

# Pre-Service Primary School Teachers' Interdisciplinary Competence and their Interest, Self-Concept, and Sense of Belonging Regarding Natural and Social Sciences: Findings from a Longitudinal Study in Germany

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## Abstract

In German primary schools, natural sciences and social studies are learned and taught in an integrative manner within a subject called Sachunterricht. To teach Sachunterricht in a high-quality manner, it is reasonable to assume that primary school teachers themselves require—among other things, such as knowledge about pedagogy, teaching Sachunterricht, and the various content areas of Sachunterricht—a distinct interest, academic self-concept, and sense of belonging regarding natural and social sciences. Furthermore, they should possess a solid interdisciplinary competence that enables them to teach natural and social sciences in an integrative way. In the present study, we conducted a longitudinal survey of pre-service primary school teachers from a German university over a period of 2 years to investigate the changes in their (self-evaluated) interdisciplinary competence; the changes in their interest, academic self-concept, and sense of belonging regarding natural and social sciences; and the correlations between these constructs. Our data analysis revealed a decrease over time in participants' sense of belonging to natural and social sciences, as well as their (self-evaluated) interdisciplinary competence, while their academic self-concept in natural and social sciences remained stable. Participants' interest in social sciences decreased, while their interest in natural sciences increased. Moreover, we found varying degrees of correlation between these constructs. In summary, the results of the present study provide important insights into the professional development of pre-service primary school teachers within university-based teacher education for teaching natural and social sciences in primary school. The implications of these findings are discussed in detail at the end of this paper.

## Keywords:

Sachunterricht, Pre-Service Teacher Education, Natural Sciences, Social Sciences, Interest, Self-Concept, Sense of Belonging, Interdisciplinary Competence, Longitudinal Study



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## Introduction

In Germany, children's formal education typically begins at the age of six, when they start primary school. In total, primary school in Germany comprises four to six school years, and it is the only school type in Germany in which nearly all children of the same age cohort learn together. In addition to German and mathematics, the core curriculum of primary school in Germany explicitly includes the subject Sachunterricht (Kultusministerkonferenz, 2015). The aim of Sachunterricht<sup>a</sup> is to enable children to acquire elementary knowledge about physical and social aspects of the world, develop competencies for navigating and participating in their everyday lives, and obtain the prerequisites for later learning in natural and social sciences (Köhnlein, 2015). Therefore, Sachunterricht is a multidisciplinary subject in which natural and social sciences are learned and taught in an integrated manner<sup>b</sup> (Kahlert, 2014; Tänzer, 2014; Thiel, 2003).

Due to its core curriculum status, teaching Sachunterricht is one of the key responsibilities of primary school teachers in Germany. In order to teach Sachunterricht in a high-quality manner, primary school teachers require pedagogical professionalization, as well as professionalization in teaching Sachunterricht (Gesellschaft für Didaktik des Sachunterrichts, 2003; 2019). Most importantly, however, primary school teachers also require professionalization in the content areas of Sachunterricht, namely in natural sciences, such as biology, chemistry, and physics, as well as in social sciences, such as economics, political science, history, geography, and sociology (Gesellschaft für Didaktik des Sachunterrichts, 2003; 2019). This professionalization in the content areas of Sachunterricht involves not only the acquisition of knowledge and skills but also affective-motivational orientations related to natural and social sciences (Blömeke et al., 2015; Kleickmann, 2015; Lange, 2015).

In particular, these affective-motivational orientations include the constructs of interest, academic self-concept, and sense of belonging. On one hand, within educational research, interest is usually conceptualized as the "specific and distinguished relationship between a person and [...] concrete things, a topic, a subject-matter or an abstract idea" (Krapp & Prenzel, 2011, p. 31). On the other hand, academic self-concept refers to the cognitive representations of one's own abilities in academic performance situations (Gabriel-Busse et al., 2018; Dickhäuser et al., 2002; Shavelson et al., 1976), and sense of belonging to an academic domain is defined as individuals' feeling or sensation of connectedness and social affiliation with and within an academic domain (Feser, 2021; Pendergast et al., 2020). The domain-specific manifestations of these three constructs (i.e., teachers' interest, academic

self-concept, and sense of belonging regarding natural sciences and, analogously, teachers' interest, academic self-concept, and sense of belonging regarding social sciences) are considered key features of teachers' domain-specific professional identity. Therefore, they are essential for teachers attempting to acquire knowledge in natural and social sciences themselves and provide high-quality teaching in natural and social sciences to their students (for details see Feser & Haak, 2022).

In addition to the above, to teach natural and social sciences within Sachunterricht in an integrative manner, primary school teachers themselves must be able to link their knowledge of multidisciplinary issues within the various content areas of Sachunterricht (e.g., issues related to sustainability, the digital world, or climate change; Künzli David et al., 2016; Lenoir & Hasni, 2016; Wilhelm & Brühwiler, 2016). Consequently, it is reasonable to claim that primary school teachers also require interdisciplinary competence (Hasni et al., 2015; Pharo, et al., 2012), meaning the knowledge and skills required to address multidisciplinary issues in an interdisciplinary way, as well as the motivational and volitional readiness to do so (Petrie, 1992; Engelhardt, 2019).

In light of the above, it is not surprising that Sachunterricht is considered one of the most difficult subjects to teach (if not the most difficult one) for primary school teachers in Germany (Klafki, 1992). There is a consensus among teacher educators that university-based teacher education should enable pre-service primary school teachers to acquire the proper professionalization for teaching Sachunterricht, which empowers them to cope with the various requirements mentioned above in their future careers (Gesellschaft für Didaktik des Sachunterrichts, 2003; 2019; Marquardt-Mau et al., 1996). The extent to which university-based teacher education succeeds in this endeavour is one of the major issues addressed within research on teaching Sachunterricht.

On one hand, the development of pre-service primary school teachers' knowledge about pedagogy, teaching Sachunterricht, and the various content areas of Sachunterricht has already been thoroughly investigated by previous research (e.g., Appleton, 2003; Hartmann, 2018; Kirsch, 2022; Lange et al., 2012; Meschede et al., 2017; Niermann, 2017; Schmidt, 2015; Sothayapetch et al., 2013). The results of existing studies confirm that pre-service primary school teachers' knowledge and skills within these fields can be improved by university-based teacher education (Kleickmann, 2015; Meschede et al., 2020). Furthermore, in line with international research, it was shown that pre-service primary school teachers' content knowledge in natural and social sciences is tendentially lower as compared to that of pre-service

secondary school teachers (for a literature review, see Niermann, 2017).

On the other hand, studies (conducted in Germany) that address pre-service primary teachers' interest, academic self-concept, and sense of belonging regarding natural and/or social sciences are scarce (e.g., Beudels et al., 2021; Feser & Plotz, 2023; Lenzgeiger, 2022; Reichhardt, 2018; Wang & Sneed, 2019). Studies focusing on natural sciences have found that these affective-motivational orientations, although distinguishable, tend to be substantially correlated with one another (Feser & Plotz, 2023; Wang & Sneed, 2019). An analogous finding looms for social sciences. For example, the study of Reichhardt (2018) showed that primary school teachers' interest and academic self-concept regarding political sciences are strongly correlated. Additionally, a pattern in research seems to be emerging indicating that pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding natural and/or social sciences are relatively stable constructs that only change—if at all—over extended time periods within university-based teacher education (Beudels et al., 2021; Lenzgeiger, 2022).

Beyond that, thus far, the role of pre-service primary school teachers' interdisciplinary competence in teaching Sachunterricht has been addressed within educational research primarily from a theoretical perspective (e.g., Kalcsics, 2021; Künzli David et al., 2016; Wilhelm & Brühwiler, 2016). Although there is a growing body of research that empirically investigates university students' interdisciplinary competence, especially within higher education (e.g., Braßler & Dettmers, 2017; Engelhard 2019; Mansilla & Duraising, 2007) and engineering education (e.g., Richter & Paretti, 2009; Tormey & Laperrouza, 2023), to the best of our knowledge, such research has not yet been conducted with respect to the interdisciplinary competence of pre-service primary school teachers. In particular, there is a lack of empirical research, in Germany and internationally, about whether pre-service primary school teachers' interdisciplinary competence changes over their university-based teacher education and to what extent interdisciplinary competence is correlated with the domain-specific orientations of pre-service primary school teachers (e.g., their interest, academic self-concept, and sense of belonging regarding natural and/or social sciences).

#### ***Aim of the present study***

With the present study, we aim to add to previous research and address the research gaps detailed above. More precisely, we conducted a longitudinal study at a German university in which we surveyed pre-service primary school teachers over a period of 2 years during their undergraduate studies in

natural and social sciences (for details, see below). This longitudinal study was guided by the following research questions:

- (RQ1a) Do pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding natural sciences change during their undergraduate studies in natural sciences, and if so, to what extent?
- (RQ1b) Do pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding social sciences change during their undergraduate studies in social sciences, and if so, to what extent?
- (RQ2) Does pre-service primary school teachers' (self-evaluated) interdisciplinary competence change during their undergraduate studies in natural and social sciences, and if so, to what extent?
- (RQ3) To what extent do pre-service primary school teachers' (self-evaluated) interdisciplinary competence and their interest, self-concept, and sense of belonging regarding natural and social sciences correlate with one another during their undergraduate studies?

Regarding research question RQ1, within the present study we expect at most moderate changes in pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding natural and/or social sciences, because previous research indicates that these constructs change only over extended time periods within university-based teacher education, if they change at all (see Introduction). Similarly, based on previous research findings, we expect substantial correlations between primary teachers' interest, academic self-concept, and sense of belonging regarding the natural and/or social sciences (research question RQ3). Conversely, due to the lack of previous research, it was not possible for us to draw up elaborate expectations regarding the change of pre-service primary school teachers' interdisciplinary competence and its correlative relationships with other constructs within the present study (research questions RQ2 and RQ3).

Below, we describe the context and design of our longitudinal study. Subsequently, we report and discuss the results of our data analysis regarding research questions RQ1 to RQ3.

#### **Method**

##### ***Context of the study***

The present study was conducted within the university-based teacher education program "Sachunterricht"

at the Universität Hamburg, Germany (Universität Hamburg, 2022). Pre-service teachers studying the “Primary Education” or “Primary Education for students with special education needs” degree programs at the Universität Hamburg can take this teacher education program as an elective. One major goal of this teacher education program is to provide pre-service primary school teachers a solid knowledge base within the content areas of Sachunterricht. Accordingly, the curriculum of this program comprises courses on both the natural and social sciences (see Figure 1). In their first two semesters, the pre-service primary school teachers study social sciences within various courses on economics, political sciences, sociology, history, and geography. Subsequently, they attend a two-semester course in which biology, chemistry and physics are taught in an integrative manner, together with an accompanying natural sciences laboratory class.

**Data collection**

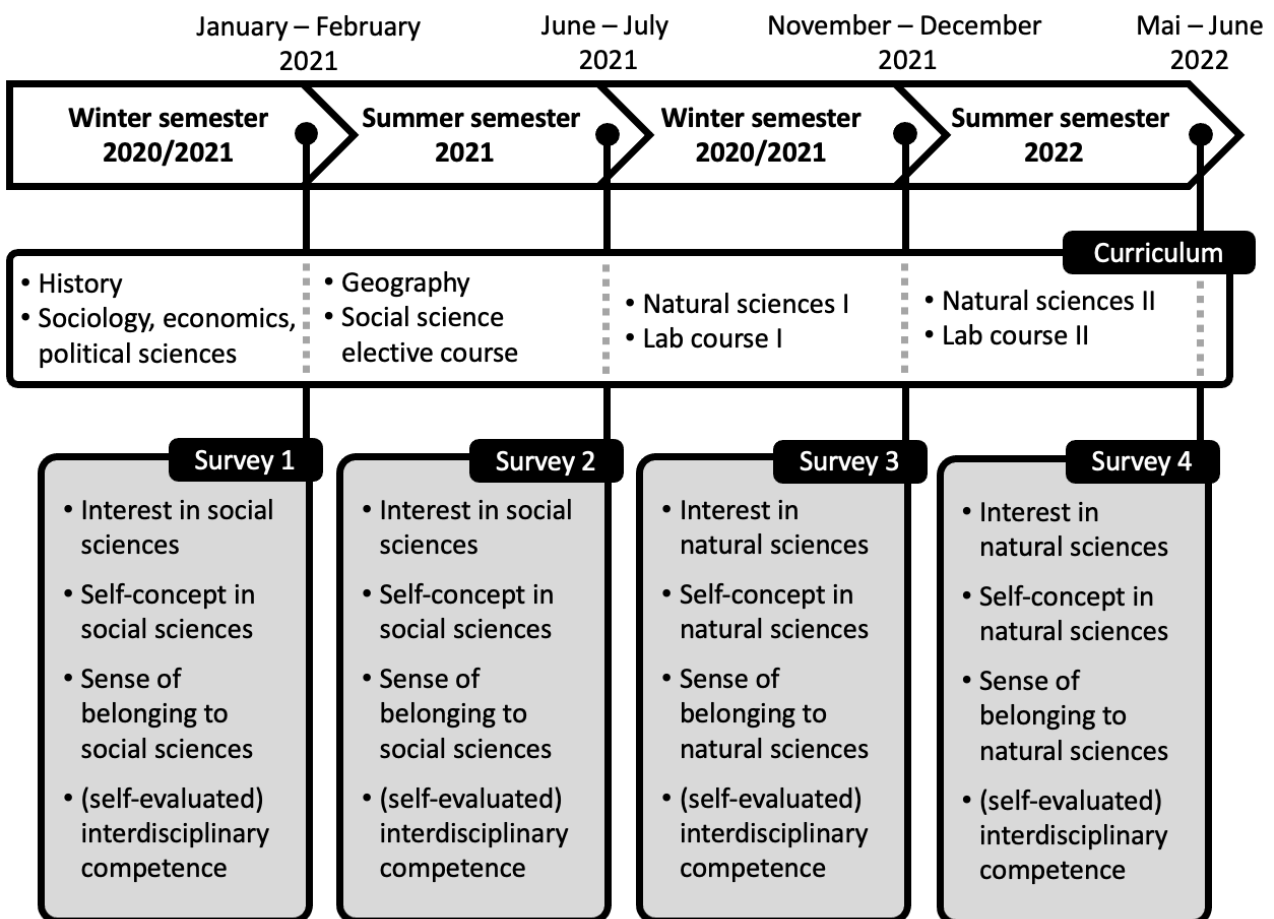
Pre-service primary school teachers who started the teacher education program “Sachunterricht” in the winter semester (April - September) of 2020/2021 were invited to participate in the present study (N = 164). Incentives for participation were not offered.

Data collection was conducted longitudinally via four online surveys spanning from the winter semester of 2020/2021 to the summer semester (September - March) of 2022 (Survey 1 to 4; see Figure 1). In accordance with the ethical and legal standards for educational research in Germany (Watteler & Ebel, 2019), the surveys were conducted anonymously and voluntarily. To match participants’ responses across the four online surveys, subject-generated identification codes were used (Yurek et al., 2008).

Within each of the four surveys, participants’ (self-evaluated) interdisciplinary competence was surveyed (see Figure 1). Furthermore, in line with the curricular order of the teacher education program “Sachunterricht” (see Context of the study), the focus of the four questionnaires differed (see Figure 1): the online questionnaires used in the winter semester of 2020/2021 (Survey 1) and summer semester of 2021 (Survey 2) surveyed participants’ interest, academic self-concept, and sense of belonging regarding social sciences. Analogously, the online questionnaires used in the winter semester of 2021/2022 (Survey 3) and summer semester of 2022 (Survey 4) surveyed participants’ interest, academic self-concept, and sense of belonging regarding natural sciences.

**Figure 1**

*Design of the longitudinal data collection*



**Measures**

Table 1 summarizes the descriptive statics and psychometric properties of the instruments we used within the four online surveys of the present study. In the following sub-sections, these instruments are described in more detail. Further information, as well as an overall presentation of the questionnaires, are published in the technical report of the present study (see Feser & Michalik, 2023).

*Interest in natural and social sciences*

To assess participants' interest in natural and social sciences, we used two scales developed by Rau (2017). Each of these scales consists of five items, which participants are asked to response to on a 4-point Likert scale. The items of both scales are nearly identical in wording; they only differ in whether they refer to natural or social sciences (e.g., "I am interested in learning something new in natural sciences" versus "I am interested in learning something new in social sciences").

*Academic self-concept in natural and social sciences*

We used adapted versions of the instrument developed by Elsholz (2019) to assess participants' academic self-concept in natural and social sciences (number of items: five; bipolar response scale with scores ranging from 1 to 7). Analogously to the interest scales, the items of these scales differ only in whether they address natural or social sciences (e.g., "For me, learning new things in my natural science studies is easy/difficult" versus "For me, learning new things in my social science studies is easy/difficult").

*Sense of belonging to natural and social sciences*

To assess the participants' sense of belonging to natural sciences, we used the instrument developed by Feser (2020). This instrument consists of 21 items (e.g., "I feel connected to the natural sciences community"), which require responses on a 5-point Likert scale. To assess participants' sense of belonging to social sciences, we adapted this instrument and changed the wording of the items to indicate social sciences (e.g., "I feel connected to the social sciences community").

*(Self-evaluated) Interdisciplinary competence*

While knowledge about pedagogy, teaching Sachunterricht, and the various content areas of Sachunterricht is usually surveyed using paper-and-pencil or vignette tests, it is quite difficult to survey pre-service primary school teachers' interdisciplinary competence. Interdisciplinary competence is domain-unspecific and defined in terms of an individual's proficiency to cope within multidisciplinary contexts (see Introduction). For this reason, within empirical research, interdisciplinary competence is typically surveyed based on self-evaluations on the part of the participants (e.g., Claus & Wiese, 2019; Engelhardt, 2019; Lattuca et al., 2013; Tormey & Laperrouza, 2023). Therefore, to survey pre-service primary school teachers' interdisciplinary competence within the present study, we used an adapted version of the self-evaluation scale developed by Engelhardt (2019). This adapted version consists of six items, the wording of which was specified on the university-based teacher education program "Sachunterricht" and which participants are asked to response to on a 5-point

**Table 1**

*Descriptive statics and psychometric properties for the instruments used based on our surveyed sample*

| Instrument | Survey         | N <sub>item</sub> | N  | M    | SD   | Min  | Max  | α   | r <sub>it</sub> |
|------------|----------------|-------------------|----|------|------|------|------|-----|-----------------|
| SB-S       | t <sub>1</sub> | 21                | 75 | 3.36 | .57  | 2.18 | 4.38 | .75 | .36 to .64      |
|            | t <sub>2</sub> |                   | 44 | 3.18 | .63  | 1.72 | 4.50 | .83 | .44 to .72      |
| SC-S       | t <sub>1</sub> | 5                 | 67 | 4.81 | .99  | 2.80 | 7.00 | .92 | .74 to .86      |
|            | t <sub>2</sub> |                   | 44 | 4.60 | 1.15 | 1.00 | 7.00 | .93 | .72 to .88      |
| IN-S       | t <sub>1</sub> | 5                 | 81 | 3.12 | .53  | 1.60 | 4.00 | .82 | .54 to .66      |
|            | t <sub>2</sub> |                   | 46 | 2.85 | .57  | 1.60 | 3.80 | .85 | .62 to .71      |
| SB-N       | t <sub>3</sub> | 21                | 48 | 3.19 | .55  | 1.40 | 4.04 | .67 | .36 to .51      |
|            | t <sub>4</sub> |                   | 44 | 3.05 | .68  | 1.57 | 4.92 | .78 | .46 to .71      |
| SC-N       | t <sub>3</sub> | 5                 | 46 | 4.06 | 1.12 | 1.00 | 7.00 | .92 | .72 to .86      |
|            | t <sub>4</sub> |                   | 45 | 4.14 | .97  | 2.20 | 6.80 | .87 | .58 to .80      |
| IN-N       | t <sub>3</sub> | 5                 | 48 | 2.81 | .54  | 1.60 | 4.00 | .84 | .55 to .72      |
|            | t <sub>4</sub> |                   | 46 | 2.91 | .49  | 1.80 | 4.00 | .81 | .50 to .73      |
| IDC        | t <sub>1</sub> | 6                 | 78 | 3.57 | .63  | 1.17 | 5.00 | .77 | .38 to .71      |
|            | t <sub>2</sub> |                   | 45 | 3.49 | .66  | 1.83 | 4.83 | .76 | .25 to .74      |
|            | t <sub>3</sub> |                   | 47 | 3.33 | .56  | 2.33 | 4.83 | .73 | .26 to .71      |
|            | t <sub>4</sub> |                   | 43 | 3.33 | .67  | 1.50 | 4.83 | .80 | .30 to .72      |

Note. SB-S = sense of belonging to social sciences; SC-S = self-concept in social sciences; IN-S = interest in social sciences; SB-N = sense of belonging to natural sciences; SC-N = self-concept in natural sciences; IN-N = interest in natural sciences; IDC = self-evaluated interdisciplinary competence; t<sub>1</sub> = Survey 1; t<sub>2</sub> = Survey 2; t<sub>3</sub> = Survey 3; t<sub>4</sub> = Survey 4; N = number of participants; N<sub>item</sub> = number of items; M = arithmetic means; SD = standard deviation; min = minimum score; max = maximum score; α = Cronbach's alpha; r<sub>it</sub> = range of the items' selectivity coefficient.

Likert scale (e.g., “I can interconnect subject-specific concepts of different fields of the teacher education program ‘Sachunterricht’ and, as a result, achieve a better understanding”).

### Participants and data analysis

Table 2 summarizes the participation rate across the four online surveys of the present study. In the first survey, the participation rate was 50.0 %; in the following three surveys, this rate dropped to between 28.0 and 29.9 %. In total, 103 (62.8 %) of the 164 pre-service primary school teachers who started the teacher education program “Sachunterricht” in the winter semester of 2020/2021 participated in at least one online survey. Only 23 (14.0 %) pre-service primary school teachers participated in all four surveys.

As a result, like many other longitudinal studies, the present study suffered from a substantial non-participation rate, as well as a declining re-participation rate. Thus, to decrease potential biases and reductions in test strength due to missing data, we utilized multiple imputation within our data analysis (Cox et al., 2014; Nissen et al., 2019) based on the assumption that it is plausible to predict the levels of a participant’s attribute at a given point in time by using the levels of that attribute at a different point in time (e.g., predicting participants’ interest in social science in the summer semester of 2021 based on their interest in social science in the winter semester of 2020/2021). For this multiple imputation, we used the data derived from the 60 pre-service primary school teachers (36.6 %) who participated in two or more surveys. Table 3 summarizes the central descriptive statistics of this sub-sample as compared to all pre-service primary school teachers who were invited to participate in the present study. The percentage share of missing values within this dataset ranged from 8.3 %, for participants’ interest in social science in the winter semester of 2020/2021, to 38.3 %, for participants’ self-evaluated interdisciplinary competence in the summer semester of 2022.

**Table 2**  
Participation rate across the four surveys

| Survey    | N  | %    | $N_p$    | N   | %    |
|-----------|----|------|----------|-----|------|
| $t_1$     | 82 | 50.0 | 1        | 43  | 26.2 |
| $t_2$     | 47 | 28.7 | $\geq 1$ | 103 | 62.8 |
| $t_3$     | 49 | 29.9 | $\geq 2$ | 60  | 36.6 |
| $t_4$     | 46 | 28.0 | $\geq 3$ | 38  | 23.2 |
| $t_1-t_4$ | 23 | 14.0 | 4        | 23  | 14.0 |

Note.  $t_1$  = Survey 1 (winter semester 2020/2021);  $t_2$  = Survey 2 (summer semester 2021);  $t_3$  = Survey 3 (winter semester 2021/2022);  $t_4$  = Survey 4 (summer semester 2022);  $t_1-t_4$  = Survey 1 to Survey 4; N = number of participants; % = percentage based on the total number of pre-service primary school teachers invited to participate in this study (N = 164);  $N_p$  = number of surveys in which the same pre-service primary school teachers participated.

**Table 3**  
Descriptive statistics of the analyzed sample

|  |        | Invited to participate   | Participated in $\geq 2$ surveys |
|--|--------|--------------------------|----------------------------------|
| Total                                      |        | 164 (100 %)              | 60 (100 %)                       |
| Age  | M      | No information available | 22.56                            |
|  | SD     |                          | 4.84                             |
| High school graduation grade point average | M      | No information available | 2.18                             |
|  | SD     |                          | .57                              |
| Gender                                     | Female | 143 (87.20 %)            | 55 (91.67 %)                     |
|  | Male   | 21 (12.80 %)             | 5 (8.33 %)                       |
| Training in special education              | Yes    | 128 (78.05 %)            | 43 (71.67 %)                     |
|  | No     | 36 (21.95 %)             | 17 (28.33 %)                     |

Note. This table is based on the data derived from Survey 1; the German school grade scale (high school graduation grade point average) ranges from 1 = very good to 6 = insufficient; M = arithmetic means; SD = standard deviation; training in special education = pre-service primary school teachers who do (not) participate in a teacher education program about teaching students with special educational needs.

Data analysis was conducted using R Version 4.2.1 (The R Foundation for Statistical Computing, 2023). Via the “mice” package Version 3.14 (van Buuren & Groothuis-Oudshoorn, 2011), multiple imputation was performed (imputation method: linear regression through prediction; number of imputations: 200; number of iterations: 10). To examine research question RQ3, we performed pooled correlation analyses (Pearson’s  $r$ ) between participants’ interdisciplinary competence and their interest, self-concept, and sense of belonging regarding natural and social sciences for each of the four online surveys (Heymans & Eekhout, 2019). Analogously, to address research questions RQ1 and RQ2, we used pooled paired-sample t-tests (Heymans & Eekhout, 2019); for research question RQ2, we also conducted a pooled Page’s trend test beforehand (Page, 1963). Within these data analyses, we estimated the parameters of interest for each imputed dataset separately and combined them following Rubin’s rules (Rubin, 1987).

### Limitations

Given our study design and methodological approach, the present study has some limitations that should be considered. First, due to a substantial non-participation rate and declining re-participation in our study, we utilized multiple imputation within our data analysis to decrease potential biases and reductions in test strength. Nevertheless, it is possible that the results of the present study still may exhibit some bias (Heymans & Eekhout, 2019), especially because our analyzed sample comprises only 36.6 % of all pre-

service primary school teachers who were invited to participate. Additionally, the participants in the present study were solely recruited within the university-based teacher education program "Sachunterricht" at the Universität Hamburg, Germany (see Context of the study). Consequently, it is conceivable that further results regarding RQ1 to RQ3 may emerge if the present study is replicated with pre-service primary school teachers' participating in university-based teacher education programs significantly differing from the programs in Hamburg. Moreover, our data collection was carried out during the COVID-19 pandemic. Because research indicates that pre-service teachers' professionalization within university-based teacher education was heavily influenced by the COVID-19 pandemic (e.g., An & Zakaria, 2022; Kan et al., 2022; Tekel et al., 2022), it is reasonable to assume that the results of the present study reflect this influence as well.

**Results**

*Changes in interest, academic self-concept, sense of belonging, and interdisciplinary competence*

In summary, the following pattern regarding research question RQ1 emerged within our data analysis (see Table 4): first, neither participants' academic self-concept in natural science nor their academic self-concept in social sciences showed a statistically

significant change over time. The descriptive level hints, if at all, that there may be a very small decrease in participants' academic self-concept in social sciences ( $p = .118$ ;  $d = -.22$ ). Second, both participants' sense of belonging to natural sciences and their sense of belonging to social sciences showed a statistically significant decrease over time ( $p < .001$ ). Furthermore, in both cases, the magnitude of this decrease was identical and moderate ( $d = -.67$ ). Third and finally, participants' interest in natural and social sciences showed different changes over time. On one hand, participants' interest in social sciences decreased significantly between Surveys 1 and 2 ( $p = .045$ ;  $d = -.32$ ). On the other hand, between Surveys 3 and 4, their interest in natural sciences significantly increased ( $p = .036$ ;  $d = .35$ ). The magnitudes of these changes in interest are small.

Regarding the change in participants' (self-evaluated) interdisciplinary competence during their undergraduate studies (research question RQ2), the results of the pooled Page's trend test indicate a small but significant decrease over time ( $L = 1558.49$ ;  $\rho = .195^c$ ;  $p = .004$ ). However, as illustrated in Table 4, a more detailed analysis using pooled paired-sample t-tests revealed a significant, moderate decrease in participants' (self-evaluated) interdisciplinary competence only between Surveys 2 and 3 ( $p = .003$ ;  $d = -.53$ ).

**Table 4**

*Mean differences regarding participants' interest, self-concept, sense of belonging, and self-evaluated interdisciplinary competence across the four surveys*

Surveys 1 and 2 (winter semester 2020/2021 to summer semester 2021)

| Instrument | $M_1$ | $SD_1$ | $M_2$ | $SD_2$ | $t$   | $p$ | $d$  |
|------------|-------|--------|-------|--------|-------|-----|------|
| SB-S       | 3.33  | .59    | 3.17  | .60    | -3.68 | *** | -.67 |
| SC-S       | 4.73  | 1.07   | 4.62  | 1.12   | -1.20 | .12 | -.22 |
| IN-S       | 3.01  | .53    | 2.91  | .55    | -1.73 | *   | -.32 |
| IDC        | 3.54  | .66    | 3.55  | .58    | .17   | .43 | .03  |

Surveys 2 and 3 (summer semester 2021 to winter semester 2021/2022)

| Instrument | $M_2$ | $SD_2$ | $M_3$ | $SD_3$ | $t$   | $p$ | $d$  |
|------------|-------|--------|-------|--------|-------|-----|------|
| IDC        | 3.55  | .58    | 3.39  | .55    | -2.91 | **  | -.53 |

Surveys 3 and 4 (winter semester 2021/2022 to summer semester 2022)

| Instrument | $M_3$ | $SD_3$ | $M_4$ | $SD_4$ | $t$   | $p$ | $d$   |
|------------|-------|--------|-------|--------|-------|-----|-------|
| SB-N       | 3.20  | .55    | 3.03  | .62    | -3.64 | *** | -0.67 |
| SC-N       | 4.14  | 1.02   | 4.11  | .89    | -0.52 | .30 | -.10  |
| IN-N       | 2.85  | .51    | 2.91  | .44    | 1.83  | *   | .35   |
| IDC        | 3.39  | .55    | 3.43  | .57    | .850  | .20 | .16   |

Note. SB-S = sense of belonging to social sciences; SC-S = self-concept in social sciences; IN-S = interest in social sciences; SB-N = sense of belonging to natural sciences; SC-S = self-concept in natural sciences; IDC = self-evaluated interdisciplinary competence; M = pooled arithmetic means; SD = pooled standard deviation; t = t-value (one-tailed pooled paired sample t-test); p = p-value; d = pooled Cohen's d with correlation adjustment for paired samples (see Cohen, 1988, p. 49); \*p < .05; \*\*p < .01; \*\*\*p < .001.

**Correlation analyses**

Table 5 summarizes the results of our pooled correlation analyses. Our data analysis revealed that pre-service primary teachers' interest, academic self-concept, and sense of belonging regarding natural sciences correlate with one another at a moderate to high level (Survey 3:  $.57 \leq r \leq .61$ ; Survey 4:  $.54 \leq r \leq .60$ ). We also found an analogous pattern for participants' interest, academic self-concept, and sense of belonging regarding social sciences (Survey 1:  $.41 \leq r \leq .56$ ; Survey 2:  $.51 \leq r \leq .57$ ). However, within the social sciences, the correlations are smaller than within the natural sciences. Moreover, the correlations between these constructs hardly changed over time. Only the correlation between participants' academic self-concept and sense of belonging regarding social sciences increased noticeably ( $r = .41$  in Survey 1 versus  $r = .57$  in Survey 2).

Beyond that, our data analysis revealed that pre-service primary school teachers' (self-evaluated) interdisciplinary competence significantly correlates with their interest ( $.36 \leq r \leq .58$ ), academic self-concept ( $.34 \leq r \leq .47$ ), and sense of belonging regarding natural and social sciences ( $.35 \leq r \leq .41$ ). Overall, these correlations range from weak to moderate.

Furthermore, except for the correlation between participants' (self-evaluated) interdisciplinary competence and their interest in natural sciences, these correlations also hardly change over time ( $r = .44$  in Survey 3 versus  $r = .58$  in Survey 4).

**Discussion**

**Summary**

Within the present study, we investigated whether and to what extent pre-service primary school teachers' (self-evaluated) interdisciplinary competence, as well as their interest, academic self-concept, and sense of belonging regarding natural and social sciences, change during their undergraduate studies. Furthermore, we analyzed the extent to which these constructs correlate with one another. The results of our data analysis show that participants' academic self-concept regarding natural and social sciences did not change significantly over time, but their sense of belonging to both domains decreased significantly. Participants' interest in social sciences decreased significantly, while their interest in natural sciences increased significantly over time. Page's trend test indicates a small decrease in pre-service primary school teachers' (self-evaluated) interdisciplinary

**Table 5**

*Pooled correlations (Person's r) between participants' interest, self-concept, sense of belonging, and self-evaluated interdisciplinary competence*

Survey 1 (winter semester 2020/2021)

|      | SB-S   | SC-S   | IN-S   | IDC   |
|------|--------|--------|--------|-------|
| SB-S |        | .41*** | .56*** | .36** |
| SC-S | .41*** |        | .51*** | .34** |
| IN-S | .56*** | .51*** |        | .36** |
| IDC  | .36**  | .34**  | .36**  |       |

Survey 2 (summer semester 2021)

|      | SB-S   | SC-S   | IN-S   | IDC    |
|------|--------|--------|--------|--------|
| SB-S |        | .57*** | .53*** | .35**  |
| SC-S | .57*** |        | .51*** | .43*** |
| IN-S | .53*** | .51*** |        | .40**  |
| IDC  | .35**  | .43*** | .40**  |        |

Survey 3 (winter semester 2021/2022)

|      | SB-N   | SC-N   | IN-N   | IDC    |
|------|--------|--------|--------|--------|
| SB-N |        | .57*** | .61*** | .41*** |
| SC-N | .57*** |        | .60*** | .43*** |
| IN-N | .61*** | .60*** |        | .44*** |
| IDC  | .41*** | .43*** | .44*** |        |

Survey 4 (summer semester 2022)

|      | SB-N   | SC-N   | IN-N   | IDC    |
|------|--------|--------|--------|--------|
| SB-N |        | .54*** | .60*** | .39**  |
| SC-N | .54*** |        | .60*** | .47*** |
| IN-N | .60*** | .60*** |        | .58*** |
| IDC  | .39**  | .47*** | .58*** |        |

Note. SB-S = sense of belonging to social sciences; SC-S = self-concept in social sciences; IN-S = interest in social sciences; SB-N = sense of belonging to natural sciences; SC-N = self-concept in natural sciences; IN-N = interest in natural sciences; IDC = self-evaluated interdisciplinary competence; \*\*p < .01; \*\*\*p < .001.



competence across the four surveys of our study; particularly between Surveys 2 and 3, a significant decrease is evident. Beyond that, the correlations between pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding natural and social sciences were moderate to high and remained relatively stable over time. Participants' (self-evaluated) interdisciplinary competence correlated with the above-mentioned constructs at a weak to moderate level, which—with very few exceptions—also did not change over time.

### *Conclusion and suggestions for future research*

With the limitations stated at the end of the Method section in mind, the results of the present study are, on one hand, in line with those of previous research (see Introduction). Consistent with the findings of other studies, we found that pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding natural sciences, although distinguishable, are substantially correlated with one another. Correspondingly, our data analysis also revealed a similar result for pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding social sciences. Additionally, within the present study, participants' interest, academic self-concept, and sense of belonging regarding natural and social sciences changed over time only weakly to moderately, if they changed at all. These results are also in line with the results of previous research indicating that these constructs are relatively stable and only change within university-based teacher education over extended time periods. An educational implication that derives from these results is that short-term interventions that aim to promote pre-service primary school teachers' interest, academic self-concept, or sense of belonging regarding natural and/or social sciences may show their intended outcomes—if at all—only to a very limited extent. Conversely, implementing the promotion of these motivational orientations as a cross-cutting and longitudinal component of university-based teacher education may be a more promising approach.

On the other hand, the present study, first and foremost, extends the current state of the research and provides starting points for potential future research. Our study revealed a significant decrease in pre-service primary school teachers' interest in social sciences and sense of belonging to natural and social sciences. One potential cause of these declines could be negative socialization experiences that pre-service primary teachers' may encounter during their undergraduate studies in natural and social sciences. Especially based on the results of previous research, it seems reasonable to assume that negative proficiency expectations on the part of

lecturers toward pre-service primary school teachers (Muenks et al., 2020) and/or the labeling of pre-service primary school teachers as “second-class students” within faculties that predominantly award social status based on students' subject-specific knowledge and skills (Oevermann, 2010) are likely to negatively influence the development of pre-service primary school teachers' interest in and sense of belonging to university-based teacher education. Furthermore, a decrease in interest in social sciences and sense of belonging to natural and social sciences may also be influenced by cultural and societal expectations regarding primary teachers that have been explicitly and/or implicitly passed on to the participants (Feser & Haak, 2022). For example, societal messages such as “primary school teachers are generalist and not subject teachers like secondary school teachers” may shift pre-service primary teachers' focus to subject-unspecific or purely pedagogical aspects of their undergraduate studies, leading to a decrease in their sense of belonging to natural and social sciences and/or their interest in social sciences. As a result, future research should investigate whether the decreases in interest and sense of belonging encountered in the present study are replicable in other contexts of pre-service primary school teacher education. It would also be fruitful for future research to further examine the causes of such decreases.

In addition to a significant decrease in participants' interest in social sciences, the present study also revealed a significant increase in their interest in natural sciences. A potential cause for these changes in interest may be the different levels of satisfaction that pre-service primary school teachers have with their undergraduate studies in natural and social sciences. Adding to the above, another cause of the decrease in participants' interest in social sciences could be the fact that courses in their social science studies are not sufficiently aligned with the learning requirements and/or expectations of pre-service primary school teachers. As a result, participants may have developed the notion that social sciences, as academic disciplines, are less relevant or applicable to their future teaching practice, which, in turn, may have led to decreased interest in the social sciences. Conversely, the undergraduate natural science courses participants attended may have increased participants' interest in natural sciences by offering learning opportunities for developing knowledge and skills in natural science that they perceive as meaningful for their future teaching careers, or these courses may have provided participants with a solid understanding of the relevance of the natural science to primary science education (Marquant-Mau, 2001; Thomas & Durant, 1987). This interpretation is supported by the results of an evaluative survey accompanying the present study (for details, see Feser & Michalik, 2023). This survey revealed that pre-service primary school

teachers perceive the content of natural sciences courses within the university-based teacher education program "Sachunterricht" as more relevant to their future teaching careers than the content of social science courses. Additionally, several previous studies indicate that university-based teacher education programs whose content and structure are aligned with the professional development needs of pre-service primary school teachers positively influence their interest (e.g., Appleton, 1995; Beudels et al., 2021; Jarret, 1999; Novak & Wisdom, 2018). Nevertheless, further research concerning the development of pre-service primary school teachers' interest should be conducted, especially because studies addressing their interest in social sciences have hardly been conducted thus far (for an exception, see Lenzgeiger, 2022).

The results of the present study also provide important insights into pre-service primary school teachers' (self-evaluated) interdisciplinary competence. On one hand, our data analysis revealed weak to moderate correlations between participants' (self-evaluated) interdisciplinary competence and their interest, academic self-concept, and sense of belonging regarding natural and social sciences. A similar result was found in previous studies by Scott et al. (2014; 2015), in which potential correlations between university students' (self-evaluated) interdisciplinary competence and their interest in physics, feeling of being recognized as a physics person, and physics identity were investigated. Therefore, it seems reasonable to assume that there may be limited but existing associations between pre-service primary school teachers' (self-evaluated) interdisciplinary competence and their interest, academic self-concept, and sense of belonging regarding natural and social sciences. However, the results of the present study certainly do not reveal any information about causal associations, specifically whether pre-service primary school teachers' interest, academic self-concept, and sense of belonging regarding natural and social sciences are impacted by their interdisciplinary competence, and/or vice versa. Nor can it be ruled out that the correlations just mentioned are spurious due to additional influencing or moderating factors (i.e., previous research hints that university students' curiosity is associated with both their interdisciplinary competence (Spelt et al., 2009) and their domain-specific affective-motivational orientations (e.g., Herpratiwi et al., 2018; Knecht, 2022; Yalız Solmaz, 2017)). Consequently, future research should be conducted to further clarify the associations between pre-service primary school teachers' (self-evaluated) interdisciplinary competence and their affective-motivational orientations related to natural and social sciences, such as their interest, academic self-concept, and sense of belonging.

Finally, on the other hand, within the present study, a small decrease in pre-service primary school teachers' (self-evaluated) interdisciplinary competence during their undergraduate studies in natural and social sciences was evident. Specifically, we found a moderate decrease between the two surveys in which the participants' curriculum moved from the social to the natural sciences (Surveys 2 and 3). One reasonable cause for this decline could be that the undergraduate courses participants attended solely promoted the acquisition of subject-specific knowledge and skills, rather than an interdisciplinary linking of such knowledge and skills. This, in turn, may have improved participants' knowledge and skills in natural and/or social sciences but, at the same time, may also counteracted any development regarding their interdisciplinary competence. Relatedly, especially when participants were shifting from social science to natural science courses, they may have encountered scientific concepts and methods that they perceived as new and unfamiliar. This potentially constituted a challenge to their interdisciplinary thinking and, accordingly, could explain the decrease in their (self-evaluated) interdisciplinary competence. However, an alternative interpretation of the observed decrease is based on the fact that, in the present study, participants' interdisciplinary competence was surveyed via self-evaluations and that, in educational research, it is well known that students may tend to overestimate their own competencies, especially when their competencies are low (e.g., Lindsey & Nagel, 2015; Mahmood, 2016; Kruger & Dunning, 1999). In all four surveys of the present study, the mean of the participants' (self-evaluated) interdisciplinary competence was notably higher than the theoretical mean on a five-point Likert scale ( $3.39 \leq M_{1/2/3/4} \leq 3.55$  versus  $M_{\text{theoretical}} = 3.00$ ; see Table 4). In other words, participants self-evaluated their interdisciplinary competence as fairly high, and the significant decrease in their self-evaluated interdisciplinary competence describes a shift toward the medium level. Thus, assuming that, at the beginning of their studies, pre-service primary school teachers' interdisciplinary competence was low rather than high and developed positively during their undergraduate studies, it may also be plausible that participants initially overestimated their interdisciplinary competence but, over time, gradually adopted a more realistic self-evaluation. This development, in turn, may have manifested itself in the empirical data as a decrease in participants' (self-evaluated) interdisciplinary competence. In our view, both these interpretations of the decrease in participants' (self-evaluated) interdisciplinary competence within the present study are quite reasonable. In order to clarify the extent to which one of these interpretations more accurately describes the change in primary school teachers' (self-evaluated) interdisciplinary competence during their undergraduate studies, further research is needed. In this regard, future research that aims to replicate the

results of the present study are needed, particularly studies that survey primary school teachers' interdisciplinary competence using measures other than self-evaluations.

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### Footnotes

<sup>a</sup>An approximate translation for Sachunterricht is natural sciences and social studies in primary education. Literally, the term Sachunterricht translates as education (German: Unterricht) on factual matters (German: Sache). For a comparison of Sachunterricht and the current primary school curricula in other European countries, see Blaseio (2021).

<sup>b</sup>More precisely, a further and very important domain integrated within Sachunterricht is technology education (Gesellschaft für Didaktik des Sachunterrichts, 2013). However, because technology education within Sachunterricht is not addressed in the present study, it is not discussed further in this paper.

<sup>c</sup> $\rho$  is the overall rank correlation between Surveys 1 to 4 (in reversed ordering) and the data (Page, 1963). Due to the reversed ordering of Surveys 1 to 4 within its calculation,  $\rho$  is positive. Interpreted as an effect size,  $\rho$  indicates an overall small decrease of participants' (self-evaluated) interdisciplinary competence over time.

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