains are therefore either congruent but inconsistent (showing strong Social and at the same time strong Realistic interests), or they are consistent but incongruent (showing either weak Social or weak Realistic interests). We call this the *STEM teacher-congruence-dilemma* because, in the teaching context, STEM subjects, such as chemistry, technical education or engineering, are characterized by both relatively high Realistic interests and high Social interests.

According to Holland (1997), people primarily seek congruence; however, inconsistent interest profiles are rarely found in society. Accordingly, teaching domains associated with inconsistent interest profiles (e.g. high Realistic and high Social interests), such as technical or engineering subjects, have problems finding enough candidates, which suggests that the math/science teacher shortage (Kearney, 2016; Sutcher et al., 2016) can be caused by a lack of the respective inconsistent interest profiles in society (Köhler et al., 2019; Leon et al., 2018).

3.2. Individual interest profiles of teachers

In line with the interest profiles that are used to describe the teacher profession, (pre-service) teachers actually show high Social interests. Even if other variables such as gender, socio-economic background and cognitive abilities are controlled for, vocational interests and especially Social interests are an important predictor for the decision to enroll in a teacher education program (Klusmann, Trautwein, Lüdtke, Kunter, & Baumert, 2009; Roloff Henoch et al., 2015). *Pre-service teachers* show higher Social interests than students who do not aspire to become teachers (*non-teaching students*). In addition, pre-service teachers show, albeit less clearly, higher Artistic (van Rooij et al., 2020) as well as lower Realistic and Investigative interests (Klusmann et al., 2009; Leon et al., 2018).

Similar difference patterns can be observed within the teacher education when *arts/language pre-service teachers* are compared to *math/science pre-service teachers*. Arts/language pre-service teachers report higher Artistic as well as lower Realistic and Investigative interests (Abel, 1997; Kaub et al., 2012, 2016; Kaub, Stoll, Biermann, Spinath, & Brünken, 2014; Roloff Henoch et al., 2015).

The results of previous studies indicate that there are strong gender differences regarding the Big Six interests with women more interested in Social activities and men more interested in Realistic activities (Su & Rounds, 2015; Su et al., 2009; Morris, 2016), even within STEM and non-STEM fields (Ertl & Hartmann, 2019; Su & Rounds, 2015). These gender differences also occur with respect to teacher education (and the teacher profession)

[3] In addition to congruence and consistency there are more constructs in the context of Holland's (1997) theory that allow to describe interest profiles in more detail including the constructs of differentiation and elevation. The respective definitions of these constructs and the results regarding these constructs are not central for the current investigation but can be found in the supplements (see supplements 21 to 27).

[4] Regarding the teacher occupation in the O*NET, the Social dimension was rated the most appropriate. This includes elementary school teachers, middle school teachers, secondary school teachers, special education teachers, postsecondary teachers for philosophy and religion, history, education, sociology, political science, geography, biological science, chemistry, engineering, mathematical science etc. (O*NET, 2018).

(Swanson, 2012; Urton, Wilbert, Grosche, & Hennemann, 2016). Of course, this does not mean that women cannot show high Realistic interests or that men cannot show high Social interests. According to the social cognitive career theory (Lent, Brown, & Hackett, 1994), it is assumed that socially constructed processes mediate the effect of gender on interest development. So, even if female pre-service teachers (and arts/language pre-service teachers) show higher Social interests than male pre-service teachers (and math/science pre-service teachers), it is important to note that male (and math/science) pre-service teachers still have high Social interests (Abel, 1997; Swanson, 2012). Since both male and math/science pre-service teachers not only show high Social but also relatively high Realistic interests, their profiles should have a lower *consistency* than the profiles of female and arts/language pre-service teachers. Even though it has hardly been explicitly investigated, there is some empirical evidence supporting this hypothesis (Köhler et al., 2019; Swanson, 2012).

Since teaching is a predominantly Social environment, pre-service teachers with high Social interests have a high *congruence*. Therefore, female and arts/language pre-service teachers are more congruent to the environment of teaching than males and math/science teachers (Kaub et al., 2012; Urton et al., 2016).

In summary, pre-service teachers show high Social interests. In addition, they show vocational interests that are related to the subject they are going to teach. Regarding STEM subjects that can best be described using the Realistic dimension, we expect a STEM teacher-congruence-dilemma since they would require both, high Realistic and high Social interests that are located antagonistic in the hexagon (see Fig. 1), which is associated with unfavorable interest profiles in terms of lower consistency and/or lower congruence. This might be even a bigger problem for male pre-service teachers since they, in general, show higher Realistic interests than female students.

4. The current study

We are using data of a large-scale study that differentiates between study subjects (including teaching domains) on a fine-grained level when examining vocational interests of pre-service teachers and non-teaching students. Based on Holland's (1997) theory and the results of previous studies regarding interests of students within and outside of teacher education, we formulate five research questions and derive several hypotheses. In general, we expect students' vocational interests to be a function of study subject, gender and the teaching/non-teaching variable. The focus of our study is on whether male STEM pre-service teachers have especially unfavorable interest profiles compared to other pre-service teachers. We will differentiate the analyses between study subjects in a fine-grained way but derive our hypotheses from the rough classification of study subjects in STEM (mathematics, physics, chemistry, biology and geography) and non-STEM (German language, social sciences and economics) as it has been done in previous studies (Kaub et al., 2016; Roloff Henoch et al., 2015).[5] Since we aim at revealing teacher-specific findings regarding RIASEC interests, it is necessary to compare students who aspire to work in the teaching profession with students who do not intend to become teachers. Therefore, the first research question relates to differences between pre-service teachers from different teaching domains and non-teaching students with corresponding majors.

[5] In the current study, we use the term “sciences” to refer to the natural sciences and thus assign social sciences and economics to the non-STEM field.

(1) How far do the vocational interests of pre-service teachers distinguish from non-teaching students?

STEM subjects are predominantly characterized by Realistic and Investigative interests. Within teacher education, studies of STEM subjects also get a strong social dimension, since pre-service teachers should not only acquire content knowledge (e.g. about physical laws), but also how to teach this content in school. As a result, STEM pre-service teachers should show high Realistic, Investigative and Social interests. Therefore, and in line with both expert ratings and the results of previous studies (Klusmann et al., 2009; Roloff Henoch et al., 2015), we hypothesize that STEM pre-service teachers have higher Social interests than STEM students who do not aspire to work in the teaching profession (non-teaching students). We assume that this difference occurs for both females and males and correspondingly derive two hypotheses:

(1a) Female STEM **pre-service teachers** have higher Social interests than female STEM **non-teaching students.**
(1b) Male STEM **pre-service teachers** have higher Social interests than male STEM **non-teaching students.**

We cannot consistently expect similar differences between pre-service teachers and non-teaching students within the non-STEM field since there are non-STEM majors that are strongly characterized by Social dimension also outside of teacher education. This is in line with the study by Roloff Henoch et al. (2015) when they could not find any significant differences between pre-service teachers and non-teaching students regarding the examined RIASEC dimensions.

As we are interested in the vocational interest profiles of future teachers in the first place and focus on the question of how far male STEM pre-service teachers show unfavorable interest profiles, we relate the remaining research questions solely to pre-service teachers. The next research question relates to differences between STEM and non-STEM pre-service teachers.

(2) How far do the vocational interests of STEM and non-STEM pre-service teachers distinguish from one another?

Both non-STEM and STEM pre-service teachers are presumed to have high Social interests. Regarding Realistic, Investigative and Artistic interests though, we expect differences similar to the results of previous studies (Abel, 1997; Kaub et al., 2012, 2014, 2016; Roloff Henoch et al., 2015). We expect to observe these differences for both females and males. Therefore, we derive the following hypotheses:

(2a-c) Female STEM pre-service teachers have higher Realistic/higher Investigative/lower Artistic interests than female non-STEM pre-service teachers.

(2d-f) Male STEM pre-service teachers have higher Realistic/higher Investigative/lower Artistic interests than male non-STEM pre-service teachers.

(3) How far do the interest constructs of consistency and congruence of STEM and non-STEM pre-service teachers distinguish from one another?

According to theory and previous research, both non-STEM and STEM pre-service teachers should show high Social interests. In addition, STEM pre-service teachers are expected to show also relatively high Realistic interests which are antagonistic to Social interests according to Holland's (1997) hexagonal RIASEC model (see Fig. 1). Therefore, STEM pre-service teachers should show a low consistency. According to Holland (1997) there are fewer persons in

society with inconsistent interest profiles. This means that there are fewer candidates that fit the STEM teacher profession having both high Realistic and high Social interests. Therefore, we expect that, on average, the congruence of STEM pre-service teachers is lower as compared to non-STEM pre-service teachers. This assumption is supported by previous research (Kaub et al., 2012, 2016).

(3a-b) Female STEM pre-service teachers have a lower consistency/lower congruence than female non-STEM teachers.

(3c-d) Male STEM pre-service teachers have a lower consistency/lower congruence than male non-STEM teachers.

(4) How far do the vocational interests of male and female pre-service teachers differ?

Based on previous research including meta-analytic findings (Ertl & Hartmann, 2019; Su & Rounds, 2015; Su et al., 2009; Morris, 2016), we expect gender differences regarding pre-service teachers' Realistic, Investigative, Social and Artistic interests even within STEM and non-STEM fields.

(4a-d) **Male** non-STEM pre-service teachers have higher Realistic/higher Investigative/lower Artistic/lower Social interests than **female** non-STEM pre-service teachers.

(4e-h) **Male** STEM pre-service teachers have higher Realistic/higher Investigative/lower Artistic/lower Social interests than **female** STEM pre-service teachers.

(5) How far do the interest constructs consistency and congruence of male and female pre-service teachers distinguish from one another?

As already mentioned, male pre-service teachers are supposed to have higher Realistic and lower Social interests even within STEM and non-STEM fields. As a result, males not only fit less into the social work environment of teachers, but also their antagonistic Realistic and Social interests are on a more similar level. That is why we expect male pre-service teachers to be less consistent and less congruent than female pre-service teachers within their subjects. Correspondingly, we derive the following hypotheses.

(5a-b) **Male** non-STEM pre-service teachers have a lower consistency/lower congruence than **female** non-STEM pre-service teachers.

(5c-d) **Male** STEM pre-service teachers have a lower consistency/lower congruence than **female** STEM pre-service teachers.

Taking research questions 3 and 5 together, we expect male STEM pre-service teachers to have unfavorable interest profiles regarding the constructs of consistency and congruence. The data of a large-scale study allows us to see if differences between STEM and non-STEM subjects, as well as between male and female pre-service teachers, are equal for all STEM and non-STEM subjects or if a fine-grained differentiation is necessary as suggested by the results of previous studies outside of the teaching context (Ertl & Hartmann, 2019; Su & Rounds, 2015).

5. Method

The current study analyzes data from the German National Panel Study (NEPS; Blossfeld, Roßbach, & von Maurice, 2011; see also acknowledgements) focusing on the cohort of first year students (SC5:12.0.0). The survey of this cohort started in the winter term 2010/2011 (FDZ-LIfBi, 2018b) and is currently still running. The data for the analyses of this paper comes from wave 1 (interest variables) that was surveyed directly at study entry.

Students were coded as pre-service teachers when they articulated that they were inscribed in a pre-service-teacher course. The resulting sample was 6743 students of the NEPS panel including 2977 pre-service teachers (of different teaching domains) as well as 4766 non-teaching students of the respective majors. They distribute across the teaching domains/majors of biology (701), chemistry (386), economics (1977), geography (332), German language (1285), mathematics (1244), physics (307), and social sciences (511). Further study subjects couldn't be included because they didn't comprise of an appropriate number of students required for statistical analyses. Please see supplement 1 for the specific distribution of students.

The variables analyzed regarding students' interests were students' vocational interests as well as their occupational aspirations which describe the occupations students intend to work in. Students' vocational interests were surveyed with respect to the RIASEC dimensions by the IILS-II scales (Wohlkinger, Ditton, von Maurice, Haugwitz, & Blossfeld, 2011; see also FDZ-LIfBi, 2018a, p.699-704). The IILS-II consists of items of the General interest structure test (Bergmann & Eder, 2005) and the ICA-D (von Maurice, 2006), the German version of the Inventory of Children's Activities - Revised (ICA-R1, Tracey & Ward, 1998). The IILS-II scales comprised of 3 items with a five-point Likert scale for each of the RIASEC dimensions. Although these scales are shorter, the internal consistency is acceptable (Cronbach's α for Realistic: $\alpha = 0.704$; Investigative: $\alpha = 0.625$; Artistic: $\alpha = 0.629$; Social: $\alpha = 0.749$; Enterprising: $\alpha = 0.523$; Conventional: $\alpha = 0.561$).[6]

Students' occupational aspirations were surveyed by a question asking about their aspired profession. These aspirations were classified by the ISCO-08 code. These ISCO classifications were matched with the respective interest codes provided by the O*NET (2018) database using the ISCO-08 to 2010 SOC crosswalk provided by the Bureau of Labor Statistics (2018). Some aspirations were coded quite roughly that no interest pattern could be assigned, but overall, 96.7% of the aspirations provided could be coded (see also Ertl & Hartmann, 2019).

Consistency was calculated according to the model of Tracey, Wille, Durr, and De Fruyt (2014) with an implementation of the syntax of Bergmann (2015). Please see supplement 20 for the exact specifications.

Interest congruency was conceptualized as the length of the congruence vector, which is the Euclidean distance between the interest profile of the student and the interest profile of the aspiration (Eder, 1998; Tracey & Sodano, 2013).

SPSS 25.0 was used for all analyses. The intended method for analysis was one 8x2x2 MANOVA (study subject x gender x study program) for the interest variables. However, as the study subjects naturally have imbalances with respect to subject choice by gender and study program, the cell sizes differ to a certain extent. Furthermore, the large sample size caused that the Levene test of equality of error variances gains significant even for smallest effects for some of the variables analyzed (e.g. $F_{(31,6701)} = 2.21$ for the interest values). These conditions require that the results of the ANOVA should be interpreted with care. Therefore, we will discuss significance of the differences based on the confidence intervals (see Field, Miles, & Field, 2019) and provide the quality indicators of the ANOVAS in the respective supplements (see supplements 2 to 15 for RIASEC dimensions; see supplements 16 to 20 for consistency and congruence).

[6] The hexagonal structure of the dimensions was verified by testing the hypothesized order relations against randomization (see Hubert & Arabie, 1987) with the RANDALL program (see Tracey, 1997; CI = 0.81; p = .017; see also; Ertl & Hartmann, 2019).

6. Results

In the following, we will present the results regarding the vocational interest profiles of non-teaching students and pre-service teachers. For pre-service teachers, we will also focus on consistency and congruence.

6.1. Differences between STEM pre-service teachers and STEM non-teaching students regarding social interests (RQ1)

Hypotheses 1a and 1b refer to the differences between pre-service teachers and non-teaching students regarding Social interests in the STEM fields. In all STEM subjects investigated (mathematics, physics, chemistry, biology and geography), we could clearly observe higher values in the Social dimension for female and male pre-service teachers in comparison to female and male non-teaching students. Therefore, hypotheses 1a and 1b can be accepted.

In the frame of research question 1, we also analyzed differences regarding the remaining RIASEC dimensions. Here, the most concise result was that pre-service teachers not only showed higher Social interests but also higher Enterprising interests as compared to non-teaching students (see Figs. 2–7; see supplement 14 for a more detailed description; see supplements 28 to 35 for complete RIASEC profiles for each subject).

6.2. Differences between STEM and non-STEM pre-service teachers regarding Realistic, Investigative and Artistic interests (RQ2)

Based on previous studies, one can expect that pre-service teachers in STEM fields have higher Realistic, higher Investigative and lower Artistic interests as compared to pre-service teachers in non-STEM fields. In contrast to previous studies, STEM fields and non-STEM fields were differentiated on a fine-grained level in the current study when these hypotheses were tested. This is to say that pre-service teachers in five STEM fields (mathematics, physics, chemistry, biology, geography) were compared to pre-service teachers in three non-STEM fields (German language, social sciences, economics).

Overall, the hypotheses concerning the interest differences between STEM and non-STEM pre-service teachers (hypotheses 2a-f) can partially be confirmed since pre-service teachers in STEM fields tended to have higher Realistic, higher Investigative and lower Artistic interests than non-STEM pre-service teachers. This was particularly evident in male and female pre-service teachers in the STEM fields mathematics, chemistry and biology when compared to pre-service teachers in the non-STEM field German language since they all showed higher Realistic, higher Investigative and lower Artistic interests. In addition, male and female pre-service teachers in chemistry and biology also showed higher Investigate interests as compared to their counterparts in the non-STEM fields social sciences and economics.

However, there were also deviations from such clear and as expected patterns. For example, pre-service teachers in the STEM field geography did not differ from pre-service teachers in the non-STEM fields with respect to Investigative interests (please see supplement 15 for a more detailed description of the results).

6.3. Differences between STEM and non-STEM pre-service teachers regarding congruence and consistzency (RQ3)

Hypotheses 3a-d can mainly be confirmed, meaning that pre-service teachers in STEM fields showed less favorable interest profiles in the sense of a lower consistency and a lower congruence (see Figs. 8 and 9). This applies for male and female pre-service teachers in all STEM fields as compared to male and female pre-service teachers in the non-STEM field German language. Moreover, female pre-service teachers in the STEM field chemistry and male pre-service teachers in the STEM field biology showed a lower consistency and a lower congruence than their counterparts in the non-STEM fields social sciences and economics (please see supplement 20 for a more detailed description of the results).

6.4. Differences between male and female pre-service teachers regarding Realistic, Investigative, Artistic and Social interests (RQ4)

Gender differences were as expected but not significant for every STEM and non-STEM field. Therefore, the hypotheses 4a-h

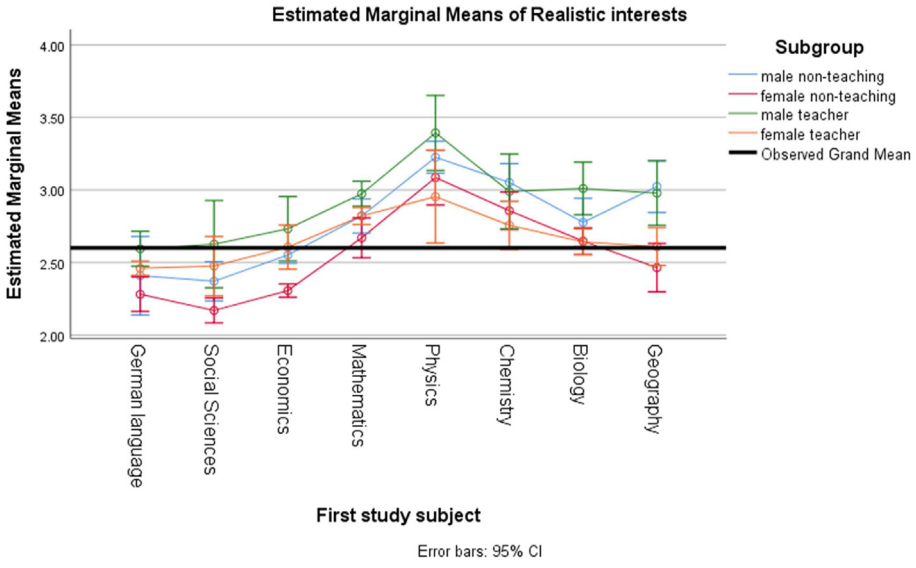

Fig. 2. Means and 95% confidence intervals for the students' Realistic interests, for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students in the different subjects (min = 1; max = 5). Tables with the respective values could be found in the supplements 2 and 3. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

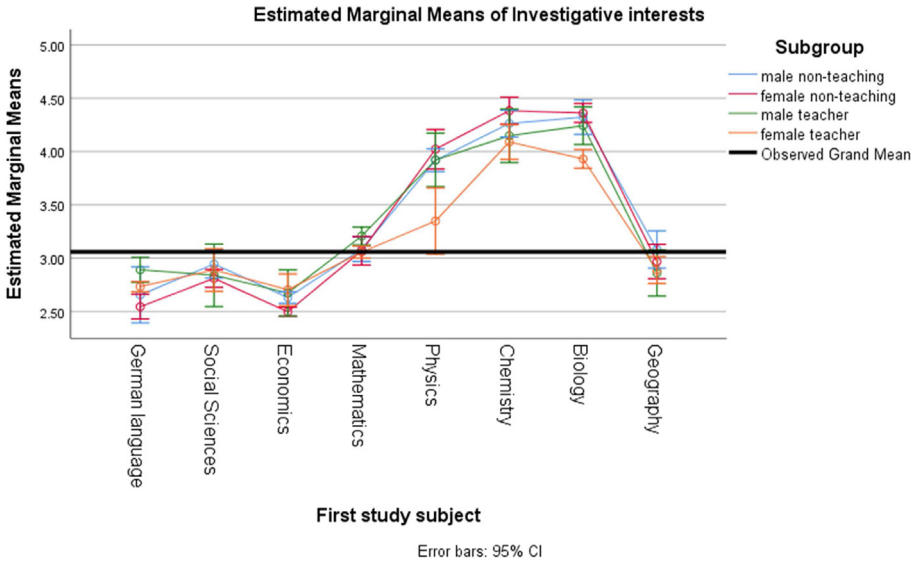

Fig. 3. Means and 95% confidence intervals for the students' Investigative interests, for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students in the different subjects (min = 1; max = 5). Tables with the respective values could be found in the supplements 4 and 5. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

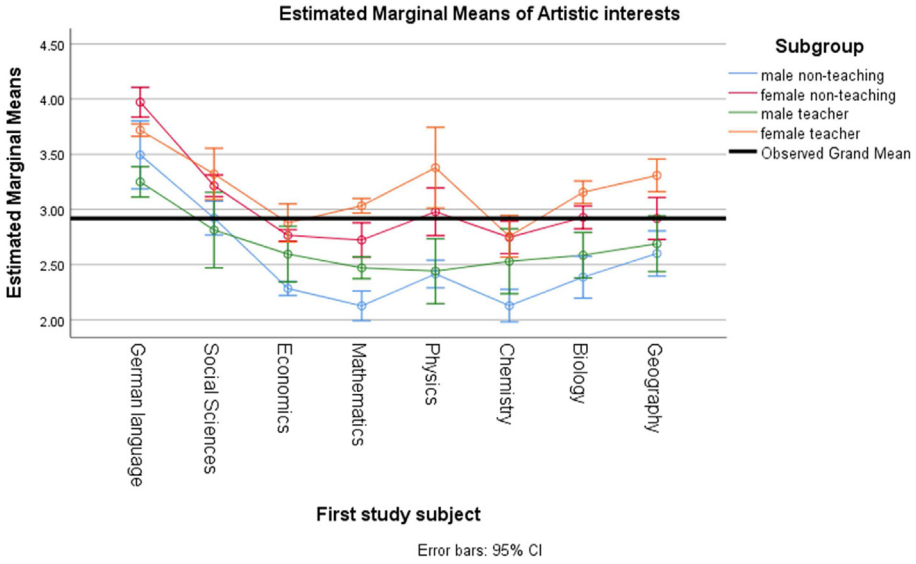

Fig. 4. Means and 95% confidence intervals for the students' Artistic interests, for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students in the different subjects (min = 1; max = 5). Tables with the respective values could be found in the supplements 6 and 7. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

can only partially be confirmed. Amongst non-STEM fields, the only gender differences were between pre-service teachers in German language with males showing, as expected, lower Artistic and Social interests than females. Regarding pre-service teachers in the STEM fields mathematics and biology, all expected gender differences concerning Realistic, Investigative, Artistic and Social interests were confirmed. Male and female pre-service teachers in physics differed as expected regarding Investigative and Artistic interests while male and female pre-service teachers in geography showed the assumed gender differences with respect to Realistic and Artistic interests. For chemistry, there were no gender differences at all.

6.5. Differences between male and female pre-service teachers regarding congruence and consistency (RQ5)

Hypotheses 5a-d can mainly be confirmed since male pre-service teachers tended to show a lower consistency and a lower congruence as compared to female pre-service teachers within the same field. Regarding non-STEM fields, the interests of male pre-service teachers in German language and social sciences were less consistent than the interests of female pre-service teachers. In addition, male pre-service teachers in German language also showed a lower congruence. With respect to STEM fields, a lower consistency and a lower congruence for males can be reported for pre-service teachers in mathematics, physics and biology.

Overall, the results indicate that pre-service teachers across

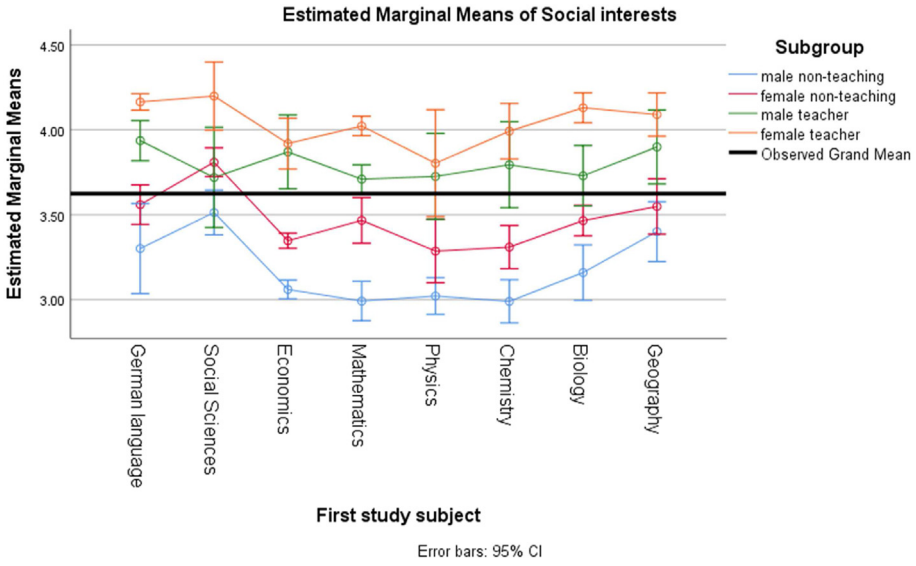

Fig. 5. Means and 95% confidence intervals for the students' Social interests, for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students in the different subjects (min = 1; max = 5). Tables with the respective values could be found in the supplements 8 and 9. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

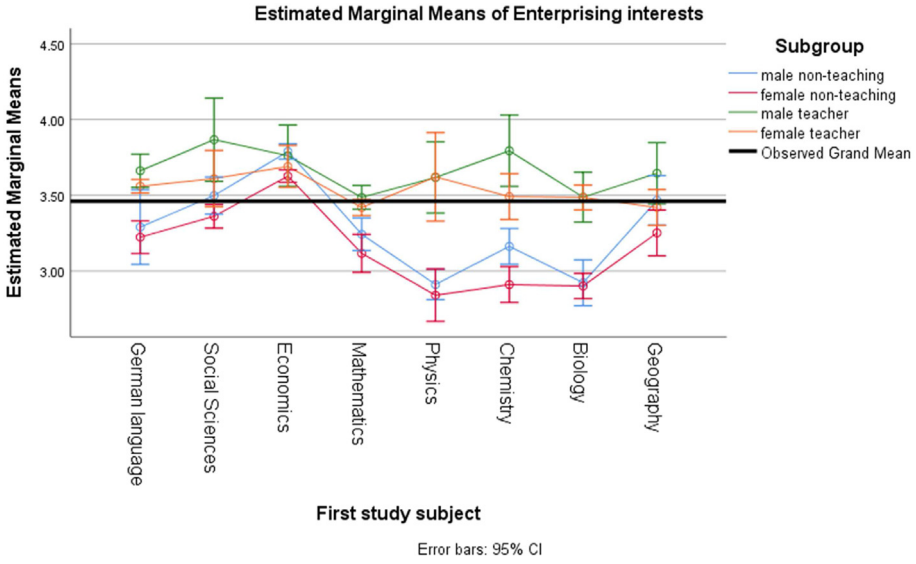

Fig. 6. Means and 95% confidence intervals for the students' Enterprising interests, for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students in the different subjects (min = 1; max = 5). Tables with the respective values could be found in the supplements 10 and 11. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

different teaching domains show high Social and high Enterprising interests as compared to non-teaching students with corresponding majors. The current study also indicates that male pre-service teachers in STEM fields additionally tend to show high Realistic and Investigative interests. This combination of antagonistic interests (R, I vs. S, E) corresponds to the results indicating that male pre-service teachers in STEM fields show low consistency and low congruence.

7. Discussion and conclusions

In this section we will first discuss the results regarding the five research questions. Then, we will discuss the question in how far male STEM pre-service teachers show unfavorable interest profiles. We will also draw conclusions on how pre-service teachers could be supported in dealing with a work environment that is characterized by inconsistent RIASEC profiles. Finally, we will discuss the limits of the current study regarding the measurement of congruence and make suggestions for future investigations, in particular by relating to the FIT-choice model.

The results regarding research question 1 are clear. In line with previous studies (Klusmann et al., 2009; Roloff Henoch et al., 2015), pre-service teachers in STEM showed higher Social interests than non-teaching students with a corresponding subject. Pre-service teachers in non-STEM fields also presented higher Social interests than non-teaching students. These results correspond to expert ratings emphasizing Social interests as being characteristic for teacher education and the teacher profession (Bergmann & Eder,

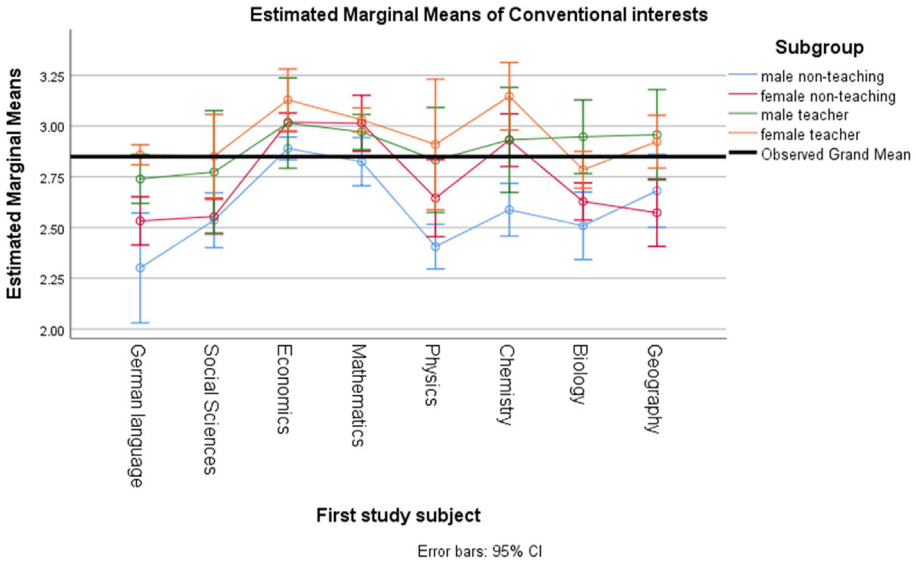

Fig. 7. Means and 95% confidence intervals for the students' Conventional interests, for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students in the different subjects (min = 1; max = 5). Tables with the respective values could be found in the supplements 12 and 13. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

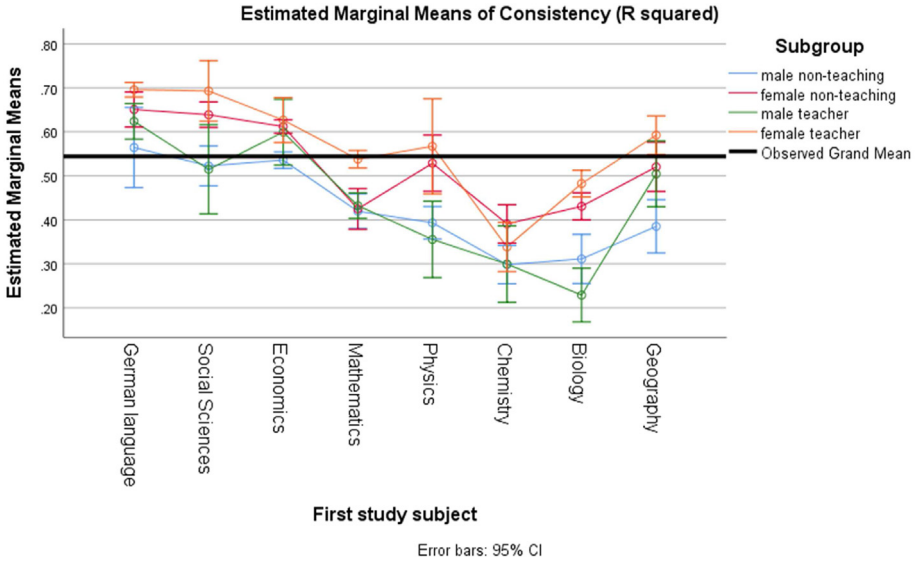

Fig. 8. Means and 95% confidence intervals of students' interest consistency (R^2) for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students. Tables with the respective values could be found in the supplements 16 and 17. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

2018; Gottfredson & Holland, 1996; Joerin Fux et al., 2012; O*NET, 2018). Additionally, Enterprising interests were related to teacher education with pre-service teachers mostly showing higher scores than non-teaching students. According to Holland (1997), people with Enterprising interests strive for leadership and control. One explanation for the high interest scores regarding the Enterprising dimension could be that pre-service teachers choose the teacher profession based on their interests and believe the teacher profession to be associated with leading and controlling other people. This corresponds to studies showing that interests are important predictors for enrolling in teacher education (Klusmann et al., 2009; Roloff Henoch et al., 2015) and that teachers tend to see classroom management comprising control (Kunter et al., 2013; Woolfolk Hoy & Weinstein, 2006). In previous investigations, Enterprising interests played a minor role. For example, Roloff Henoch et al. (2015) analyzed differences between pre-service teachers and non-teaching students only regarding the dimensions Realistic, Investigative, Artistic and Social, but they found differences regarding extraversion with pre-service teachers showing higher scores. According to the meta-analysis by Larson et al. (2002), the Big Five are related to the Big Six, and in particular, higher extraversion is associated with higher Enterprising interests. In the current study, all RIASEC dimensions were analyzed, which presented that the Realistic and the Investigative dimension mostly revealed differences between STEM and non-STEM students while the Artistic dimension mostly revealed gender differences some of which with a medium-sized effect. Overall, the differences between pre-service teachers and non-

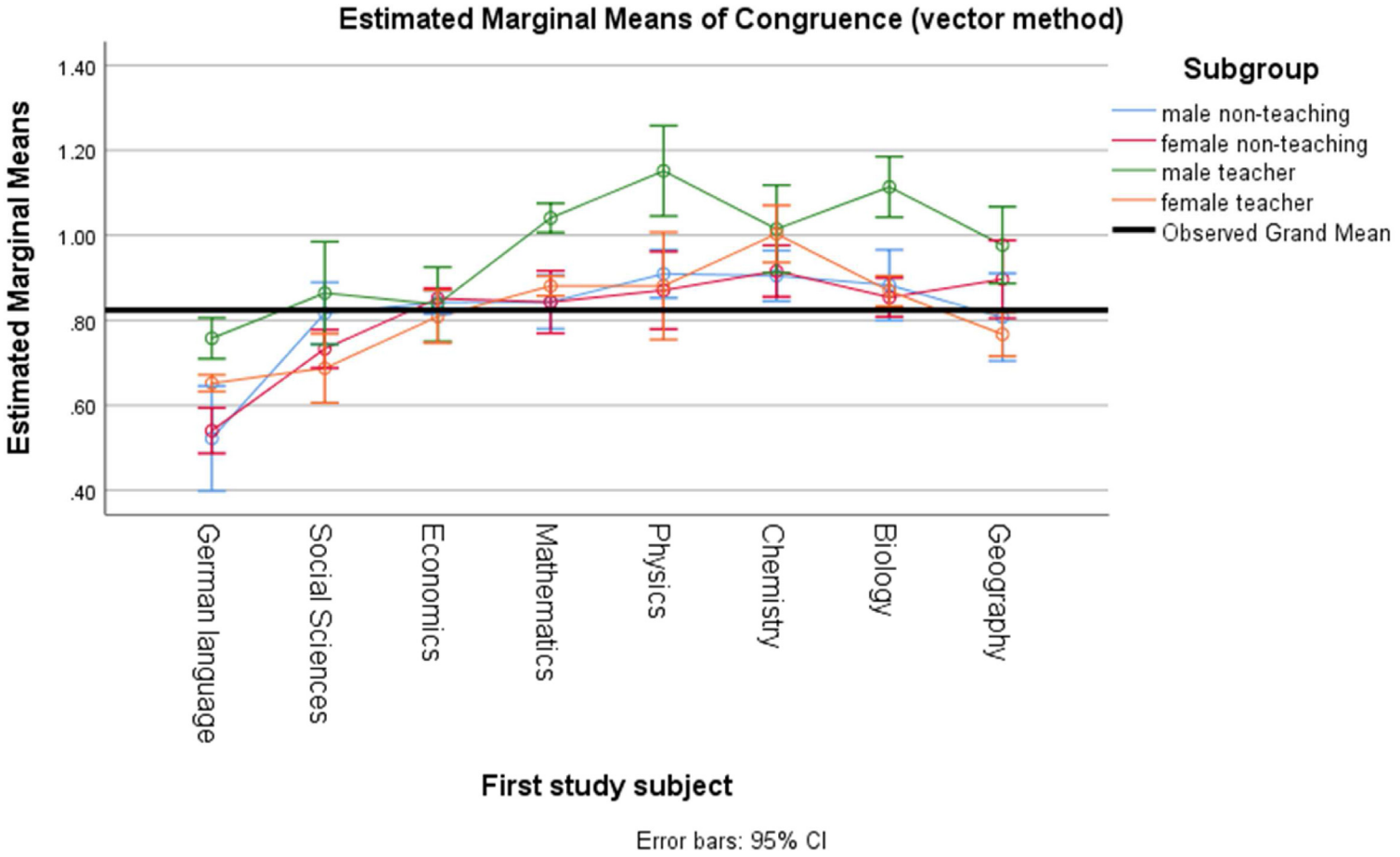

Fig. 9. Means and 95% confidence intervals of students' congruence between their interests and vocational aspirations for male non-teaching (blue), female non-teaching (red), male teaching (green) and female teaching (light brown) students based on an analysis with interest vectors (lower means indicate higher congruence). Tables with the respective values could be found in the supplements 18 and 19. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

teaching students regarding the RIASEC dimensions indicate that pre-service teachers choose their career path based on their high Social and high Enterprising interests.

7.1. The need to differentiate within STEM and within non-STEM

The results regarding research questions 2 to 5 revealed clear tendencies regarding the interest differences between STEM and non-STEM pre-service teachers and regarding gender differences within STEM and non-STEM fields. But the hypotheses based on the results of previous studies could only partially be confirmed when STEM and non-STEM fields were differentiated on a fine-grained level. This indicates that, to a certain extent, a rough distinction between STEM and non-STEM fields may be useful, but that there is also a variance within STEM and non-STEM fields that, if ignored, can lead to misleading results and wrong conclusions.

Regarding research question 2 and interest differences between STEM and non-STEM pre-service teachers, four subjects were particularly noticeable. Pre-service teachers in German language almost always presented lower Realistic, lower Investigative and higher Artistic interests as compared to pre-service teachers in all STEM fields. Therefore, German language could be described as a prototype for the non-STEM field within teacher education. Results concerning pre-service teachers in geography rarely confirmed the hypotheses. Especially regarding the Investigative dimension, geography can hardly be seen as a typical STEM subject. In contrast, pre-service teachers' particularly high Investigative interests characterized the STEM fields of chemistry and biology.

Results regarding research question 4 and differences between male and female pre-service teachers within STEM and non-STEM fields were very similar to meta-analytic findings (Su & Rounds, 2015; Su et al., 2009; Morris, 2016), specifically that women presented higher Artistic and Social interests while men presented higher Realistic and Investigative interests. As with previous studies (Ertl & Hartmann, 2019; Su & Rounds, 2015), gender differences could be observed within STEM and non-STEM fields. Some subjects just like mathematics and biology showed the expected gender differences with respect to all interest dimensions. In contrast, there were no gender differences for chemistry, social sciences and economics. This again indicates that not all STEM and non-STEM fields can be described equally, but instead a fine-grained distinction on the level of subject fields and gender is necessary (Ertl & Hartmann, 2019; Su & Rounds, 2015). If male and female pre-service teachers differ in their interests within the same subject, it is likely that they also differ in congruence and consistency. In the current study, such gender differences were analyzed regarding consistency and congruence (research question 5). These variables are related to relevant outcomes like performance (Nye et al., 2012, 2017), which is to say that either women or men in certain subjects have unfavorable interest profiles in terms of consistency and congruence and in turn, possibly perform worse. This gender difference can be expected in the fields of German language, mathematics, physics and biology where male pre-service teachers show a lower interest consistency and a lower congruence as compared to their female pre-service teacher counterparts. In contrast, men and women within economics and chemistry appear to show no differences regarding their congruence and consistency at all, which suggests less of a gender-specific performance gap for students who already are in these fields.

7.2. The STEM teacher-congruence-dilemma

Based on theory, previous studies and our results, it is reasonable to assume that Social and Enterprising interests are associated to teacher education. Both types of interests emphasize social interaction (Holland, 1997) and can be seen as prerequisites for teaching and (at least from the perspective of teachers) classroom management (Kunter et al., 2013; Woolfolk Hoy and Weinstein, 2006). The other RIASEC dimensions are more dependent on the subjects the pre-service teachers are going to teach. For non-STEM subjects, the subject-specific interests are identical or at least similar to Social and Enterprising interests. As a consequence, pre-service teachers in these subjects tend to show a high consistency (since other RIASEC dimension such as Realistic and Investigative are relatively low) and a high congruence (since the teaching work environment is predominantly characterized by the Social dimension). In contrast, pre-service teachers in STEM subjects not only had high Social and Enterprising interest scores but also high scores regarding the antagonistic dimensions Realistic and Investigative (see Fig. 1). Thus, pre-service teachers tended to have a lower consistency and a lower congruence than pre-service teachers in non-STEM fields, which was especially true for chemistry and biology (research question 3). In addition, male pre-service teachers tended to have lower values regarding congruence and consistency (research question 5). Similar differences were observed in previous studies (Kaub et al., 2012, 2016; Köhler et al., 2019; Leon et al., 2018; Swanson, 2012; Urton et al., 2016). Therefore, male pre-service teachers in STEM fields indeed seem to show unfavorable interest profiles. But, since male pre-service teachers in STEM subjects also show high Social and Enterprising interests, the low values regarding congruence and consistency are less a result of the 'wrong' people enrolling for teacher education but are based more on the interest profiles of STEM subjects in the frame of teacher education. In the light of our results, it does not appear to be useful to promote a higher interest consistency amongst pre-service teachers in STEM. The reason for this is what we call the *STEM teacher-congruence-dilemma*: if teachers in STEM subjects ought to be congruent to their work environment, then they have to show not only high Social and Enterprising interests but also high Realistic and Investigative interests, which in turn leads to a low consistency.[7] Since males tend to show higher Realistic and Investigative interests than women, even within STEM fields, this dilemma is especially relevant for men. Nevertheless, we can make conclusions regarding the support of (male) teachers in STEM fields. Showing antagonistic interests may cause inner conflicts about how to reconcile different preferences. It can also lead to doubts about the career chosen, since a lot of different occupations either demanding high Social and Enterprising interests or high Realistic and Investigative interests may seem to be a good alternative. Provided that STEM teachers show antagonistic interests, support supplies should focus on the reflection about the career path chosen and about ways how to deal with contradicting preferences that are actually characteristic for the STEM teacher profession. The results of our study can also be used to recruit students who have not yet considered becoming a teacher (van Rooij et al., 2020). The RIASEC interests were found to be even more stable than the Big Five (Low, Yoon, Roberts, & Rounds, 2005). Therefore, it may be quite difficult to change the interests through teacher education programs, which is why it should be ensured that the recruited students do not only show the interests typical of STEM. Of special interest, regarding the identification of potential future teachers, would therefore be those students in STEM who not only

[7] This combination of interests also causes a high interest profile elevation, and in turn, a low differentiation (Bullock & Reardon, 2008; Chi, Leuty, Bullock-Yowell, & Dahlen, 2019; Hirschi & Läge, 2007; Jaensch, Hirschi, & Spurk, 2016; Tracey et al., 2014). According to Holland (1997) and previous research, a low differentiation is also connected to a low career choice readiness and doubts about choosing a specific career path (Hirschi & Läge, 2007).

show high Realistic and/or high Investigate interests but also high Social and Enterprising interests.

As one of the limits of the current study, the lower values of pre-service teachers in STEM regarding congruence may also be a methodological issue and to some part may depend on the low subject-specificity of the interest profiles within the O*NET (2018). Therefore, future studies could generate subject-specific interest profiles for teacher education and the teacher profession. As the results of the current study show, one should thereby differentiate within STEM and non-STEM fields on a fine-grained level (see also supplements 36 to 39). Future studies could also analyze other STEM and non-STEM fields as well as other types of schools so that potential support supplies are well thought and customized. In addition, the current study used a binary categorization of gender, which does not consider people who do not identify with either of the two categories and which may also blur the diversity within each gender category. Future studies should therefore not only consider a different operationalization of gender, but also disclose, for example, different masculinities within the teacher population (Heinz, Keane, & Davison, 2021).

As mentioned in the introduction, previous research on the career choice of teachers mainly used the FIT-choice model and the question of how this approach relates to Holland's RIASEC model arises. The two models seem to be useful regarding different samples or different stages of career choice. While the FIT-choice model aims at people who already are in the teacher profession or at least know that they aspire it (see also Pohlmann & Möller, 2010), the Holland model is not restricted to a specific occupation and in practice, can be especially helpful for people who do not know yet which career could be a good choice. However, future studies can investigate how the career choice motives of the FIT-choice model are related to Holland's model, in particular to congruence and consistency. For example, it could be assumed that especially those people show a lack of congruence who have chosen teaching as a 'fallback career'. In addition, it could be examined how the RIASEC interests are related to the "core motivations" of pre-service teachers that were indicated by previous research using the FIT-choice scale (Heinz et al., 2017; Watt et al., 2012). We believe that such research could further deepen the dialogue between the teacher education literature and the literature on occupational choice as it was intended initially by the implementation of the FIT-choice model (Watt & Richardson, 2012).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tate.2021.103622.

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