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What Influences Attitudes and Confidence in Teaching Physics and Technology Topics? An Investigation in Kindergarten and Primary-School Trainee Teachers

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Abstract: This study investigated the correlations of general knowledge, vocational interests, and personality with trainee teachers' attitudes and perceived capabilities in teaching physics and technology topics in kindergarten and primary school. A quantitative survey was composed using the Nature–Human–Society questionnaire, the general knowledge test BOWIT, the general interest structure test AIST-R, and the 10-item Big Five Inventory. The sample consisted of 196 female trainee teachers for kindergarten and primary school, and the results showed that only a few trainee teachers favoured teaching physics and technology topics. The bivariate analyses indicated that investigative and realistic interests were highly correlated with their confidence in teaching physics and technology topics, followed by significant relationships with possessing general knowledge in science and technology. The relationships with personality, especially neuroticism and extraversion, were also evident, but they were not as strong. The results were further differentiated in various subgroups (i.e., a group who favoured teaching physics and technology topics versus a group who did not, as well as a group with the typical interest profile of kindergarten and primary-school teachers versus a group with a social and investigative interest profile), which provided additional insights.

Keywords: teacher; kindergarten; primary school; physics; technology; knowledge; interest; personality; attitude; self-efficacy

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1. Introduction

In light of the international demand for early science education, kindergarten and primary-school teachers' attitudes and self-perceptions are concerning. Several studies have shown that many kindergarten and primary-school teachers do not like teaching science or certain science topics and often have low confidence in their ability to teach science [1–9]. This internal orientation of teachers can be problematic since it may outwardly manifest in a teacher's behaviour and thus in their education practice. Research has found that many kindergarten and primary-school teachers avoid teaching science or teach science topics, especially physics, less often than other topics [10–14]. Consequently, without an early introduction to the sciences, sustainable education may not come to fruition. Studies have shown that the interests and the abilities that a child will pursue well into adulthood have often been inspired during these formative years [15,16]. Therefore, committed kindergarten and primary-school teachers should encourage children's curiosity and be willing to explore the natural world with them. Such early promotion of the sciences can establish a strong fundamental basis for further education [17,18]. Among the scientific disciplines, natural science, technology, engineering, and mathematics (STEM) fields have a concerning shortage of skilled professionals; therefore, an early introduction to science and technology education may be even more crucial [19,20]. Studies have shown that early science education can influence career choices [21]. Children gain their first educational experiences in science not only in formal learning settings but often also through the parent–child and the grandparent–grandchild relationship [21,22]. A study has shown that the best predictor of elementary-school teachers' confidence in teaching science topics were teachers own early science experiences in kindergarten, followed by the number of science courses taken in college [4]. Conversely, negative science experiences in a teacher's school education can lead to a negative attitude towards science and teaching science [2,4,7].

In psychology, the term "attitude" refers to a set of "beliefs, feelings, and behavioural tendencies toward socially significant objects, groups, events or symbols" [23] (p. 150). Attitudes, as internal frameworks, become apparent through evaluative statements of favour or disfavour and express "the relationship (either positive or negative) between the self and an attitude object" [24] (p. 169) [25]. Therefore, "attitudes are an important part of the self-concept" [24] (p. 169). As a cognitive representation of oneself, the self-concept includes the knowledge about "personal characteristics, such as traits, abilities, values, preferences, and opinions, as well as beliefs about one's social identities" [26] (p. 4682). Educational studies that report on teachers' confidence refer to teachers' beliefs concerning their abilities and capabilities [27]. These self-related cognitions are domain-specific and are conceptually distinguished in psychology as self-concept and self-efficacy: "Self-efficacy considers someone's evaluative beliefs about their future capacities, such as their confidence in being able to gain a particular examination, while self-concept broadly considers someone's belief about their abilities, integrating historical experiences" [27] (p. 51). Both self-concept and self-efficacy are self-perceptions and are a result of individual cognitive appraisal [28]. A person's self-perceived competence and confidence may or may not correspond to the person's actual competence, but regardless, they influence "behavioural, affective, and cognitive outcomes" [29] (p. 21) [30]. Bandura [31] stated that "beliefs of personal efficacy constitute the key factor of human agency. If people believe they have no power to produce results, they will not attempt to make things happen" (p. 3). Thus, self-efficacy affects motivation and the degree of effort put towards future challenges and is a strong predictor of success in a career [32,33]. In the case of kindergarten and primary-school teachers, it was demonstrated that their beliefs concerning their self-efficacy determine both their teaching effectiveness and teaching practices [34]. In previous studies regarding first-year students of a kindergarten and primary-school-teacher program, researchers found that trainee teachers' low perceived capabilities in teaching physical and technical contents correlated with low content knowledge in science and technology. Moreover, if their general knowledge in science and technology was higher, then the probability that they would enjoy teaching science and technology topics was higher [35]. In the next section, we will define the construct "general knowledge" while providing relevant results from previous studies.

1.1. Theoretical Background and Prior Research on "General Knowledge"

The term "general knowledge" is defined as "the breadth and depth of knowledge that one's culture deems essential, practical, or otherwise worthwhile for everyone to know" [36] (p. 601). Hence, it includes factual knowledge concerning different domains, such as history, politics, sociology, science, and technology [37,38]. From a psychological point of view, general knowledge reflects a part of an individual's cognitive capacity. In the Gf–Gc theory of Cattell, knowledge is assigned to crystalized intelligence (Gc), which means the ability to assimilate, store, and retrieve relevant information [39,40]. Genc et al. [34] delivered a neuroanatomical explanation for interindividual differences in general knowledge. They found that general knowledge and fluid intelligence (Gf) have "distinguishable neural fundaments" and demonstrated that the "successful formation and retrieval of general knowledge is heavily dependent on the quality of widely distributed brain network" [36] (p. 600). Consequently, it was stated that "individuals with more efficiently connected brain networks hold more general knowledge" [36] (p. 666). However, knowledge development also depends on whether a person uses one's learning potential. Whether knowledge acquisition ultimately occurs depends on personality or learning motivation. A high level of general knowledge has been correlated with the personality trait of openness [41]. Therefore, individual differences in knowledge can be attributed to cognitive factors (e.g., intelligence) and non-cognitive variables (e.g., personality and vocational interest) [42–44]. Additionally, environmental conditions, such as access to information sources, is always central [37]. Regardless of the level of intelligence, the more one knows, the more knowledge one can acquire. Thus, prior knowledge influences the acquisition of further knowledge [38,45].

In higher education, results of general-knowledge tests, such as the knowledge quiz "Studentenpisa", have shown clear differences in knowledge between students of different disciplines. On average, trainee teachers can answer fewer questions correctly than students of other subject studies without a teaching focus [46]. A differentiated view on trainee teachers and their teaching levels was shown when future secondary-school teachers performed better in knowledge tests than future primary-school teachers [47]. The best performance in general-knowledge tests has been achieved by political science and history students, which may be due to the similarity in the content of this major to many areas of general knowledge. Slightly above average performance was found in students of physics and natural sciences [46]. Factor-analytical evaluations of general-knowledge tests, such as the "Bochumer Wissenstest" (BOWIT) and the "Studentenpisa", reveal two clearly distinguishable knowledge domains: the social sciences and humanities (e.g., politics, history, culture, and economics) and the natural sciences and technology (e.g., biology, physics, and information technology) [41]. In the knowledge domain of the natural sciences and technology of the "Studentenpisa", students majoring in natural science scored above average while students majoring in education scored below average [46]. Specific subject-knowledge tests in natural sciences showed that primary-school trainee teachers have significant deficits in physics and chemistry and were less deficient in biology [12,14].

Furthermore, prior knowledge or ability positively influences a person's self-efficacy [48]. Likewise, a person's performance or achievements have been shown as significant predictors of their academic self-concept [49]. Therefore, it may be reasonable to assume that an increase in knowledge results in an increase in a person's self-concept and self-efficacy. According to Bandura's self-efficacy theory, mastery experiences may be the most effective sources for the development of self-efficacy. When a person knows that they have the ability to accomplish something difficult, they become more confident in their abilities and competencies to overcome other challenges [31,48,50].

The results of various studies, including those involving the "Studentenpisa" test, have shown that knowledge level correlates with domain-specific study subjects and vocational interests. Previously, John Dewey [51] stated that interests inspire individuals to acquire knowledge, and Cattell [52] posited that interests guide an individual to invest their fluid abilities and acquire knowledge [53], especially domain-specific knowledge. This means that people accumulate more knowledge in subjects that interest them. Interest leads to increased attention to topics in a particular subject, which provides opportunities for knowledge acquisition. However, a reciprocal interaction can be assumed between knowledge and interests. The acquisition of knowledge in a certain area may also cause someone to develop an interest in that area [37,42,43]. In the next section, we will define "vocational interest".

1.2. Theoretical Background and Prior Research on "Vocational Interest"

Interests are described as relatively stable curiosities or concerns that are cognitively and emotionally anchored in the personality. Together with abilities, interests are assumed to play the strongest influencing role in choosing a profession [54]. According to Holland's theory of career choice (also known as the RIASEC model), six basic vocational interest orientations can be distinguished: realistic (R), investigative (I), artistic (A), social (S), enterprising (E), and conventional (C). Each person's interest profile can be assigned to one or more of these six vocational interest orientations. If several orientations of the RIASEC model are used to describe a populations' vocational interests, many possible subtypes result. Typically, individual interest profiles are specified with a three-letter

RIASEC code (e.g., RIE) containing the three most pronounced interests [54,55]. Similar to Krapp et al. [56], Holland assumed that interests emerge from a person's interactions with their environment. For example, a child first discovers that they prefer certain activities over others; later, the preferred activities translate into interests, which finally lead to the acquisition of specific knowledge and relevant skills, which further deepens those interests [54,55].

In Holland's theory, six types of work environments correspond to the six interest types and can thus be assigned a specific RIASEC code. For example, the vocational environment of primary-school teachers is classified as SAE, which expresses its social, artistic, and enterprising activities. The profession of a physics teacher is represented as IRS and that of a physicist as IRC. In these two professions, investigative and practical (realistic) activities are common practice [54]. Holland's interest types I, R, and C, which are dominant among physicists, are described by Prediger as "thing orientations", whereas the interest types S, A, and E, which are frequently found among primary-school teachers, are described as "person orientations" [57].

Holland [55] maintained that people always look for work environments that correspond to their interest types. If a person–environment fit is established, for example, if a social-type finds themselves in a social-work environment or an investigative-type in an investigative-work environment, the probability of the person's satisfaction and commitment to the job will increase. Holland's person–environment model was empirically confirmed [58] and has been evident in study choices, as well. Students with identical or similar interest patterns have increasingly been found in the same major fields of study [59].

The best predictor for the selection of an education major is a person's social (S) interest [60]. Moreover, the social interests of prospective primary-school teachers are significantly higher than those of prospective secondary-school teachers [59]. Kindergarten and primary-school teachers have a robust pedagogical interest and enjoy working with children, whereas secondary-school teachers have a more pronounced interest in specific subject matter [61]. Within the group of prospective secondary-school teachers, trainee teachers of the natural sciences had higher realistic (R) and investigative (I) interests and lower artistic (A) and, for some, lower social (S) interests than trainee teachers in majors other than the natural sciences [60,62]. A comparison of trainee teachers to students majoring in subjects other than education showed that future technology teachers had lower interest orientations in I and R than engineering students. However, the most significant difference between these groups was the significantly lower social interest among engineering students than among technology trainee teachers [63]. Generally, trainee teachers were less investigative, realistic, conventionally oriented, and more artistically and socially interested [62]. This applied particularly to the interest profiles of primary-school teachers, for whom the SAE profile empirically dominated [64].

The relationship between interests and self-efficacy, related to the perceived-capability concept, has also been discussed in previous research. Lent et al. [33,65] argued that interests differ from self-efficacy, even if they are linked. Empirical findings have shown that realistic and investigative interests were correlated with self-efficacy in engineering, and self-efficacy in science was correlated with investigative interests. The literature has often assumed a reciprocal relationship between interests and perceived self-efficacy [31]. For example, it has been suggested that a person will likely develop an interest in those areas in which they perceive themselves as skilled or capable. Conversely, if a person is interested in a task, they will be more motivated to attempt it and thus have more opportunities to develop confidence in their abilities in that area [31,66]. However, findings on the cause–effect relationship have been inconsistent, and "there seems to be more evidence of interest predicting self-concept than the other way around" [66] (p. 3).

Generally, vocational interest has been considered a specific personality trait that manifests itself as a consistent preference for a topic or occupational activity [67]. However, to describe the personality of an individual, the concept of interest is not enough. Therefore, we will now examine the so-called "Big Five" general personality traits

1.3. Theoretical Background and Prior Research on the "Big-Five" Personality Traits

The "Big Five" is the most popular model for defining human personalities. This model of differential psychology has emerged after decades of research and depicts the most empirically validated personality traits. The five domains underlying one's personality are openness, conscientiousness, extraversion, agreeableness, and neuroticism. The Big Five comprises various characteristics of a person's behaviour, feelings, and thoughts in certain situations. Since each of the five personality traits present differently in a person, a personality profile can be created. Personality traits are both genetically and environmentally determined and are considered stable in adulthood [68–70].

A study with over 23,000 university students in Germany demonstrated that the differences in the Big Five characteristics are also reflected in the studied subject. For the student group of prospective educators, particularly high levels of agreeableness and extraversion were found, which are two traits that are advantageous for this vocation since the ability to work with and collaborate with other people is required. Comparatively, both personality traits (i.e., agreeableness and extraversion) were below average in the natural sciences student group [71]. On average, STEM students were quieter and more introverted as well as more reserved with other people [60]. However, science students generally had above-average scores in openness, and thus they reported enjoying exploration and discovering new things as well as reflecting critically on them [71]. Regarding openness, there was contradictory data among teachers: some studies have reported teachers' openness scoring as above average [71], whereas others have reported them as below average [59,60]. Upon differentiating the group of teachers according to their preferred school level to teach, trainee teachers who prefer primary school had lower scores in the personality trait of openness and higher scores in agreeableness, as compared to trainee teachers who chose secondary school [59]. Within both groups of trainee teachers, personality differences were found between those focusing on STEM subjects and those focusing on non-STEM subjects. The comparison of STEM and non-STEM trainee teachers suggested that non-STEM trainee teachers may be more extraverted [54]. Conversely, the personality of physicists has often been described as particularly introverted and emotionally stable [72].

In general, conscientiousness and emotional stability have been considered essential criteria for academic and work success. This has also been applied to teachers, whereas the personality trait of extraversion may predict teachers' working performance and personal satisfaction [73]. Furthermore, "the Big Five personality traits are associated with grades and achievement tests ... as well as with educational attainment" [74] (p. 2). A meta-analysis demonstrated frequent relationships between the Big Five personality traits and the interest orientation based on the RIASEC model. Openness was correlated with artistic and investigative interests, extraversion with enterprising and social interests, agreeableness with social interest, and conscientiousness with conventional interest [75,76].

Certain personality traits can also influence self-efficacy. Empirical findings have shown, for example, that conscientious people tend to have higher levels of self-confidence. These people are characterised by self-discipline and a sense of duty, which is reflected by the fact that they work hard and are persistent. In contrast, neuroticism has mostly been negatively correlated with self-efficacy and has been characterised by anxious and nervous thoughts and behaviours, which suggests that emotional stability may be positively related to confidence in one's capability [73,77]. In the case of extraversion, the findings have been contradictory: some studies have found that extraverted and energetic people generally rate their self-efficacy in teaching to be higher [34,77], whereas others have reported no correlation between extraverted teachers and their self-efficacy assessments [78]. Openness has had a positive correlation with academic self-efficacy, which has also been linked to a desire to try new tasks [32]. There have also been controversial findings regarding agreeableness: Some studies have shown that agreeableness could not predict academic self-efficacy, suggesting that tolerant and selfless behaviour may not be an indicator for increased self-efficacy [32], while another study showed that "only agreeableness was found to be positively associated with all dimensions of teaching self-efficacy" [34] (p. 14).

1.4. Research Rationale, Aims and Questions of This Study

As shown in the literature, there has been evidence that knowledge, interests, and personality can influence a person's self-efficacy in a particular area, but this combination of variables have not yet been tested in kindergarten and primary-school trainee teachers. Therefore, the aim of this study was to explore and identify what roles general knowledge, vocational interests, and personality play in the self-assessments of kindergarten and primary-school trainee teachers regarding teaching science topics, especially physics and technology. The focus of this analysis was deliberately placed on those teaching topics in natural and social sciences that were reported as less popular among kindergarten and primary-school teachers. This study considered the challenge that many kindergarten and primary-school teachers prefer not to teach science, and this has contributed to the need for increased research, especially in educational settings, if the international call for early science education is to be met. In the Swiss education system, kindergarten and primary-school teachers must teach physics and technology in class, regardless of their preferences. They do not have the authority to reject certain subject topics since all natural and social sciences topics have been integrated into one subject. Therefore, the curricular integration of different disciplines (e.g., physics, technology, biology, geography, history, social sciences, religious studies, economics) into one subject has increased the risk that some teaching content areas may be underrepresented in teaching practice due to a teacher's discomfort or preferences. In addition, since the topics in the natural sciences can vary widely and may induce different levels of interest among kindergarten and primary-school trainee teachers, the data regarding their interests should be recorded in a comprehensive manner. In previous studies concerning kindergarten and primary-school teachers, their attitudes towards different topics or disciplines in the natural sciences has not typically been differentiated, which was why this study investigated trainee teacher's self-assessment regarding animate nature (e.g., biology) and inanimate nature (e.g., physics, technology) separately. Furthermore, this study provided versatile insight into the assessments of kindergarten and primary-school trainee teachers regarding the different areas of social and natural sciences. This holistic view was developed to better classify the trainee teachers' self-assessment regarding physics and technology. Thus, this study explored the confidence levels of kindergarten and primary-school trainee teachers regarding topics in physics and technology, as compared to other areas of the natural and social sciences; we also explicitly recorded which curricular topics of the natural and social sciences were the most or least favoured by trainee teachers. With the ranking of various curricula contents of the Swiss subject "nature–human–society", this study would indicate whether teaching contents related to physics and technology were generally rated negatively or whether certain topics in physics and technology were favoured among kindergarten and primary-school trainee teachers.

As previously mentioned, this study examined the impact of the trainee teacher's characteristics (e.g., general knowledge, vocational interest, personality) in early teacher education and how they may have influenced their level of confidence in teaching physics and technology. By focusing on trainee teachers and not on in-service teachers, the results of this study provided beneficial information for teacher education by highlighting the impact of early influences on trainee teachers before they enter a teaching program. The results of this study should also indicate, if applicable, that for the physics and technology, more consideration should be placed on student attitudes and self-efficacy during teacher training. The professional competence of a teacher includes not only their professional knowledge (e.g., content knowledge, general pedagogical knowledge), but also the associated willingness and readiness to teach certain subject matter or topics.

A second main objective of this study was to provide a differentiated and diverse picture of the kindergarten and primary-school trainee teachers who participated rather than describe the participants as a whole, as has been typical in previous studies. Based on the results of prior research in secondary-school teachers, we expected to find differences between kindergarten and primary-school trainee teachers who favoured teaching physics and technology topics and those who did not favour them. Therefore, we formed different groups of trainee teachers and examined differences in their general knowledge, their interests, and their personalities and how those influenced their teaching preferences. Within this context, we also investigated whether a set of variables could predict group membership and showed which characteristics were typical for trainee teachers who favoured teaching physics and technology. To acquire more differentiated insights, we determined the characteristics of trainee teachers with the typical interest profile for kindergarten and primary-school teachers and of trainee teachers with an interest profile that would be more suitable for physics and technology teaching. By analysing the two different groups separately, we could highlight whether the relationships among general knowledge, personality, and self-confidence towards teaching physics and technology topics were the same between both groups.

Finally, once the significant relationships between the variables in the sample and in the different subsamples were acquired, regression models were applied to investigate how general knowledge, interests, and personality could be predictive of trainee teachers' confidence in teaching physics and technology. This final step allowed us to examine the prediction accuracy of trainee teachers' general knowledge, vocational interest, and personality in relation to their confidence in teaching physics and technology.

In summary, the following research questions were pursued in this study:

- How did trainee teachers assess their confidence in teaching physics and technology, and what were their self-assessments in regard to teaching other topics in social and natural sciences? How did they rank by popularity physical and technical teaching topics in a series of natural and social sciences topics? Which characteristics of general knowledge, vocational interest, and personality were related to trainee teachers' confidence and attitudes towards teaching physics and technology?
- How and what aspects of general knowledge, vocational interest, and personality did trainee teachers who favoured teaching physics and technology differ from trainee teachers who did not? Which subgroup-specific relationships were found in the subsamples?
- How and what aspects of general knowledge and personality did trainee teachers with an interest profile typical for kindergarten and primary-school teachers differ from trainee teachers with an interest profile that was considered more suitable for physics and technology teaching? Which subgroup specific relationships were found in the subsamples?
- Which of the assumed influence factors (general knowledge, vocational interest, and personality) could accurately predict trainee teachers' confidence? Were there differences in those influences depending on the group affiliations?

2. Materials and Methods

2.1. Research Design

A cross-sectional study design was followed to simultaneously measure the predictor variables (i.e., general knowledge, interests, and personality) and the criterion variables (i.e., attitude, perceived capability) in trainee teachers of kindergarten and primary school. Therefore, the present work is mainly descriptive, as it determined the distribution of numerous characteristics at once, and it identified correlations between variables as well as differences between groups of trainee teachers [79].

Accordingly, quantitative survey methods were used to collect data from a large number of trainee teachers as precisely as possible to examine statistical interactions. The quantitative approach was used to ensure an objective and uniform assessment of the investigated constructs [79]. Therefore, it was advantageous that structured and validated data-collection instruments were available for the variables studied and that they were suitable for the sample of trainee teachers. Data relative to the criterion variables were collected with the "Nature–Human–Society" (NMG) questionnaire, and those relative to the predictor variables were collected with a German general knowledge test called "Bochumer

Wissenstest" (BOWIT), the RIASEC test "Allgemeiner Interessen-Struktur-Test—Revision" (AIST-R), and the Big-Five-Inventory 10. The questionnaires and tests used are presented in more detail below (see Section 2.3).

2.2. Sample

For this investigation, German-speaking trainee teachers enrolled in their first year of a study program for kindergarten and primary-school teachers were included in the sample. Since gender differences in general knowledge and interest orientation have been reported in the literature [34], male trainee teachers, of whom there were few, had to be excluded from the sample. Data was collected at the University of Teacher Education Bern (Switzerland). Trainee teachers were recruited during an academic course and were asked to complete a series of questionnaires and knowledge tests within one hour. Participating in this paper-and-pencil survey was voluntary and anonymous.

The sample comprised 196 female trainee teachers with an average age of 22.43 years (SD = 5.35) and a median age of 21 years. During their previous education in secondary schools, 75 participants (38.3%) chose a social or pedagogical focus, 37 (18.9%) chose a natural science or technical focus, 22 (11.2%) chose an economic focus, 14 (7.1%) chose another focus, 8 (4.1%) chose a literary, historical, or geographical focus, 8 (4.1%) chose a professional focus, and 6 (3.1%) chose an artistic focus. Twenty-six participants (13.3%) did not provide any information about their previous education.

2.3. Measuring Instruments

2.3.1. The Nature–Human–Society Questionnaire (In German: Natur–Mensch–Gesellschaft Fragebogen, i.e., NMG Questionnaire)

The NMG questionnaire [80] was developed for kindergarten and primary-school trainee teachers in Switzerland to collect their personal assessments regarding various natural and social sciences. Participants were asked to assess 63 statements on a 5-point Likert scale (1= do not agree at all, 5 = fully agree). The statements referred to one of the following seven content areas: social/ethical, cultural/religious, historical/political, geographical, economic, physical/technical, and biological. For each content area, the following three scales were formed from the item pool: first, the scale "affection", referred to positive feelings and affinity to a specific NMG-content area; second, the scale "perceived capability", described self-efficacy in the field of disciplinary knowledge and the ability to accumulate and impart knowledge in a specific content area of NMG; third, the scale "experience", included positive memories and familiar experiences acquired in formal and informal learning settings regarding a specific NMG-content area.

The internal consistency of the three scales concerning all NMG-content areas ranged between 0.68 and 0.88 [80].

On the same page with the questionnaire, participants responded to a Q-sort task in which they had to rank 12 curriculum topics in the natural and social sciences, according to their individual teaching preferences. This ranking also evidenced their three favourite topics to teach [80].

2.3.2. General Knowledge Test (In German: Bochumer Wissenstest, i.e., BOWIT)

The short version of the Bochum knowledge test [38] was used to measure students' general knowledge. The single-choice questions (with four answer options and one additional option for "no answer is correct") of the test referred to the semantic declarative knowledge of the following disciplines: arts/architecture, biology/chemistry, food/sports/health, geography/traffic, history/archaeology, society/politics, maths/physics, philosophy/religion, language/literature, technology/information, and economy/law. The 45 questions of the BOWIT short version were assigned to two scales: "social sciences and humanities" and "natural sciences and technology". Both knowledge domains were found by factor analysis of the BOWIT full version, which is composed of 154 items and tests general knowledge in the different aforementioned disciplines. Since the indicated processing time for the BOWIT full version is 45 min, the more time-efficient short version was chosen for this study, considering that participants were asked to complete other questionnaires and that knowledge tests demand high cognitive effort.

BOWIT is a valid measurement and has reliability values exceeding 0.90. However, the reliability of the BOWIT short version had not been separately measured by the BOWIT authors [38].

2.3.3. General Interest Structure Test, Revised (In German: Allgemeiner Interessen-Struktur-Test, Revised, i.e., AIST-R)

To detect trainee teachers' vocational interest profiles, participants were asked to complete the German instrument AIST-R [54]. This questionnaire comprises 60 activities that participants should rate on a 5-point Likert scale according to their interests (1 = dislike, 5 = like). The items referred to the six interest orientations of Holland's RIASEC model [55], which can be described as follows:

The "realistic interest" (R) is typical for individuals who favour practical working activities, for example, with machines in agriculture or manufacturing. The "investigative interest" (I) is dominant in individuals who prefer intellectual and explorative scientific activities, especially in the field of mathematics and science. The "artistic interest" (A) is often found in people who enjoy being creative and expressive, for example, in the arts, music, drama, or writing. A "social interest" (S) is typically found in individuals who enjoy working with people, helping activities, and teaching. The "enterprising interest" (E) is common among people who prefer to lead and influence others so that they are often in positions of power and are focused on political and economic profit. Finally, the "conventional interest" (C) is typical for people who favour administrative activities, such as analysing numbers and data. A person's interest profile is derived from the three most pronounced interest orientations. In Hollands theory, there are typical interest profiles for certain occupational groups. For example, a social, artistic, and enterprising orientation (SAE) is the typical interest profile of kindergarten and primary-school teachers [54,55].

The internal consistencies of the six AIST-R scales range between 0.82 and 0.87 [54].

2.3.4. Big Five Inventory 10 (BFI-10)

The 10-item Big Five inventory [81] is a short questionnaire with 5-point Likert scale items (1 = does not apply, 5 = fully applies) that measure how pronounced the Big Five personality traits (i.e., extraversion, agreeableness, conscientiousness, neuroticism, and openness) are in a person. The Big Five factors model was built using the lexical approach and was a result of the structural analyses of many adjectives describing a person's behaviour [82]. The extracted Big Five can capture interindividual differences in personality and are characterised as follow:

"Extraversion" implies individual characteristics, such as sociability, activity, eloquence, and assertiveness. People with low scores in extraversion are usually described as introspective, quiet, and reserved. "Agreeableness" entails a high level of altruism and a tendency to trust and cooperate with others and be compliant. People with low scores in agreeableness tend to be reserved, critical, and sceptical. "Conscientiousness" describes the eagerness of a person, their endurance, their discipline, and their reliability. Individuals with low scores on conscientiousness are sometimes perceived as careless, indifferent, and free-spirited. "Neuroticism" describes how emotionally stable a person is. Individuals who are high in neuroticism tend to be insecure, nervous, anxious, and depressed. People with a low score in neuroticism are perceived as more confident, carefree, relaxed, and emotionally stable. "Openness" describes a person's interest in new experiences and impressions. Individuals with a high score in openness are usually curious and imaginative, whereas individuals with low scores tend to have fixed views and little interest in new ideas and are often perceived as conservative [81–83].

The basis of the BFI-10 is the 44-item Big Five inventory [83]. This abbreviated instrument has 10 items and has proven to be highly popular due to its convenience and applicability. The authors of the German 10-item version [81] calculated test–retest reliability scores between 0.49 and 0.62. [84].

2.4. Data Analyses

The statistical software SPSS 27 was used for the quantitative data analyses. Before starting with the analyses, data were prepared. Incorrect entries were filtered out and corrected by rechecking the questionnaire. One questionnaire was not included in the sample because it was not filled in completely.

First, an exploratory data analysis was conducted. The boxplot was used to check for outliers in the data. All scores within three standard deviations were considered since they were plausible scores. No extreme outlier was in the sample. According to the central limit theorem, normal distributions can be assumed for samples larger than 30 cases so that an important prerequisite for parametric tests can be given [85–88]. Nevertheless, the distribution of variables was also graphically checked with histograms. Normality distribution tests, such as the Kolmogorov–Smirnov-Test or the Shapiro–Wilk-Test, were not applied because they are inappropriate for testing normal distributions in large samples [88,89].

Descriptive parameters were calculated for each scale to indicate frequencies, means, and standard deviations. Cronbach's alphas were calculated to estimate the internal consistency of the scales [84]. However, in one questionnaire, namely BFI-10, the calculation of Cronbach's alpha was not possible, because the scales were formed by only two items. For these scales, the reliability was evaluated with the Spearman–Brown coefficient.

Subsequently, bivariate correlation analyses by Pearson were conducted for the sample and the different subgroups to investigate the linear relationship between two variables. As a prerequisite, linearity was given by the sample and subsample data. For the Pearson correlation coefficients, normal distribution is not decisive, but for the significance test it is necessary [85–87]. Therefore, the Spearman rank correlation was additionally used for those variables that evidenced a deviation from the normal distribution, and it was checked whether the significance ranges deviated or not. Since no deviation in significance was observed, the Pearson scores were maintained.

Furthermore, differences between subgroups were calculated with the t-test for independent samples, and effect sizes were estimated by Cohen's *d*. Previously, Levene's test was used to assess the equality of variances. Depending on whether the result of Levene's test was significant or not, either the t-test for unequal variances or that for equal variances was used. T-tests for independent samples are generally considered robust to possible violations of the normal distribution assumption [86,87,90].

Finally, significant findings were considered for multivariate analyses, such as discriminant analyses or linear regression analyses. As a requirement of discriminant analysis, the equality of covariance matrices was checked with Box's M test statistic [85,87]. In addition, covariance matrices were compared graphically to check whether there were differences greater than factor 10 inside the cells or whether the sign inside the cells changed. The prerequisites of the linear regression analyses were also checked, but this happened post-hoc: the normal distribution of residuals in regression analyses were checked graphically by P-P-plots. The autocorrelation of residuals in the regression analyses were checked by the Durbin–Watson test. Heteroskedasticity was checked in the data displayed on scatterplots of the standardized residuals and predictors. Multicollinearity was checked by the variance influence factor (VIF) score and by the tolerance score. Furthermore, possible outliers in regression models were detected post-hoc by the SPSS residual diagnostic function (considering three standard deviations) and by leverage and Cook's distance measures. If detected outliers were plausible and did not result from random ticking, they were not excluded from the analysis. To be sure that the regression models were not wrongly influenced by these, the analyses were repeated without outliers, and no relevant influence was observed.

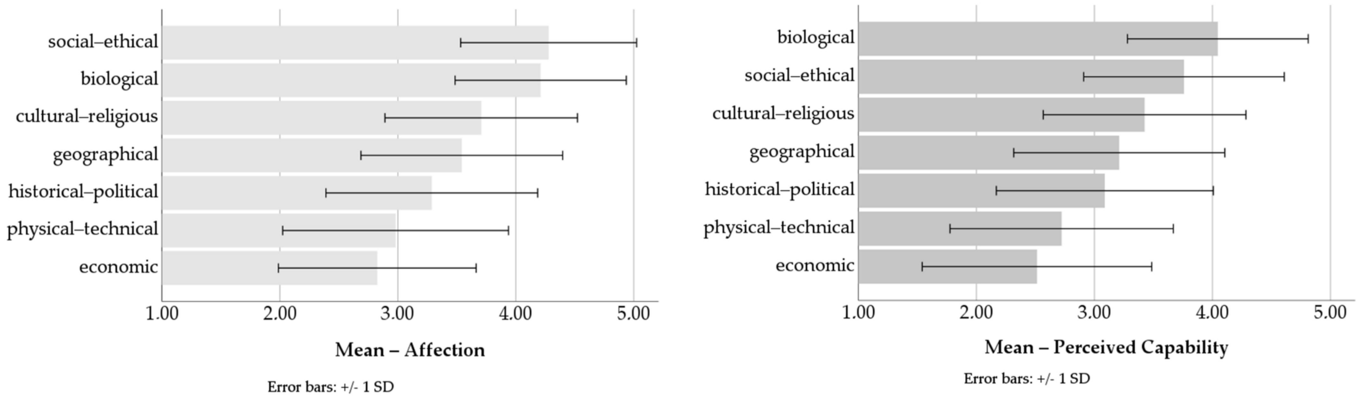
3. Results

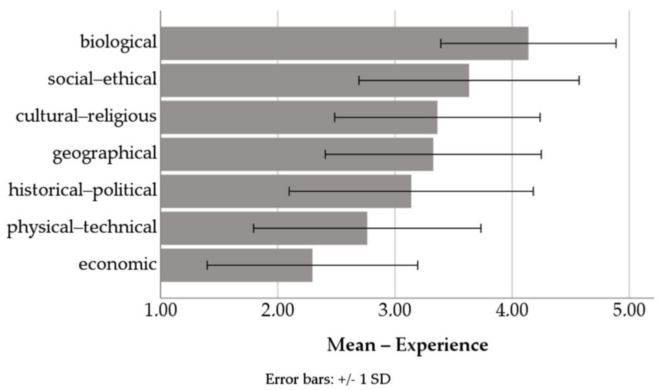
3.1. Descriptive Statistics

3.1.1. The Samples' Affection, Perceived Capability, and Experience Regarding Different NMG-Content Areas: Results of the NMG Questionnaire

In all three scales of the NMG questionnaire, namely affection, perceived capability, and experience, the participants achieved the highest scores in the biological and social–ethical content areas, whereas the lowest scores of the three NMG-scales were consistently evident in the physical–technical and economic content areas. The scores of the cultural–religious, geographical, and historical–political content areas were mid-range.

All means and standard deviations are shown in Figure 1. The internal consistency of all NMG scales was evaluated with Cronbach's alpha. The results ranged from 0.70 to 0.83 for the affection scales, from 0.68 to 0.80 for the perceived-capability scales, and from 0.77 to 0.86 for the experience scales.





NMG content areas	Aff M (SD)	PC M (SD)	Exp M (SD)
biological	4.21 (0.73)	4.05 (0.77)	4.14 (0.75)
social–ethical	4.28 (0.75)	3.76 (0.85)	3.63 (0.94)
cultural–religious	3.71 (0.82)	3.43 (0.86)	3.36 (0.88)
geographical	3.54 (0.86)	3.21 (0.89)	3.33 (0.92)
historical–political	3.29 (0.90)	3.09 (0.92)	3.14 (1.04)
physical–technical	2.98 (0.98)	2.72 (0.95)	2.76 (0.97)
economic	2.83 (0.96)	2.51 (0.97)	2.30 (0.90)

Legend: Aff = affection, PC = perceived capability, Exp = experience

Figure 1. Means (M) and standard deviations (SD) of the NMG questionnaire scales of affection, perceived capability, and experience for all NMG content areas (n = 196).

For further analyses, only scales regarding the physical–technical area were considered. Therefore, at this point, only distributions of these scales were reported. The histograms of the physical-technical affection scale, of the physical–technical perceived capability scale and of the physical–technical experience scale indicated a normal distribution.

When questioned regarding their three favourite topics to teach, the trainee teachers chose the following topics from a list of 12 NMG curricula topics, including social and natural science areas: "earth and how people live in other places" was mentioned 97 times (49.5%), "animals, woods, fields, ponds, and flowers" 93 times (47.4%), "living with other people" 86 times (43.9%), "life in early epochs" 56 times (28.6%), "think about oneself" 50 times (25.5%), "the sun, the moon, stars, planets, and universe" 49 times (25.0%), "one's hometown or place of residence" 44 times (22.4%), "how things are produced and traded" 30 times (15.3%), "water, air, and weather" 30 times (15.3%), "religions and traditions" 28 times (14.3%), "materials and their properties" 13 times (6.6%), and "technology, electricity, and innovations" 12 times (6.1%).

3.1.2. The Samples' General Knowledge: The Results of BOWIT

In the BOWIT knowledge test, the participants had an average test score of 13.83 (*SD* = 3.53) in the knowledge domain of social sciences and humanities and an average test score of 4.67 (*SD* = 2.54) in the knowledge domain of the natural sciences and technology. On the total BOWIT general-knowledge scale, the mean score was 18.49 (*SD* = 4.84), where a score of 45 points was the maximum that participants could obtain. In their norm sample of female students, the authors of BOWIT indicated a mean score of 20.25 and a standard deviation of 7.34. However, in the total norm sample, the mean was 28.76 and the standard deviation was 8.83 [33].

Concerning the distribution of the BOWIT knowledge scores in the domain of social sciences and humanities, 35 (17.9%) out of the 196 participants answered up to one-third of the questions correctly, 155 (79.1%) answered between more than one-third and up to two-thirds of the questions correctly, and 6 (3.1%) answered more than two-thirds of the questions correctly. In the knowledge domain of natural sciences and technology, the sample scores were distributed as follow: 117 (59.7%) participants answered up to one-third of the questions correctly, 77 (39.3%) answered more than one-third and up to two-thirds correctly, and 2 (1.0%) answered more than two-thirds correctly. On the total BOWIT general-knowledge scale, 58 (29.6%) received one-third of the points, 134 (68.4%) received more than one-third and up to two-thirds of the points, and 4 (2.0%) received more than two-thirds of the points.

Histograms of BOWIT scores suggested that all three BOWIT scales evidenced a normal distribution. The Cronbach's alpha was 0.61 for the BOWIT knowledge domain of the social sciences and humanities and 0.56 for the BOWIT knowledge domain of the natural sciences and technology. For the total BOWIT general-knowledge scale, it was 0.58.

3.1.3. The Samples' Vocational Interests: The Results of AIST-R

On average, participants achieved the highest scores on the AIST-R scales in the social (*M* = 40.54; *SD* = 5.82), artistic (*M* = 35.60; *SD* = 6.62), and enterprising (*M* = 32.05; *SD* = 6.21) interest areas. These scores were followed by the investigative (*M* = 29.95; *SD* = 6.47), realistic (*M* = 26.01; *SD* = 6.60), and conventional (*M* = 26.00; *SD* = 5.73) interest areas.

The histograms of AIST-R scales showed a normal distribution. The distribution of AIST-social scale, however, was slightly skewed to the left (skewness = −0.58) but could also be considered as normally distributed. The AIST-R scores of this sample produced a Cronbach's alpha range between 0.78 and 0.84.

Considering the RIASEC vocational interest profiles of the individual participants while not considering the order within the pattern, 65 trainee teachers (33.2%) had a typical interest pattern of primary-school teachers; that is, SAE (i.e., social, artistic, and enterprising) [43]. Ninety-nine participants (50.5%) still showed two components of the SAE profile; that is, 28 (14.3%) had one and 3 (1.5%) had none. In total, 182 participants (92.4%) included S for social in their RIASEC profile, whereas 79 participants (40.3%) had the I for investigative in their interest profile. In 67 participants (34.2%), the SI profile was dominant, implying a pronounced interest in the social and investigative areas.

3.1.4. The Samples' Personality Traits: Results of BFI-10

In the scales of Big Five personality traits, the average score was 3.89 (*SD* = 0.76) for conscientiousness, 3.53 (*SD* = 0.92) for extraversion, 3.08 (*SD* = 0.65) for neuroticism, 2.43 (*SD* = 0.73) for agreeableness, and 2.09 (*SD* = 0.95) for openness.

On analysing the histograms, the extraversion scale evidenced quite a normal distribution but was slightly left-skewed (skewness = −0.55); the agreeableness scale was normally distributed; the conscientiousness scale was quite normally distributed but was slightly left-skewed (skewness = −0.51); the neuroticism variable was clearly normally distributed; the distribution of the openness scale was approximately normally distributed and evidenced right-skewness (skewness = 0.73). The Spearman–Brown coefficient revealed scores between 0.23 and 0.79. To be more precise, the Spearman–Brown coefficient was 0.79 for extraversion, 0.68 for openness, 0.58 for neuroticism, 0.49 for conscientiousness, and 0.23 for agreeableness.

3.2. Correlations

Table 1 shows all the results of the conducted correlation analyses. Here, the linear relationships between the physical–technical scales and the variables of Big Five, BOWIT, and, if possible, AIST-R were analysed. The correlations were calculated for the total sample group and the subsamples with and without physics and technology as a favoured content to teach and for the interest-profile groups.

3.2.1. NMG Physical–Technical Scores and General Knowledge (BOWIT)

The BOWIT knowledge in the natural sciences and technology correlated very significantly with the physical–technical perceived-capability scale (n = 196, r = 0.24 **), the physical–technical experience scale (r = 0.23 **), and the physical–technical affection scale (r = 0.19 **). The total BOWIT general-knowledge scale correlated significantly with the physical–technical experience scale (r = 0.17 *), with the affection scale (r = 0.15 *), and with the perceived-capability scale (r = 0.15 *). The BOWIT knowledge in social sciences and humanities did not correlate significantly with any scale in the physical and technical area (see Table 1).

3.2.2. NMG Physical–Technical Scores and Vocational Interests (AIST-R)

All physical–technical scales in the NMG questionnaire correlated highly significantly with the investigative-interest scale (n = 196; affection: r = 0.66 ***, perceived capability: r = 0.53 ***, experience: r = 0.53 ***) and with the realistic-interest scale (affection: r = 0.56 ***, perceived capability: r = 0.52 ***, experience: r = 0.49 ***) of the AIST-R. Furthermore, significant correlations could be calculated between the conventional interest scale and the physical–technical affection scale (r = 0.17 *), as well as with the physical–technical experience scale (r = 0.14 *). Other statistically significant correlations between the AIST-R scales and the physical–technical scales of the NMG questionnaire were not found. The correlation scores of all scales are shown in Table 1.

3.2.3. NMG Physical–Technical Scores and Personality Traits (BFI-10)

The physical–technical perceived-capability scale was very significantly and negatively correlated with the Big Five trait of neuroticism (n = 196, r = −0.20 **) and significantly negatively correlated with extraversion (r = −0.14 *). The physical–technical experience scale also correlated significantly and negatively with the Big Five trait of extraversion (r = −0.14 *). There were no significant correlations between the physical–technical affection scale and the Big Five personality traits (see Table 1).

3.2.4. Correlations Separated by the Sub-Samples with and without Physics and Technology as Favoured Content to Teach

For these group-specific correlation analyses (see Table 1), the sample was divided into a group of trainee teachers who preferred teaching topics in physics and technology and a group who did not prefer it. Those participants who chose “technology, electricity, and innovations”, “water, air, and weather”, and/or “materials and their properties” as their first, second, or third favourite topic to teach in the Q-sort section of NMG questionnaire were included in the first group. This was the case for 49 trainee teachers. In contrast, 147 participants who stated that they preferred not to teach those topics were included in the second group.

Table 1. Correlations in the total group and in the subgroups. Relations of personality, general knowledge, and interests to physical–technical assessment.

	Total Sample (*n* = 196)			**Phy.–Techn. not Favourite (*n* = 147)**			**Phy.–Techn. Favourite (*n* = 49)**			**Interest Profile SAE (*n* = 65)**			**Interest Profile SI (*n* = 67)**		
NMG—physical–technical	**Aff**	**PC**	**Exp**	**Aff**	**PC**	**Exp**	**Aff**	**PC**	**Exp**	**Aff**	**PC**	**Exp**	**Aff**	**PC**	**Exp**
Big5—Extraversion	−0.10	−0.14 *	−0.14 *	−0.10	−0.11	−0.15 $^{+}$	−0.04	−0.14	−0.06	−0.15	−0.29 *	−0.22 $^{+}$	0.08	−0.06	−0.12
Big5—Agreeableness	−0.07	−0.04	−0.09	−0.14 $^{+}$	−0.04	−0.13	0.01	−0.13	−0.06	−0.30 *	−0.06	−0.15	−0.17	−0.13	−0.25 *
Big5—Conscientiousness	−0.01	−0.07	−0.04	−0.05	−0.07	−0.06	0.10	−0.06	−0.02	−0.01	−0.16	−0.13	−0.12	−0.17	−0.02
Big5—Neuroticism	−0.11	−0.20 **	−0.08	−0.01	−0.15 $^{+}$	−0.02	−0.30 *	−0.22	−0.18	−0.21 $^{+}$	−0.21 $^{+}$	−0.08	−0.13	−0.23 $^{+}$	−0.05
Big5—Openness	0.03	−0.03	−0.05	−0.01	−0.09	−0.08	0.01	0.13	0.05	−0.04	−0.07	−0.11	−0.09	−0.11	−0.11
BOWIT—Total	0.15 *	0.15 *	0.17 *	0.03	0.02	0.08	0.39 **	0.39 **	0.39 **	−0.01	−0.08	0.02	0.32 **	0.33 **	0.31 *
BOWIT—Soc.–Hum.	0.07	0.07	0.03	−0.06	−0.05	0.01	0.39 **	0.21	0.21	−0.19	−0.19	−0.11	0.28 *	0.23 $^{+}$	0.18
BOWIT—Sci.–Tec.	0.19 **	0.24 **	0.23 *	0.12	0.15 $^{+}$	0.14	0.21	0.44 **	0.44 **	0.25 *	0.11	0.19	0.26 *	0.32 **	0.31 *
AIST-Realistic	0.56 ***	0.52 ***	0.49 ***	0.56 ***	0.53 ***	0.50 ***	0.49 ***	0.45 **	0.40 **						
AIST-Investigative	0.66 ***	0.53 ***	0.53 ***	0.60 ***	0.52 ***	0.50 ***	0.74 ***	0.43 **	0.50 ***						
AIST-Artistic	0.08	0.08	0.12	0.15	0.19 *	0.20 *	0.06	−0.06	0.01						
AIST-Social	0.01	−0.10	−0.06	0.05	−0.07	−0.03	0.27	0.18	0.18						
AIST-Enterprising	0.01	0.01	−0.03	0.05	0.03	−0.04	0.16	0.20	−19						
AIST-Conventional	0.17 *	0.11	0.14 *	0.21 *	0.11	0.12	0.19	0.22	0.28 *						

Legend: Aff = NMG-affection; PC = NMG-perceived capability; Exp = NMG-experience. $^{+}$ = $p < 0.10$ a tendency to a significance; * = $p < 0.05$ significant; ** = $p < 0.01$ very significant; *** = $p < 0.001$ highly significant.

In the group that did not favour teaching physical or technological topics, all physical–technical scales correlated highly significantly with the AIST-R realistic scales (n = 147; affection: r = 0.56 ***, perceived capability: r = 0.53 ***, experience: r = 0.50 ***), and AIST-R investigative scales (affection: r = 0.60 ***, perceived capability: r = 0.52 ***, experience: r = 0.50 ***). In addition, significant correlations were evident between physical–technical affection and the AIST-R conventional scale (r = 0.21 *), between physical–technical perceived-capability and the AIST-R artistic scale (r = 0.19 *), and between physical–technical experience and the AIST-R artistic scale (r = 0.20 *). Furthermore, single physical–technical scales showed a tendency for a negative significant correlation with the individual Big Five traits, namely physical–technical affection and agreeableness ($r = -0.14^{+}$), physical–technical perceived-capability and neuroticism ($r = -0.15^{+}$), and physical–technical experience and extraversion ($r = -0.15^{+}$). Regarding the BOWIT knowledge scales, only a tendency for a significant correlation was evident between physical–technical perceived-capability and BOWIT knowledge in the natural sciences and technology ($r = 0.15^{+}$).

In the trainee teacher group that favoured teaching physics and technology topics, all physical–technical scales correlated highly significantly or very significantly with the AIST-R realistic scale (n = 49; affection: r = 0.49 ***, perceived capability: r = 0.45 **, experience: r = 0.40 **), and the AIST-R investigative scale (affection: r = 0.74 ***, perceived capability: r = 0.43 **, experience: r = 0.50 ***). A significant correlation again emerged between the physical–technical experience scale and the AIST-R conventional scale (r = 0.28 *). In this group, there were also very significant correlations between all physical–technical NMG-scales and the BOWIT general-knowledge scale (affection: 0.39 **, perceived capability: 0.39 **, experience: 0.39 **). Two physical–technical NMG-scales correlated very significantly with BOWIT knowledge in science and technology (perceived capability: r = 0.44 **, experience: r = 0.44 **) and one physical–technical NMG-scale correlated very significantly with BOWIT knowledge in the social sciences and humanities (affection: 0.39 **). A significant negative correlation with neuroticism (r = −0.30 *) was identified on the physical–technical affection scale.

3.2.5. Correlations Separated by the Interest-Profile Groups SAE and SI

One group was limited to the typical interest profile for kindergarten and primary-school teachers, which was characterised by social, artistic, and enterprising interest orientations (SAE). Social interest (S) was considered the best predictor for people who chose a teacher training program and became teachers, while the investigative interest (I) characterised people with a strong affinity for the sciences [54]. For this reason, a second group comprised participants with social and investigative interest profiles (SI) that was considered more suitable for teaching physics and technology.

In the SAE interest-profile group, the physical–technical affection scale correlated significantly with BOWIT knowledge in the natural sciences and technology (n = 65, r = 0.25 *). In personality traits, some negative correlations were evident: the physical–technical perceived-capability scale correlated significantly and negatively with extraversion (r = −0.29 *), and the physical–technical experience scale correlated somewhat negatively with extraversion ($r = -0.22^{+}$). The physical–technical affection scale correlated significantly negatively with agreeableness (r = −0.30 *). A tendency towards significant, negative correlations was found between the physical–technical affection scale and neuroticism ($r = -0.21^{+}$) and between the physical–technical perceived-capability scale and neuroticism ($r = -0.21^{+}$). As evidenced in Table 2, there were no other significant correlations found in the SAE subgroup.

In the interest-profile group SI, all physical–technical scales correlated very significantly or significantly with the BOWIT knowledge in natural sciences and technology (n = 67; affection: r = 0.26 *, perceived capability: r = 0.32 **, experience: r = 0.31 *). The total BOWIT general-knowledge scale also correlated very significantly with the physical–technical perceived-capability scale (r = 0.33 **), similar to the affection scale (r = 0.32 **), as well as significantly with the experience scale (r = 0.31 *). The BOWIT knowledge in social sciences and humanities correlated significantly with the physical–technical affection scale (r = 0.28 *) and tendentially significantly with the perceived-capability scale ($r = 0.23^{+}$). Concerning the correlations between the physical–technical scales and the personality traits, the following results were shown for the SI interest-profile group: the Big Five trait of agreeableness correlated significantly and negatively with the physical–technical experience scale (r = −0.25 *), and the Big Five trait of neuroticism correlated tendentially significantly and negatively with the physical–technical perceived-capability scale ($r = -0.23^{+}$). Other significant correlations between the Big Five personality traits and the physical–technical NMG-scales were not found (see Table 1).

Table 2. Linear regression analyses with the total sample and the different sub-samples. Criterion: perceived capability in physical–technical content.

	ANOVA F, (df)	R^2/R_{adj}^2	Predictors	*b*	Tolerance	VIF
Total sample (*n* = 196)	24,345 ***, (5)	0.39/0.38	AIST—Realistic	0.33 ***	0.546	1.831
			AIST—Investigative	0.25 **	0.521	1.918
			Big 5—Extraversion	−0.17 **	0.925	1.081
			Big 5—Neuroticism	−0.16 *	0.901	1.109
			BOWIT—Sci.-Tec.	0.13 *	0.935	1.069
Phy.–tec. not favourite (*n* = 147)	17,318 ***, (5)	0.33/0.31	AIST—Realistic	0.32 ***	0.492	2.031
			AIST—Investigative	0.30 **	0.449	2.226
			Big 5—Neuroticism	−0.07	0.925	1.082
			BOWIT—Sci.-Tec.	0.05	0.911	1.097
			AIST—Artistic	0.01	0.833	1.200
Phy.–tec. favourite (*n* = 49)	12,080 ***, (2)	0.35/0.32	AIST—Realistic	0.40 **	0.951	1.051
			BOWIT—Sci.-Tec.	0.35 **	0.952	1.051
Interest profile SAE (*n* = 65)	5655 **, (2)	0.15/0.13	Big 5—Extraversion	−0.34 **	0.963	1.039
			Big 5—Neuroticism	−0.27 *	0.963	1.039
Interest profile SI (*n* = 67)	4706 *, (2)	0.13/0.10	BOWIT—Sci.-Tec.	0.28 *	0.946	1.057
			Big 5—Neuroticism	−0.17	0.946	1.057

Legend: * = $p < 0.05$ significant; ** = $p < 0.01$ very significant; *** = $p < 0.001$ highly significant.

3.3. Group Differences and Discriminant Analysis

3.3.1. Differences between Groups with and without Physics and Technology as Favourite Content to Teach

In this section, differences were analysed between the trainee teachers who favoured teaching physical and technical topics and those who did not. The effect sizes (Cohen's *d*) for the mean differences in general knowledge, vocational interest, and personality characteristics are shown in Figure 2.

Regarding the Big Five personality traits, the participants who did not favour teaching physical–technical topics (n = 147, M = 3.16, SD = 0.96) had higher scores in neuroticism, as compared to the participants who favoured teaching those topics (n = 49, M = 2.87, SD = 0.86). The t-test indicated a tendency towards significance ($t = 1.969^{+}$) and an effect size of Cohen (d) of 0.32. For all other Big Five scales, no statistically significant group differences were evident. On the AIST-R questionnaire, the greatest group difference was found on the social scale. The trainee teachers who did not favour teaching physical–technical topics (M = 41.84, SD = 4.93) had highly significantly (t = 5.195 ***, d = 0.91) higher scores, as compared to the trainee teachers who favoured teaching physical–technical topics (M = 36.63, SD = 6.39). Furthermore, a very significant group difference was calculated on the AIST-R investigative scale (t = −3.333 **, d = −0.56): participants who did not favour teaching topics in physics and technology (M = 29.08, SD = 6.44) showed lower scores on the investigative scale than those who did (M = 32.55, SD = 5.91). Moreover, a very significant group difference was evident on the AIST-R enterprising scale (t = 3.223 **, d = 0.52): trainee teachers who did not favour teaching physics and technology topics (M = 32.86, SD = 5.87) showed higher scores on the enterprising scale than those who favoured teaching physics and technology topics (*M* = 29.63, *SD* = 6.62). A significant difference could be calculated on the AIST-R realistic scale ($t = -2.337$ *, $d = -0.37$): trainee teachers who did not favour teaching topics in physics and technology (*M* = 25.38, *SD* = 6.32) had lower scores than participants who favoured these topics (M = 27.89, *SD* = 7.09). A further significant difference ($t = 2.041$ *, $d = 0.33$) was also evident on the AIST-R artistic scale: The participants who did not favour teaching topics regarding physics and technology (*M* = 36.15, *SD* = 6.75) showed higher scores than participants who favoured teaching those (*M* = 33.94, *SD* = 5.97). There were no significant group differences among the BOWIT general knowledge scales.

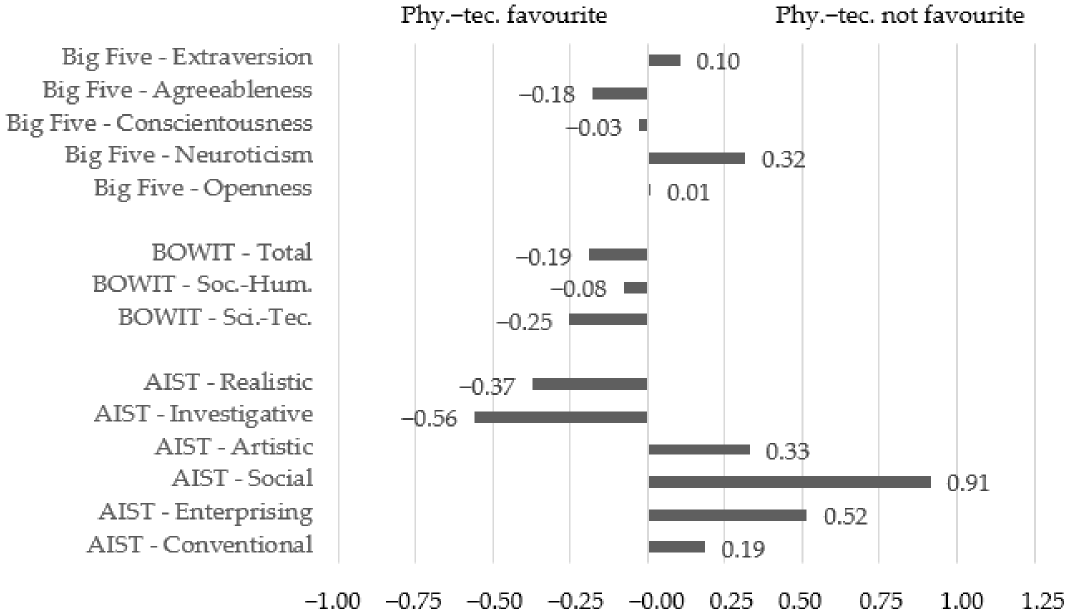


Figure 2. Effect sizes by Cohen *(d)*: differences between trainee teachers who favoured teaching physical and technical topics (*n* = 49) and those who did not (*n* = 147).

3.3.2. Discriminant Analysis: Allocation to the Groups with and without Physics and Technology as Favoured Content to Teach

Considering the sample sizes, a linear discriminant analyses was conducted to predict whether or not a participant was in the group who favoured teaching physics and technology. Predictor variables included AIST-R realistic, AIST-R investigative, AIST-R enterprising, and AIST-R social since we had observed the highest differences among these in both groups. Box's M statistics (13.340; not significant) indicated that the assumption of equal covariance matrices was given. The covariance matrices of both groups were also calculated manually, and no critical differences between the values were observed.

The discriminant function revealed a significant association between the groups and the predictors (chi-squared = 50.384 ***, *df* = 4), accounting for 23.1% of between group variability (Wilks' lambda = 0.769). This parameter was considered poor. The eigenvalue of 0.300 and the canonical correlation of 0.480 also evidenced that the variance was not explained well. The structure matrix revealed three relevant predictors, namely AIST-R social (0.770), AIST-R investigative (−0.437), AIST-R enterprising (0.422), whereas the variable AIST-R realistic was identified as a not-meaningful predictor (−0.306). The cross validated classification showed that, overall, 80.1% of the participants were classified to the correct group.

3.3.3. Differences between the SAE and SI Interest-Profile Groups

The participants with an SAE interest profile differed from the participants with an SI interest profile highly significantly in terms of the personality trait extraversion

(t = 3.630 ***, d = 0.68): The SAE sample (M = 3.87, SD = 0.72) showed a higher mean score in extraversion, as compared to the SI sample (M = 3.31, SD = 1.03).

Regarding the personality trait openness, a highly significant difference (t = −2.765 **, d = −0.50) was evident between the participants with SAE vs. SI interest profiles: the SAE sample had a lower score (M = 1.85, SD = 0.66) in openness, as compared to the SI sample (M = 2.25, SD = 1.03).

No other group differences were found in the other Big Five variables nor in the knowledge test scores of BOWIT.

3.4. Linear Regression Analyses: Which Variables Are Able to Predict Whether Anyone Has a High or Low Perceived Capability in the Physical–Technical Area?

In the following linear regression analyses, we tried to predict physical–technical perceived capability in the trainee teachers and tested the empirical quality of the selected models. Regression analyses were carried out with the total sample group and the different subgroups (see Table 2). In the regression models, we included variables that were identified as meaningful in the previous analyses. In cases of a small sample size, we selected the most suitable predictors from a theoretical point of view. All assumptions for linear regression analyses were as follows: Pearson's correlations showed linearity; all the variance inflation factor (VIF) scores were lower than 10 with tolerance scores above 0.1 so that multicollinearity could be excluded; and the Durbin–Watson statistics revealed that there were no independent errors by the residuals, and heteroscedasticity was not identified in the data; the P-P-plots of all regression models evidenced normally distributed residuals.

First, a linear regression was calculated for the whole sample (n = 196), including the predictors AIST-R realistic, AIST-R investigative, extraversion, neuroticism, and BOWIT knowledge in natural sciences and technology. The model differed highly significantly from a random explanation (ANOVA: $F(df = 5)$ = 24.345 ***). The tested model explained 38% of the variance (R^2 = 0.39, R^2_{adj} = 0.38). The variables AIST-R realistic (b = 0.33 ***), AIST-R investigative (b = 0.25 **), extraversion (b = −0.17 **), neuroticism (b = −0.16 *), and BOWIT knowledge in natural sciences and technology (b = 0.13 *) significantly predicted trainee teachers' perceived capability in the physical–technical area.

In the linear regression analysis for the group who did not favour teaching physics and technology content (n = 147), the variables AIST-R realistic, AIST-R investigative, and AIST-R artistic as well as neuroticism and BOWIT knowledge in natural sciences and technology were included to predict the criterion of perceived capability in the physical–technical area. The model was significant (ANOVA: $F(df$ = 5) = 17.318 ***) and explained about 31% of the variance (R^2 = 0.33, R^2_{adj} = 0.31). The variables AIST-R realistic (b = 0.32 ***) and AIST-R investigative (b = 0.30 **) predicted the criterion of perceived capability in the physical–technical area to be significantly high and very significant, respectively. The variables neuroticism (b = −0.07), BOWIT knowledge in natural sciences and technology (b = 0.05), and AIST-R artistic (b = 0.01) did not significantly predict the criterion.

In the group with the participants who favoured teaching physics and technology content (n = 49), a regression analysis including the predictors AIST-R realistic and BOWIT knowledge in natural sciences and technology showed the following results: the model differed significantly from a random explanation (ANOVA: $F(df$ = 2) = 12.080 ***) and explained 32% of the variance (R^2 = 0.35, R^2_{adj} = 0.32). The variables AIST-R realistic (b = 0.40 **) and knowledge in natural sciences and technology (b = 0.35 **) very significantly predicted the criterion.

For participants with an SAE interest profile (n = 65), a further linear regression analysis was conducted. In the analysis, the variables extraversion and neuroticism were included. The model was significant (ANOVA: $F(df$ = 2) = 5.655 **) and explained 13% of the variance (R^2 = 0.15, R^2_{adj} = 0.13). Extraversion (b = −0.34 **) and neuroticism (b = −0.27 **) very significantly predicted perceived capability.

Furthermore, a separate linear regression analysis was performed for participants with an SI interest profile (n = 67). As predictors, neuroticism, and BOWIT knowledge in natural sciences and technology were included. The model differed significantly from a random explanation (ANOVA: $F(df = 2) = 4.706$ *) and explained 10% of the variance ($R^2 = 0.13$, $R^2_{adj} = 0.10$). The variable BOWIT knowledge in natural sciences and technology ($b = 0.28$ *) was able to significantly predict the trainee teachers' perceived capability in the physical–technical area, whereas the variable neuroticism could not.

4. Discussion

The first part of this section clarifies how the content area of physics and technology was assessed by kindergarten and primary-school trainee teachers and how the sample was characterised regarding the assumed influencing variables.

Generally, when the scales of the NMG questionnaire were considered, it was evident that for kindergarten and primary-school trainee teachers, the physical–technical content area was one of the most unpopular across the whole spectrum of natural and social sciences. While the biological and social–ethical content areas were the most popular, the physical–technical content area ranked at the second-to-last place, only superseding the economic content. The ranking emerged broadly in terms of gained experience, affection, and perceived capability. This indicated that kindergarten and primary-school trainee teachers generally had a comparatively lower affinity for as well as fewer positive experiences and weaker self-confidence in those areas than in most other content areas of the NMG subject. These results were in line with other studies [4,5,35,75].

However, we determined the need to differentiate the factors further as there appears to be few students who favour physics and technology topics and feel confident about their ability to master them. Therefore, this study investigated to what these assessments were related and to clarify what factors were behind the difference. Among all the considered variables (e.g., general knowledge, interest, and personality), some significant correlations were found with the self-assessments concerning physics and technology content. However, initially we will describe the general characteristics of these factors in the sample.

General knowledge was rather low in this sample, which was in line with results from other studies that reported primary-school teachers had comparatively low general knowledge. The same results were found regarding knowledge in science, which was below the standard, according to comparative studies on students in educational science [46]. When we examined the correlation with knowledge, it became evident that the levels of general knowledge and knowledge in science and technology were closely related to perceived capability, affection, and experience in physics and technology content. This indicated that, especially for the trainee teachers with a high perceived capability, affinity, and positive experiences in physics and technology subjects, they had more knowledge, as compared to trainee teachers with a low perceived capability, as well as those with a lower affinity or worse experiences in this field. Bell and Kozlowski [91] found similar interactions between knowledge and self-efficacy while also considering performance in an undergrade student sample.

Our sample showed high social, artistic, and enterprising vocational interests. These results corresponded to the typical interest profile of primary-school teachers, the SAE interest profile. According to Holland, a high social interest was necessary for kindergarten and primary-school teachers, as they must interact with other people in their professional life, especially with children, and need to establish interpersonal relationships [54,55]. If an individual had such a "person orientation" [57], it was more probable that they would align well with this profession. According to Holland's theory, teachers in physics and technology should also have investigative and realistic interests [54,55]. Similarly, correlation analyses in this study consistently showed strong correlations between trainee teachers' attitudes and confidence toward the physical–technical content area and investigative and realistic interests. These results were in line with other empirical studies on the same or similar target groups [60,62]. Raising questions, making scientific inquiries, and clarifying facts in the real world as well as solving concrete problems in the physical world by exploring and working with objects and machines are typical activities of people who work as physicists or engineers [54].

The personalities of the participants in this study were characterised using the Big Five model. The most evident personality traits in the sample were conscientiousness and extraversion. This result was partly in line with other studies indicating that future educators showed particularly high extraversion. High expressions in these two personality traits have been considered favourable for professional success and satisfaction, along with having low expressions in neuroticism [73]. The correlation analyses evidenced that neuroticism, particularly, was negatively correlated with trainee teacher's perceived capability in teaching physical-technical contents, but extraversion also correlated negatively with it. This indicated that trainee teachers with high confidence in teaching physics and technology content have less emotional instability and extraversion. These two personality traits have also been characteristics of physicists [72].

In the second part of this section, we focus on the question of who favoured teaching physical–technical contents in kindergarten and primary school. Commonly, physical and technical topics were not among the favoured topics to teach by prospective kindergarten and primary-school teachers. The most popular topics have been reported as those related to animate nature and human life, whereas those related to inanimate nature consistently fall to the bottom in terms of teachers' preferences. The results of the Q-sort procedure were in line with the self-assessments in the NMG questionnaire as well as with other studies focusing on teaching science or teaching NMG [5,9,35]. This indicated that trainee teachers, in general, have not been keen on teaching topics related to inanimate nature. However, due to their teaching mandate, teachers must do so. Nonetheless, a small number of trainee teachers chose physical or technical topics as one of their top three to teach among the NMG subject. Therefore, we will now discuss what distinguishes this group from the group of trainee teachers who did not choose physical or technical topis as their favoured topics to teach.

The results of group analysis indicated that differences between trainee teachers who preferred teaching physical or technological topics and those who did not were found primarily in their interests. Trainee teachers who preferred to teach physics and technology have low social, enterprising, and artistic interests and high investigative and realistic ones, whereas kindergarten and primary-school trainee teachers who did not prefer teaching physics and technology topics did not share a "thing orientation"; rather, they focused on a "person orientation", according to Prediger [57]. Moreover, individuals who did not favour teaching physics and technology appeared to have more emotional instability since they had higher neuroticism scores, and individuals who favoured teaching physics and technology appeared more emotionally stable. However, the effect sizes of the differences (by Cohen's d) in neuroticism, artistic, and realistic interests were considered small, which indicated less perceptible differences among subjects. However, the effect sizes of the differences among social interests were considered large, and those of investigative and enterprising interests, medium. Similar results regarding social and investigative interests were also found in secondary-school science trainee teachers [59,60,62].

We also examined how well the variables classified participants into both groups with and without physics and technology as favoured teaching content. The most accurate variables for classifying participants were the social, investigative, and enterprising interests, whereas realistic interest played a less important role, as the discriminant analyses showed. However, the parameters of the discriminant analysis did not indicate an optimal separation quality of the variables considered in the discriminant function.

Having illustrated the differences between these subgroups, we now take a closer look at the correlations that became apparent. In both, perceived capability in the physics and technology content area was related to the investigative and the realistic interests. Therefore, the higher these interests were, the higher the perceived capability in that area was. The group that favoured teaching physics and technology topics also showed correlations that were not apparent in the other group. In the former, a perceived capability in physics and technology was also strongly related to general knowledge and knowledge in the natural sciences and technology.

In the third part of this section, two other subgroups are discussed: trainee teachers with an SAE interest profile and those with an SI interest profile. Both groups had a pronounced social interest but differed regarding their additional interests. While the SAE interest profile was, according to Prediger [57], an altogether "person-oriented" interest profile, the SI profile was a combined interest profile of "person-" and "thing-oriented" interests. Typically, people who were interested in physics or technology teaching have had a strong interest in things [62,63], but this did not exclude an interest in people, as the SI interest profile suggested, which was common in this study's participants. Strictly speaking, the combination of social, investigative, and realistic interests may even be the most suitable combination for teachers if only physics and technology teaching are considered [54,55]. However, primary-school teachers are not specialists but generalists and must teach a variety of subjects and different social and natural science disciplines. Empirically, a vast number of trainee teachers, around one-third of the sample, had the typical interest profile of primary-school teachers, which was a profile comprising social, artistic, and enterprising components. Hence, from a theoretical perspective, a good person–environment fit exists [54,55]. It must be noted that the SI group was more heterogeneous than the SAE group due to the SI group having a third interest orientation that varied. It may even have been that the third dominant interest was one that was similar to the SAE profile, which may have biased the analyses. However, too few participants in the sample exhibited exactly the SIR interest orientation in their RIASEC profile to build a uniform interest profile group.

When significant differences between SAE and SI groups were sought, they were found in personality but not in knowledge. The analysis evidenced that SAE trainee teachers were more extraverted and less open than SI trainee teachers, which indicated that trainee teachers with social and investigative interests were more introverted and had more open-minded personalities. These results were confirmed by former studies on STEM students who were also described as more reserved towards other people and yet willing to explore new things [54,60,71]. Furthermore, studies on primary-school teachers have confirmed the results of the SAE group. These studies indicated that primary-school teachers were generally more extraverted but less open to exploring new things [54,59,60].

When we examined the results of correlation analyses, we found similar but also different correlations in these groups. A tendency for a negative correlation between perceived capability in the physics and technology content areas and neuroticism emerged in both groups. Low neuroticism, which indicated high emotional stability, appeared to be related to high perceived capability in physics and technology content areas. In the SI group, a strong correlation emerged between knowledge in science and technology and a perceived capability in the physics and technology content areas. This indicated that trainee teachers who felt confident in physics and technology topics has also acquired more content knowledge in these areas. If the participants with the SAE interest profiles were considered, it was observed that perceived capability correlated negatively with extraversion, what means that more extraverted participants showed less perceived capability in the physical and technical area. In the SAE group, there were no significant correlations with knowledge, as compared to the SI group.

In the fourth part of this section, we present the estimated impact of the discussed variables on trainee teachers' perceived capability in the physics and technology content area. The model for the total sample evidenced that all included variables significantly contributed to the variance explanation, but the best predictors were the variables regarding interests, whereas personality and knowledge had less important roles. However, this general model did not distinguish between different trainee–teacher groups, which may have had different reasons for their confidence in the physical and technical area. Therefore, people who favoured teaching physics and technology were analysed separately from those who did not. In both subgroups, all thing-oriented interests were the best predictors, but there was a difference in the impact of general knowledge in science and technology. Only the participants who favoured teaching physics and technology based their perceived capability on general knowledge in this area.

General knowledge in science and technology also became significant in the subsample of participants with high social and high investigative interests. While neuroticism did not significantly influence the criterion in this group, personality was meaningful in the interest-profile group typically for kindergarten and primary-school trainee teachers. The personality traits extraversion and neuroticism significantly predicted their perceived capability in the physics and technology content area. This result could be taken as an indicator that, in trainee teachers with an SI interest profile, the self-efficacy and competency to teach physics and technology in kindergarten and primary school was based on their general knowledge in science and technology, whereas in trainee teachers with an SAE interest profile, the perceived capability to teach physical and technological content was is empirically based on their personality traits.

Overall, the results indicated that interests as a specific part of personality predicted perceived capability towards physics and technology more accurately than the more global personality models such as the Big Five. Trainee teachers only slightly differ in their generally personality, but they clearly differ in their interest structures, which were crucial when analysing their stance on teaching physics and technology in kindergarten and primary school. The fact that interests had such a strong influence on self-efficacy may be explained by the close relationship between interests and self-efficacy, which was discussed by Lent et al. [65].

In the fifth and last part of the chapter, we discuss the measurement instruments used in this study and offer considerations for further research and sustainable education.

A challenge in research concerning trainee teachers' preferences in the natural and social science areas has been that the NMG perspectives were not equally popular with trainee teachers. Unfortunately, only a few trainee teachers in our sample stated that they favoured teaching physical or technological topics, but these few do not necessarily represent the whole population of trainee teachers.

The reliability scores of the NMG questionnaire and the AIST-R could be described as good [64], whereas the reliability and accuracy of the short version of the general knowledge test were poor. The test manual [38] did not contain any indications regarding the accuracy of the short version, whereas the reliability of the long version was indicated as good. The poor reliability of this study placed the measurements and analyses, which that include the knowledge variables, in question. Similar poor reliability coefficients in the short version were already mentioned in a previous study with the short version of BOWIT [35]. Also, in the BFI-10, some reliability parameters must be considered as poor. Especially the reliability parameters of conscientiousness and agreeableness were not acceptable, but these variables were not included in multivariate analyses. The poor psychometric properties of these variables do not allow us to clarify the role of these variables on trainee teachers' attitude and confidence in teaching physics and technology topics.

Consequently, the data had to be interpreted carefully, and some further important aspects should be considered. It must be recognised that students in the sample were freshmen, and over their academic career, they may increase their perceived capability regarding the varied NMG topics, including physics and technology. This could be investigated in a follow-up study. This study only considered general knowledge, vocational interests, and personality as possible influences, and many other factors could be significant, such as subject-related didactical competencies. However, the present study was intended to capture the students' initial viewpoints, which, as we found, varied broadly. During teacher training, this should be considered, and teachers should be educated so they are competent and confident in teaching all topics. A child-centred view of subject content may pique students' interest in teacher training; likewise, child-centred approaches may facilitate the understanding of subject content and strengthen well-being [92,93].

Finally, the debate on the topic should be continued, not only because of the aforementioned methodological reasons but also due to the importance of interests in science being promoted early. The age at which children attend kindergarten is a crucial period, as "the wisdom of the ground plan [suggests] that, at no time, is the individual more ready to learn quickly and avidly, to become big . . . in the sense of making things, instead of 'making' people, than during this period of [their] development" [94] (p. 85–86). It is essential to take advantage of this period when children show thing-oriented interests so they can develop a sustained interest in physical and technological topics. The adjusting screw in institutional learning settings could be the teachers, as they are the ones who manage the children's learning environments; hence, they are able to encourage children's curiosity and expand their interests in physics and technology. Therefore, kindergarten and primary-school teachers should be encouraged and supported to provide learning opportunities for physics and technology, and they should be educated so that they are confident in discovering natural phenomena together with their pupils. This sort of teaching can plant an essential seed to be watered, and a sustainable learning process can be nurtured; then, these early experiences and insights will accompany children into adulthood and also help shape them as curious, open-minded people.

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