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Pre-Service Geography Teachers' Professional Competencies in Education for Sustainable Development

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Abstract: The professional competencies pre-service geography teachers acquire in university influence their contribution to education for sustainable development (ESD) in their future school careers. We assessed pre-service geography teachers' ($n = 100$) competencies and attitudes towards the official, German ESD orientation framework to determine the specific need for higher education action. The results are a high competence assessment and even higher importance assigned to the ESD-related professional competencies. In the context of ESD, pre-service teachers are most confident in their content knowledge and social and personal competencies and least confident in their pedagogical knowledge. The cross-sectional analysis shows the perceived competence level rising with the semester number and a strong positive influence of the school practice module.

Keywords: teacher education; ESD; competencies; higher education



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1. Introduction

Amid a global crisis, the need for education for sustainable development (ESD) is more apparent than ever [1]. As ESD “empowers learners with knowledge, skills, values, and attitudes to make informed decisions and take responsible actions for environmental integrity, economic viability and a just society empowering people of all genders, for present and future generations, while respecting cultural diversity” [1]. To reach the goals defined by the UNESCO models, defining competencies needed for sustainable development were developed [2–6]. The ESD competence models stress the importance of interdisciplinary thinking and holistic competencies. It is essential to integrate ESD into teachers' education to equip teachers with the necessary skills to integrate ESD into their work and become change agents [7–10]. As holistic ESD aims require disciplinary expertise to become meaningful [11] and most educational systems are organized by subjects, integrating ESD into subject didactics is vital for quick integration in schools. Since geography is inherently ESD-related [12–15] and geography education is committed to ESD [16], we assume that geography education contributes to ESD. However, the question arises as to how exactly geography education contributes to professional ESD teaching. We assessed pre-service teachers' ESD competencies within a professional acting competence model because knowing the status quo allows us to successfully connect new approaches to the present teachers' education. We thereby connected to studies assessing the interdisciplinary competence level [17–21] but set the focus on geography students only.

2. Theoretical Background

2.1. Professional Acting Competence

To connect to the teachers' education in place, we acknowledge the perspectives present on professionalizing teachers in Germany: (1) structural theory, discussing the

interaction between student and teacher within inherent conflicts in a theoretical approach [22,23], (2) professional biography, studying the professional development of teachers within the challenges of the first years of practice [24], and (3) the competence-oriented approach, defining and measuring competencies needed for teaching [25]. The structural theory and professional biography approach pursue a holistic perspective on teaching. For subject didactics, it is necessary to focus on subject-specific issues. Thus, the competence-oriented discourse is advantageous as it divides subject-specific competence from other competence dimensions [26]. The competence-oriented approach is grounded in the work of Shulman [27], who classified the various forms of knowledge required for successful teaching. The knowledge dimensions, which were best replicated in [28–32], were integrated by Baumert and Kunter [25] into a competence model for professional acting competence. The competence model thus comprises the following dimensions: pedagogical knowledge, content knowledge, and pedagogical content knowledge. Motivational and personal aspects supplement the model. This model allows the modeling of subject-specific professional teaching competencies, e.g., in the COACTIV project [33].

2.2. Professional Competence and ESD

Multiple approaches model teaching competence regarding ESD; four are most prominent [7]: (1) the UNECE model [34], (2) the CSCT model [35], (3) KOM-BiNE [36], and (4) the approach by Bertschy et al. [37]. The UNECE model promotes a holistic approach aiming at envisioning change and achieving transformation of education and the educational system. It describes educators' competencies regarding the four spheres: learning to do, learning to know, learning to live together, and learning to be [34]. While the UNECE model is visionary, compact, and calls for engagement for fundamental change, the CSCT model is a detailed and comprehensive approach. It integrates the curriculum, sustainable development, competencies, and teacher training and describes five competence domains important for teaching ESD: knowledge, system thinking, emotions, ethics and values, and action [35]. KOM-BiNE refers to the CSCT model and focuses on competencies needed to implement ESD projects. It divides competence into three levels, one describing individual aspects, one the integration in society, and one the competencies bridging both. It subdivides individual aspects into the four fields: knowing, acting, valuing, and feeling [36]. Bertschy et al. also refer to the CSCT model and develop a competence model for the individual elementary school teacher, applying the professional acting competence model by Baumert and Kunter (2006) [37]. We connected to the approach by Bertschy et al. because measuring ESD competencies within the frame of professional action competence best allows for the discussion of the contribution of existing geography teacher education to ESD.

2.3. Competence Model for ESD Teaching in Secondary Geography Education

To investigate secondary school teaching, we grounded our model in a Delphi study by Helberg-Rode and Schrüfer on competencies for secondary school ESD teaching [38]. The experts participating in the study named and ranked different competencies relevant to ESD teaching in secondary schools and assigned them to one of the competence dimensions: professional knowledge (PK), content knowledge (CK), professional content knowledge (PCK), or social and personal competence [38]. We integrated the four competence dimensions according to the competencies in our competence model (see Figure 1). Since the national context and its standards are vital to school education and ESD [39], we supplemented the model with topics demanded by the national standards [40]. We included all topics from the national standards declared as geographic by a panel of experts (n = 21) (see Figure 1) because geography teachers must be knowledgeable in these subject areas to welcome them to their teaching.

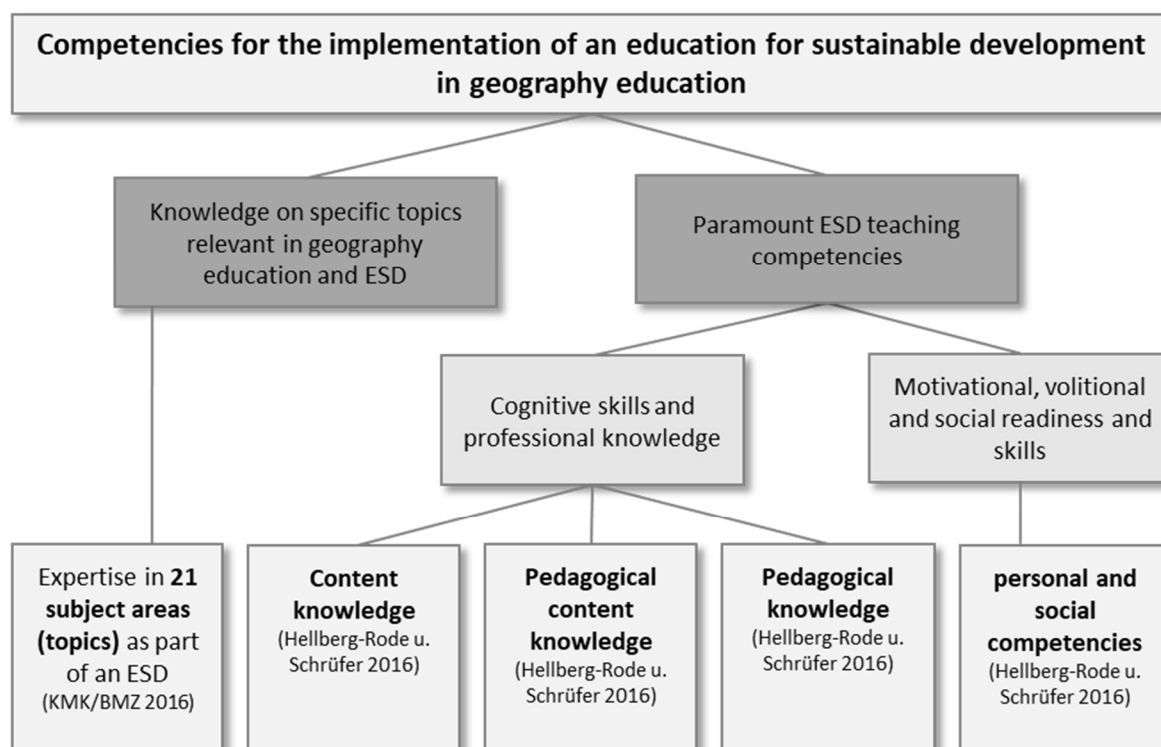


Figure 1. Competence model.

2.4. Higher Education Geography's Impact on ESD

Knowledge and interest in geographic subdisciplines might correlate differently to professional competence in ESD since teachers' understanding of sustainable development differs between social and natural science backgrounds [41–43]. Geography didactics, field, and school practice might impact competence patterns distinctively [41]. Since studies show that activating methods raise students' ESD competency level and interest successfully [13,42], we expected a positive school and fieldwork impact. The importance of the curricular integration of ESD was discussed [7–10]. Modules with explicit ESD reference should, therefore, impact the competence level significantly.

2.5. Research Questions and Scope of this Study

This study aims to assess the status quo of pre-service geography teachers' ESD competencies to help identify the specific need for action in promoting ESD competencies in pre-service teachers' higher geography education. We assessed pre-service teachers' self-conception of their ESD competencies cross-sectionally to evaluate the geography teacher education's impact on ESD competence, asking:

- How confident are pre-service geography teachers in their professional competence regarding ESD?
- How important are the specific competencies to them?
- How does the course of studies connect to self-assessed competence?

3. Methods

3.1. Research Design

This study presents our results from a cross-sectional full survey study on ESD competencies and interest in ESD among pre-service geography teachers at the University of Marburg. Before carrying out the survey, we ensured its quality by the following steps (for illustration, see Figure 2):

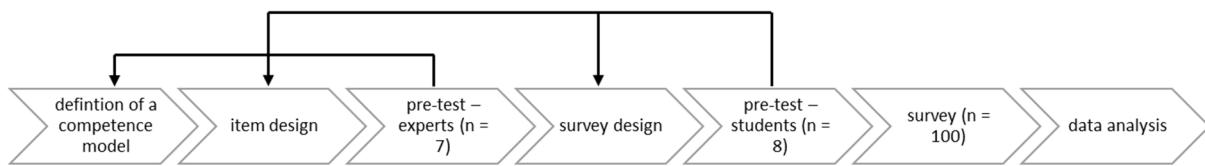


Figure 2. Research design.

(1) We defined a competence model within which we measured the pre-service teachers' level for each competency, considering scientific literature and normative frameworks. (2) We designed items following the Delphi study by Hellberg-Rohde and Schrüfer [38] and illustrated the 21 topics from the orientation framework [40] by examples. (3) Experts (geography teachers ($n = 4$) and professors in geography (education) ($n = 3$)) validated both the selected competencies and the item testing on it in a qualitative pre-testing. (4) We then designed a survey. (5) The qualitative pre-test with pre-service teachers from different semesters and genders ($n = 8$) showed that the items were understood as intended; the survey improved its structure. (6) To reach all students enrolled in geography education, the survey was carried out in the winter term of 2018/2019 and summer term of 2019 in all geography education modules at the University of Marburg. (7) All complete surveys ($n = 100$) were included in the quantitative analysis.

3.2. Survey

The survey measured the pre-service teachers' self-assessed ESD competencies and knowledge in ESD-specific topics and the subjective importance they assigned to the sub-competencies and topics (see Box A1 in Appendix A) and the socio-demographic factors: semester number, modules finished, sex, level of geography school education, second subject (a necessity in German school education). It relied on a Likert scale from 1 (not at all) to 5 (to a very high degree) with a can't judge/don't know option (−1) for the competence and interest measurements. It was distributed online using SoSci Survey.

3.3. Sample

We distributed the survey to all 375 pre-service teachers enrolled in geography at the University of Marburg and included only complete and plausible surveys ($n = 100$) in the analysis. Our sample represented gender adequately with a slight female bias: 42% of the pre-service geography teachers were female [43] and 46% of the study participants. A total of 58% of the pre-service geography teachers were male [43] and 52% of the study participants. The university statistics only classified male and female students, whereas 2% of the study participants were diverse. Students from all semesters participated in the study (see Figure 3). The teacher education program is designed for nine semesters; thus, those above were summarized. All pre-service geography teachers were enrolled in one or two subjects next to geography because all teachers need at least two subjects in Germany. In the sample, 19% also studied another social science (history, politics and economy, ethics), 24% studied natural sciences (biology, chemistry) or mathematics, 27% studied physical education, and 41% studied a language (German, German as a second language, English, Spanish). Two-thirds of the participating pre-service teachers took geography in their advanced high school education (Oberstufe).

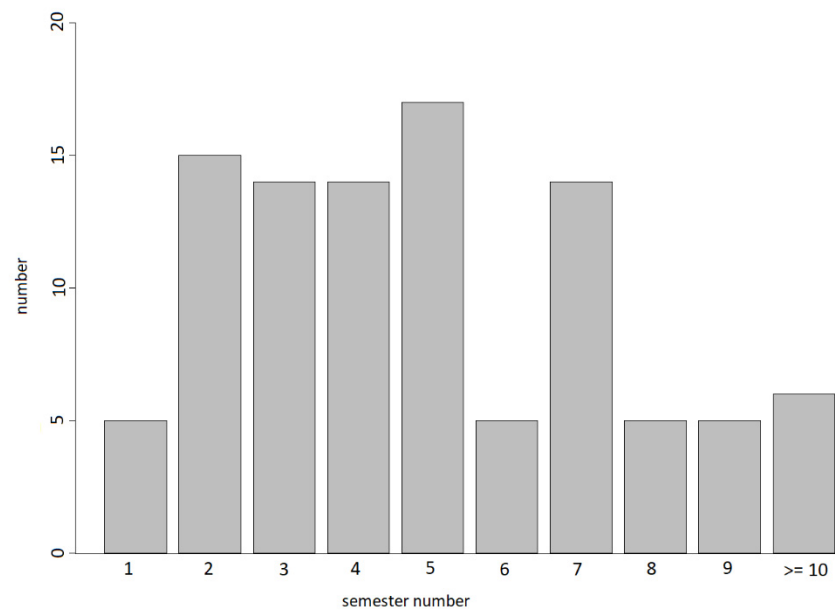


Figure 3. Students by semester number.

3.4. Analysis

We analyzed the data with the statistic software R [44] and relied primarily on the ‘PerformanceAnalytics’ package [45]. All correlations were calculated with the Spearman rank correlation. We analyzed the development of the competence levels cross-sectionally. The correlation between finished modules and competence level was calculated for every module, subdimension, and item. Modules with literal reference to sustainable development in the module description were included as such.

4. Results

4.1. Overall Results

Overall, pre-service geography teachers assessed themselves as having a high ESD competence. The median lay between 3 and 4 for all subscales with the highest results in social and personal competencies (see Figure 4). All subscales correlated with each other (see Figure 5); thus, the pre-service teachers regarded their competence level generally, over the different subscales, as higher or lower compared to their peers. The importance pre-service teachers assigned to the ESD competencies was even higher than their competence level; the median was four or above for all measured subscales (see Figure 6). The pre-service teachers’ interest correlated significantly with their competence ($p < 0.05$).

Socio-demographic factors did not affect the overall competence assessed; we saw no gender impact and no significant impact of high school geography education or second subject. Effects were only found in the importance pre-service teachers assigned to competencies: Females generally gave higher importance to ESD competencies than males ($p < 0.01$). We will now discuss the different subscales in more detail.

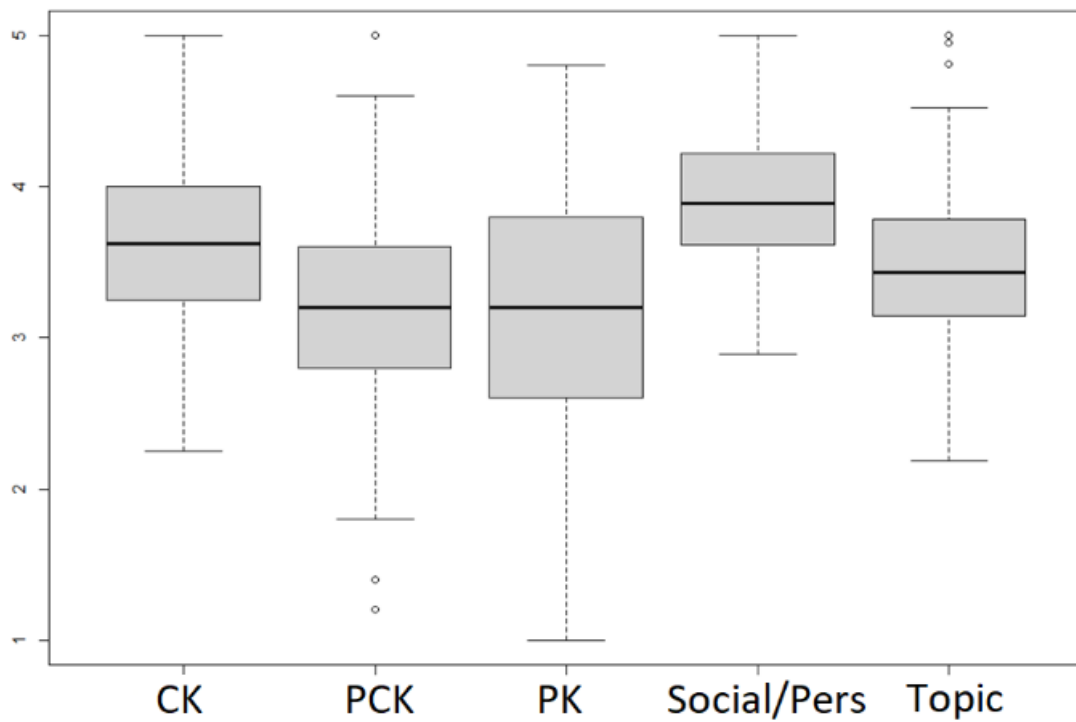


Figure 4. Competence by subscale.

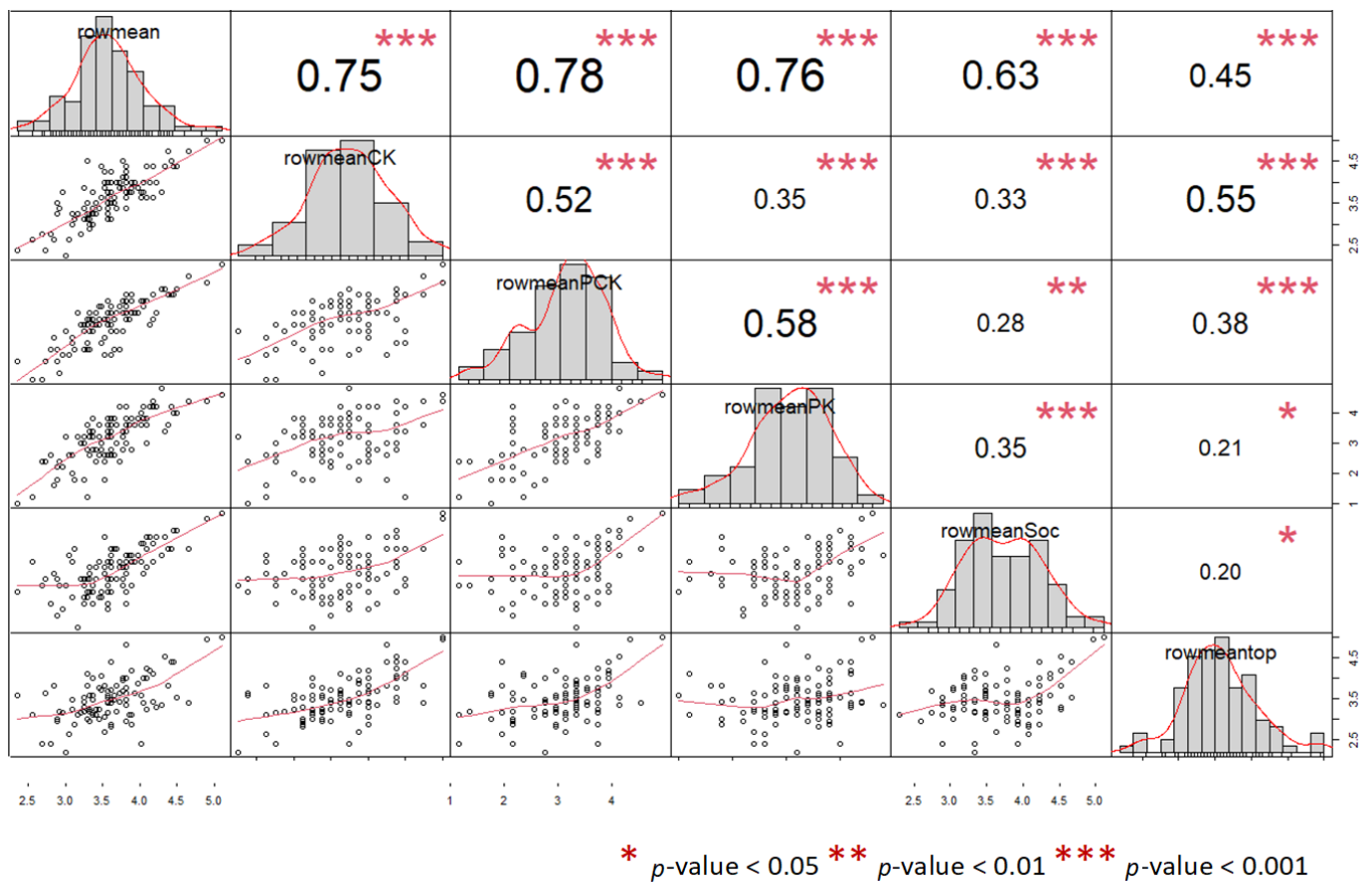


Figure 5. Correlation between subscales.

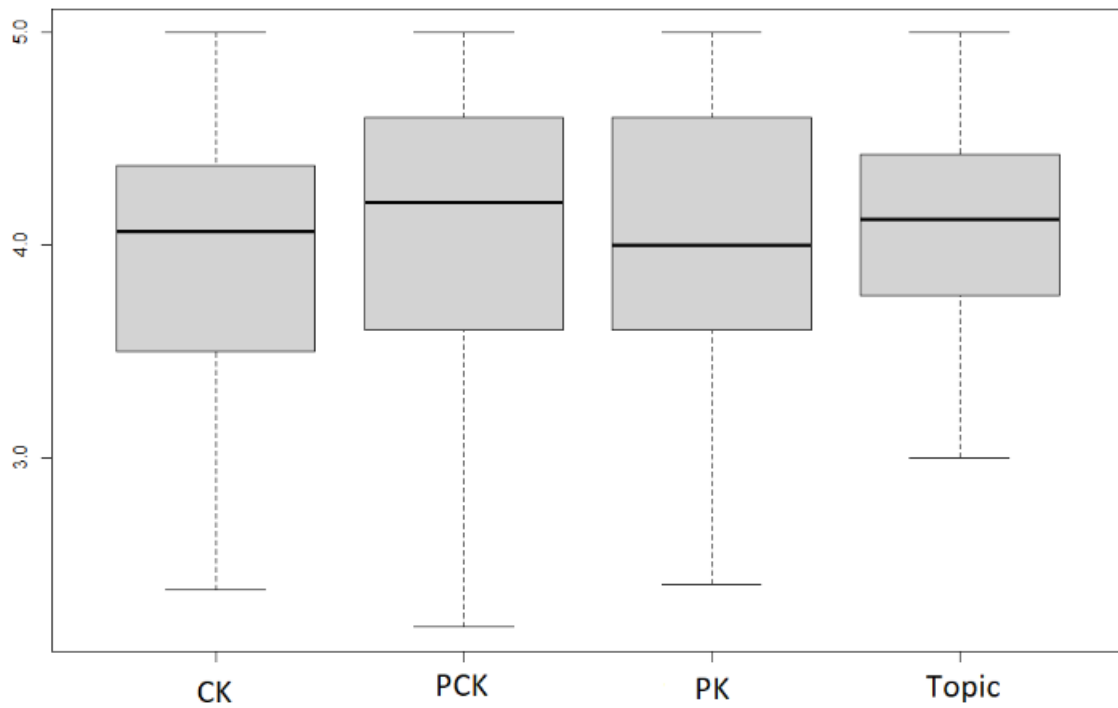


Figure 6. Importance by subscale.

4.2. Content Knowledge

The pre-service teachers assessed themselves homogenously high on ESD-related content knowledge; the median was 4 for all items (see Figure 7). They felt most competent in system thinking (CK2) (see Figure 7 and Box 1). The importance assigned to the items correlated to the assessed competence ($p < 0.01$), but it was more heterogeneous and slightly higher (see Figure 8). The median was four for all items, but dynamics and interdependencies of global processes (CK5) were rated the most important (median = 5).

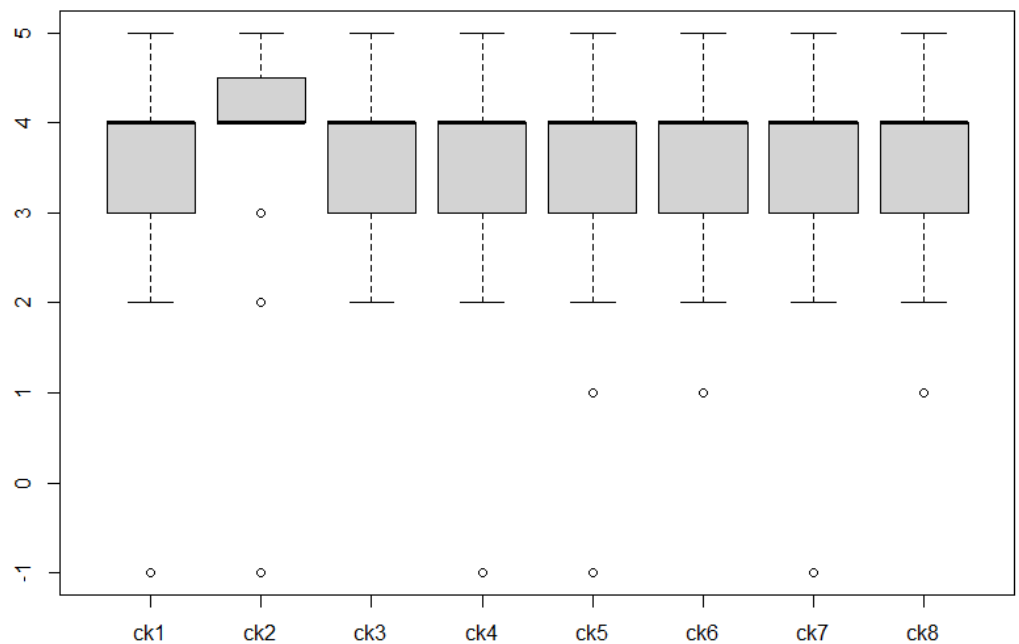


Figure 7. Content knowledge competence level by item.

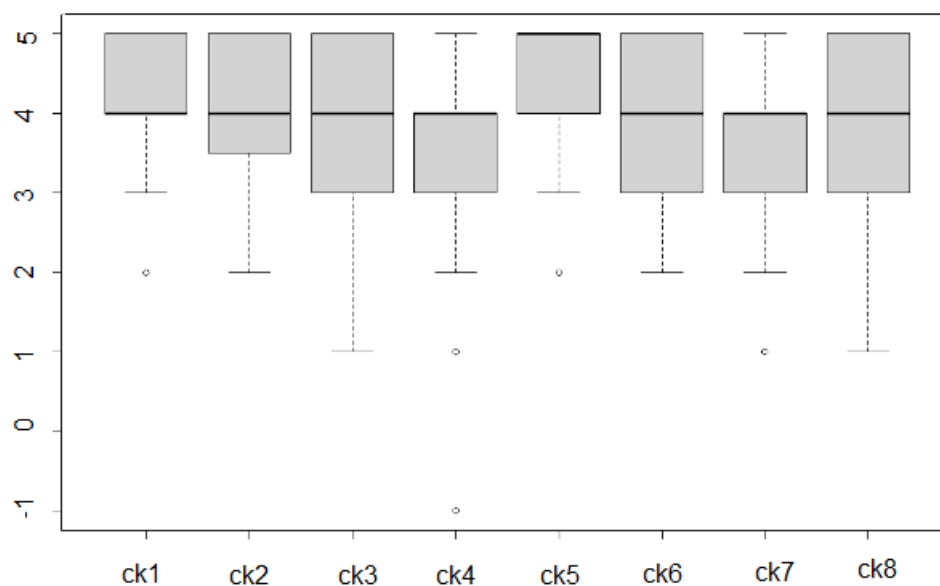


Figure 8. Content knowledge importance by item.

Box 1. Items for content knowledge.

CK1 = critical reflection and assessment of global change
 CK2 = system thinking
 CK3 = interdisciplinary analysis
 CK4 = sustainable development concept
 CK5 = dynamics and interdependencies of global processes
 CK6 = discourse on ethics
 CK7 = ecological systems

Content knowledge correlated by 0.27 with the semester number ($p < 0.01$) and by 0.34 with the school practice ($p < 0.001$). Content knowledge was thereby the dimension that was impacted by semester number and school practice the most. There was no gender effect to the competence assessment, but females significantly assigned higher importance to the CK ($p < 0.01$) than males. Pre-service geography teachers overwhelmingly expected to gain competence in CK during their higher education. They expected to foster only their competence in system thinking and global solving strategies in their later careers.

4.3. Pedagogical Content Knowledge

The pre-service teachers assessed themselves as having medium ESD-related pedagogical content knowledge; the median was 3 for all items but problem-solving-oriented thinking (PCK1), which the pre-service teachers felt more competent in (median = 4) (see Figure 9 and Box 2). The importance of the items was rated higher than their own competence; only the importance of the repertoire of methods for ESD was rated with a median of 3 (see Figure 10).

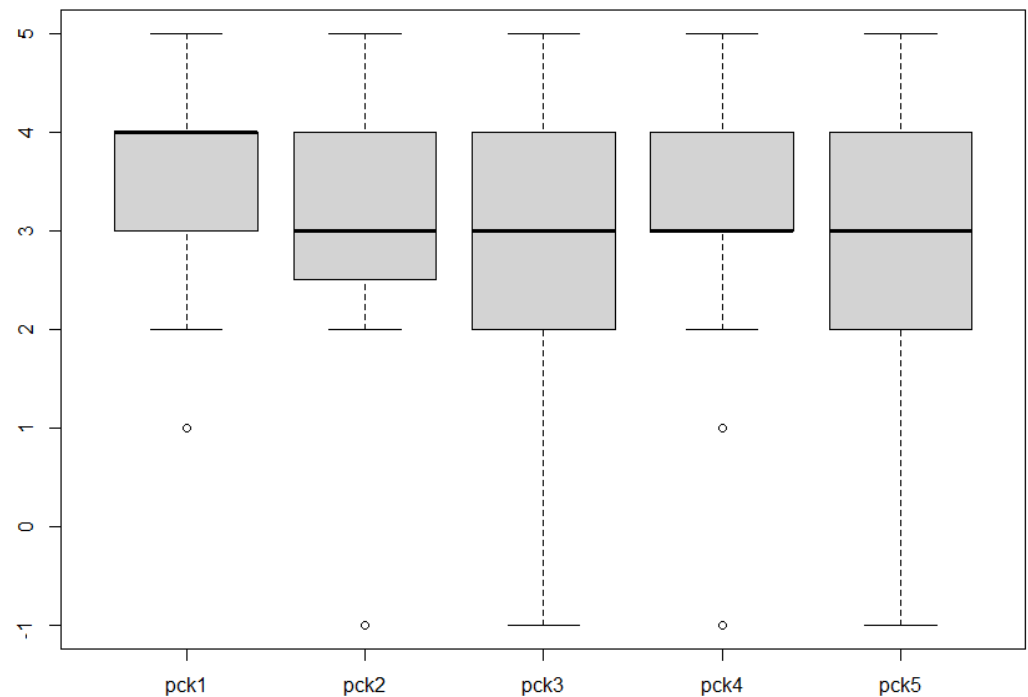


Figure 9. Pedagogical content knowledge competence level by item.

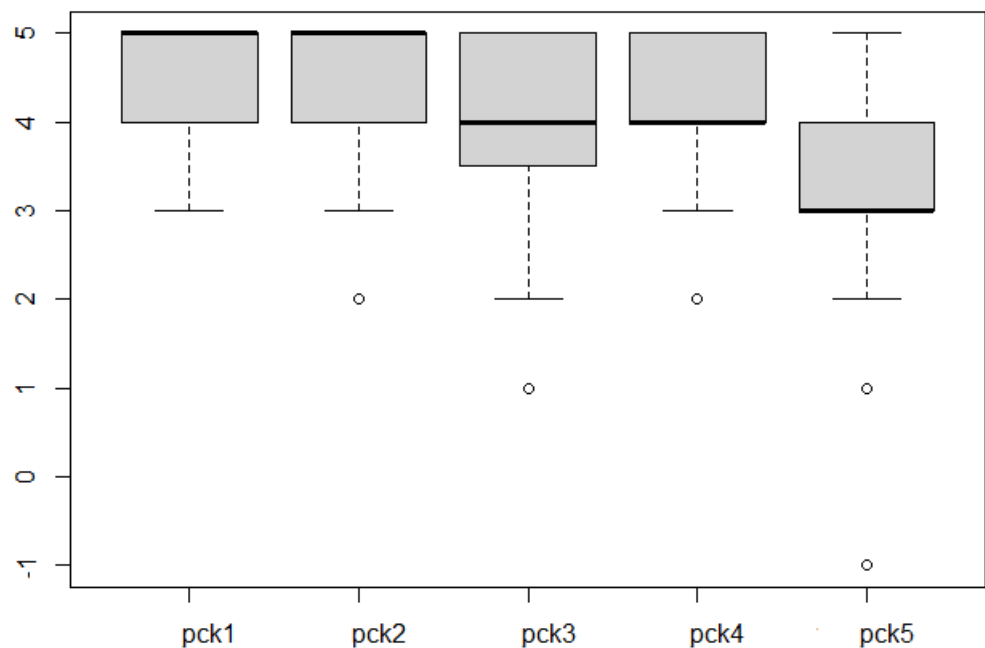


Figure 10. Pedagogical content knowledge importance by item.

Box 2. Items for pedagogical content knowledge.

PCK1 = problem-solving-oriented thinking
 PCK2 = development of assessment skills among learners
 PCK3 = the sustainability triangle or square as a structuring principle for lesson planning
 PCK4 = promote design skills
 PCK5 = repertoire of methods for ESD

There was neither a correlation between the importance and competence nor the semester number and competence level. The school practice correlated by 0.20 ($p < 0.05$) to

the competence. There was no gender effect to the competence assessment, but females significantly assigned higher importance to the PCK ($p < 0.01$) than males. Pre-service geography teachers expected to develop all five competencies during higher education.

4.4. Pedagogical Knowledge

The pre-service teachers assessed themselves as having medium ESD-related pedagogical knowledge. Still, their assessment varied between the different items, with the median ranging between three and four (see Figure 11). They felt most competent in the change of perspective (PK1 see Figure 11 and Box 3). The importance of the PK items was rated higher than the competence and more homogenously (see Figure 12). This difference resulted in a gap between the median of importance (= 4) and assessed competence level (= 3) for the items on dealing with complexity and uncertainty (PK2), participation and co-creation in terms of Agenda 21 (PK3), and open schools to cooperating with external partners (PK5).

There was neither a correlation between the importance and competence nor the semester number and competence level. The school practice correlated by 0.23 ($p < 0.05$) to the competence level. There was no gender effect to the competence assessment, but females significantly assigned higher importance to the PK ($p < 0.001$) than males. Pre-service teachers expected to develop their overall PK during their later careers and only expected to develop the competencies change of perspective (PK1) and open schools to cooperate with external partners (PK5) during higher education.

4.5. Social and Personal Competence

The pre-service teachers assessed themselves as having a high social and personal competence (see Figure 13). They felt extremely empathetic (S1) (median 5). It is noticeable that the social competencies were assessed higher than the personal (see Figure 13 and Box 4). Tolerance of ambiguity and frustration (S6) and visionary thinking (S9) were assessed as the lowest (median = 3). There was no correlation between the semester number and competence level. The school practice correlated by 0.22 ($p < 0.05$). There was no gender effect to the competence assessment.

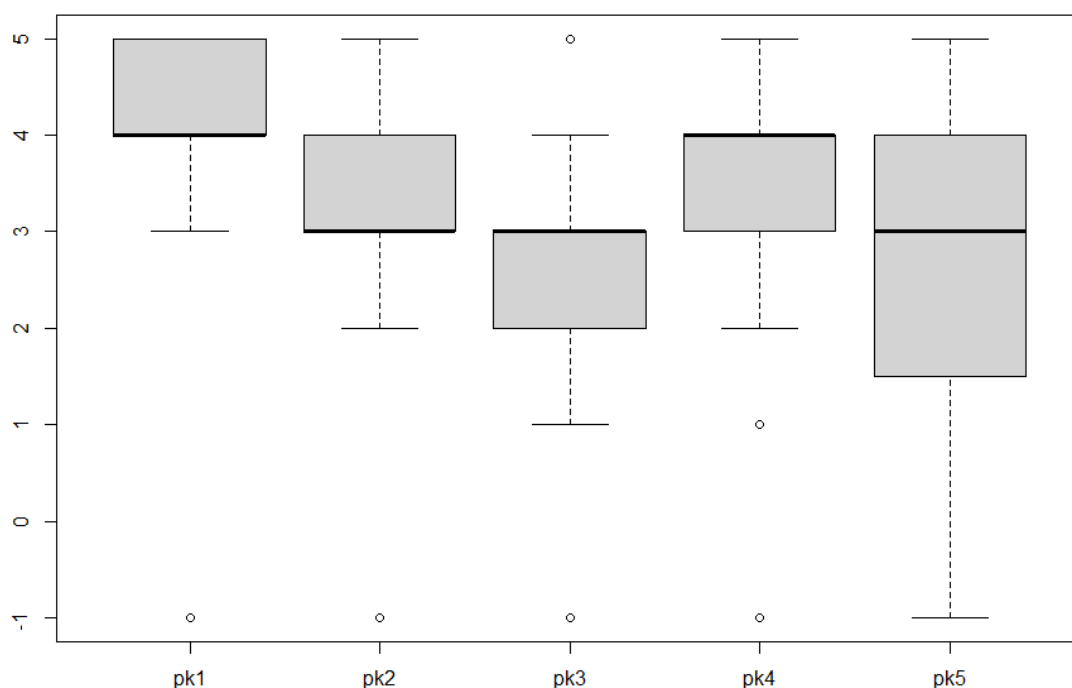


Figure 11. Pedagogical knowledge competence level by item.

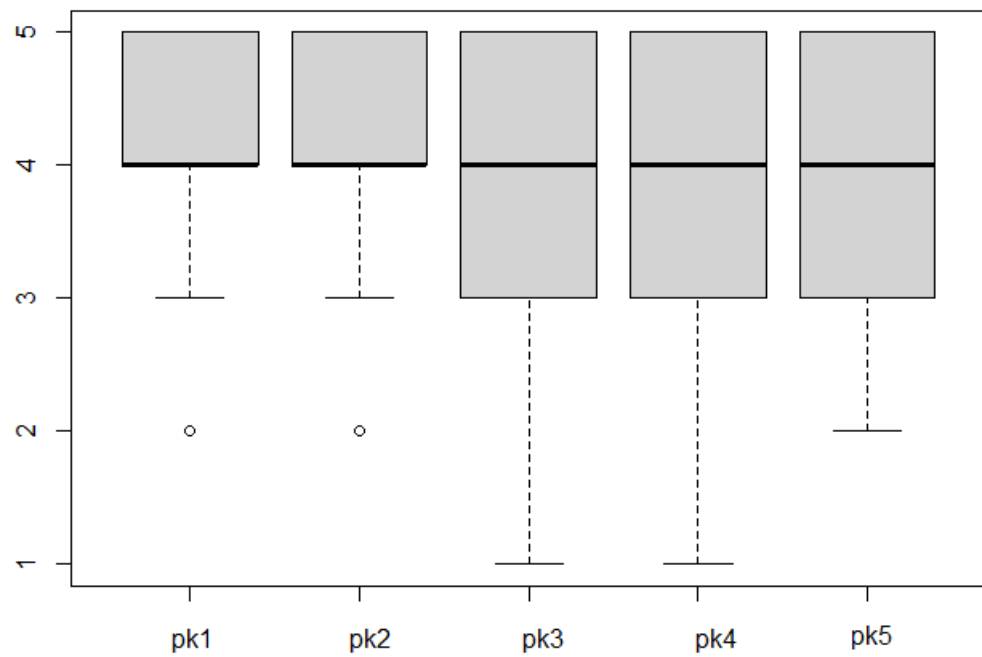


Figure 12. Pedagogical knowledge importance by item.

Box 3. Items for pedagogical knowledge.

PCK1 = change of perspective
 PCK2 = dealing with complexity and uncertainty
 PCK3 = participation and co-creation in terms of Agenda 21
 PCK4 = to act as a learning companion/learning coach
 PCK5 = open schools to cooperating with external partners

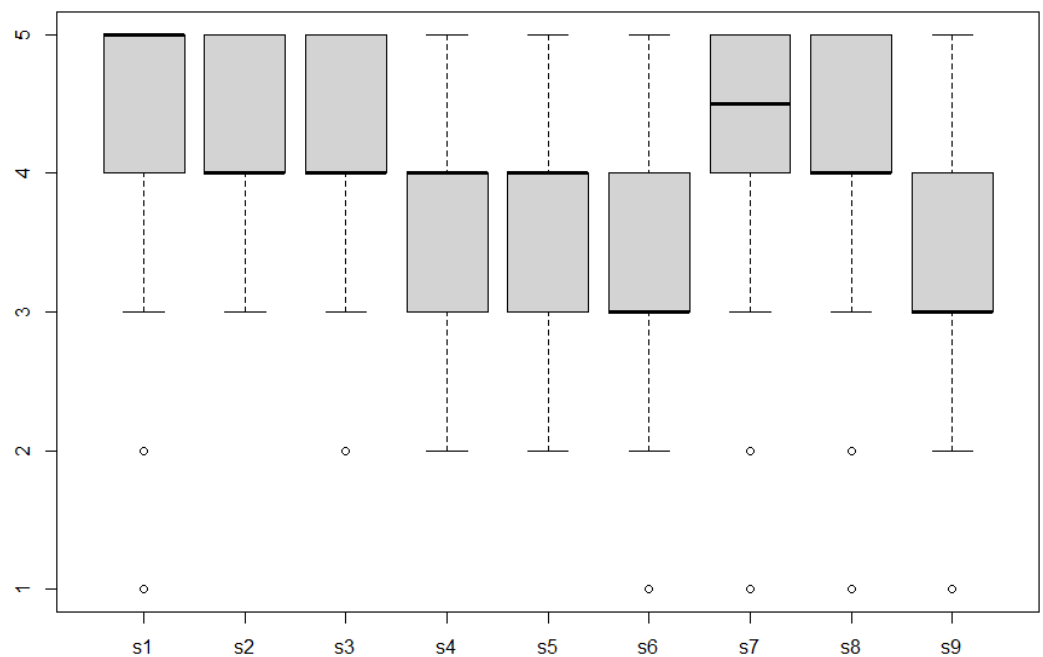


Figure 13. Social and personal competence level by item.

Box 4. Items for social and personal competence.

S1 = empathy
 S2 = communication competence
 S3 = competence in cooperating
 S4 = critical ability
 S5 = willingness to innovate
 S6 = tolerance of ambiguity and frustration
 S7 = open-mindedness
 S8 = competence in acting solitarily
 S9 = visionary thinking

4.6. ESD Topics

The pre-service teachers assessed themselves as having a medium-high competence regarding ESD topics; the median ranged between 3 and 4 (see Figure 14). They felt most competent in demographic structures and developments (T14) and least qualified in global topics (the history of globalization (T3), peace and conflict (T16), development cooperation and its institutions (T19), and global governance (T20)). Each ESD topic's importance was ranked highly with medians between 4 and 5 (see Figure 15). A rather diverse set of topics reached the highest level of importance: agriculture and food (T5), education (T7), protection and use of natural resources (T9), global environmental change (T11), and peace and conflict (T16) (see Figure 15, Box 5). Comparing competence and importance, we saw a gap in peace and conflict (T16) between a high importance and low competence level. The assigned importance correlated highly with the assessed competence ($p < 0.001$) despite this item. However, there was neither a correlation between the semester number and competence level nor the importance. The school practice correlated by 0.25 ($p < 0.05$) with the assessed competence. There was no gender effect to the competence assessment or the importance.

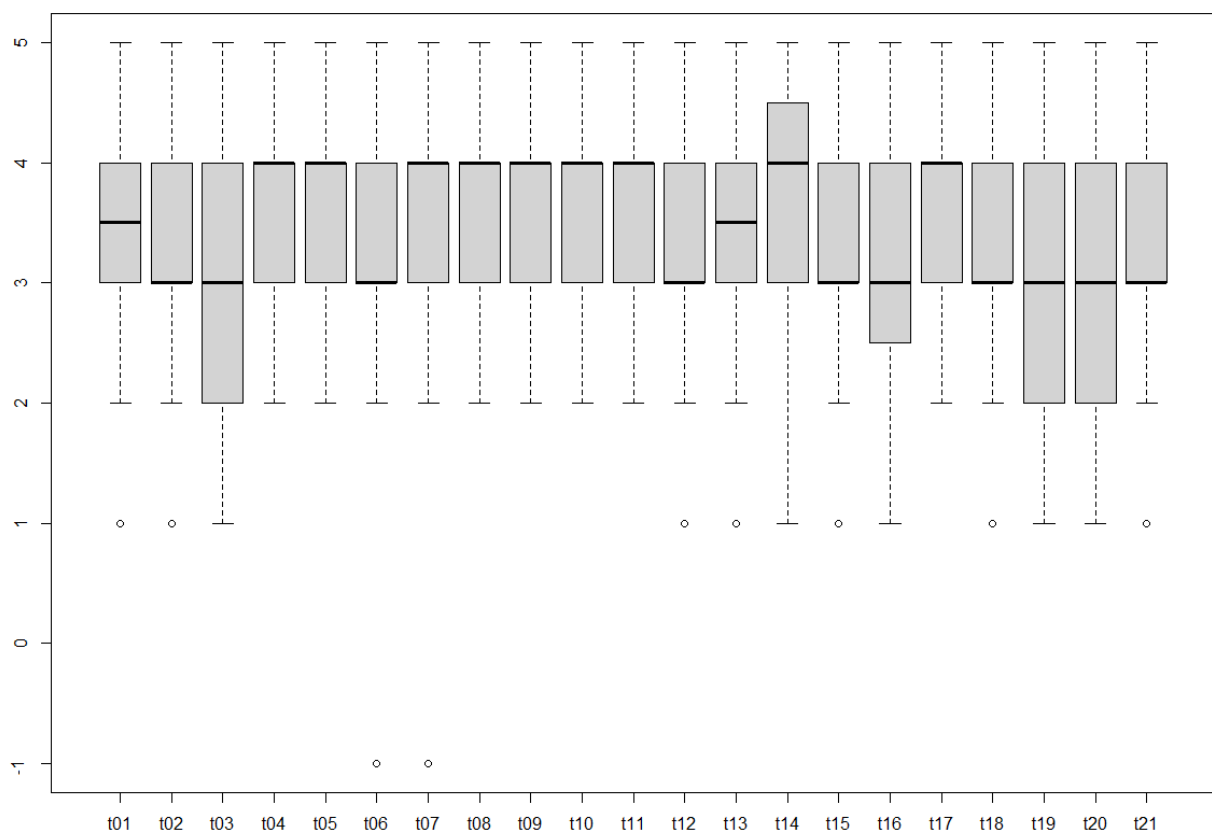


Figure 14. Competence for topics by item.

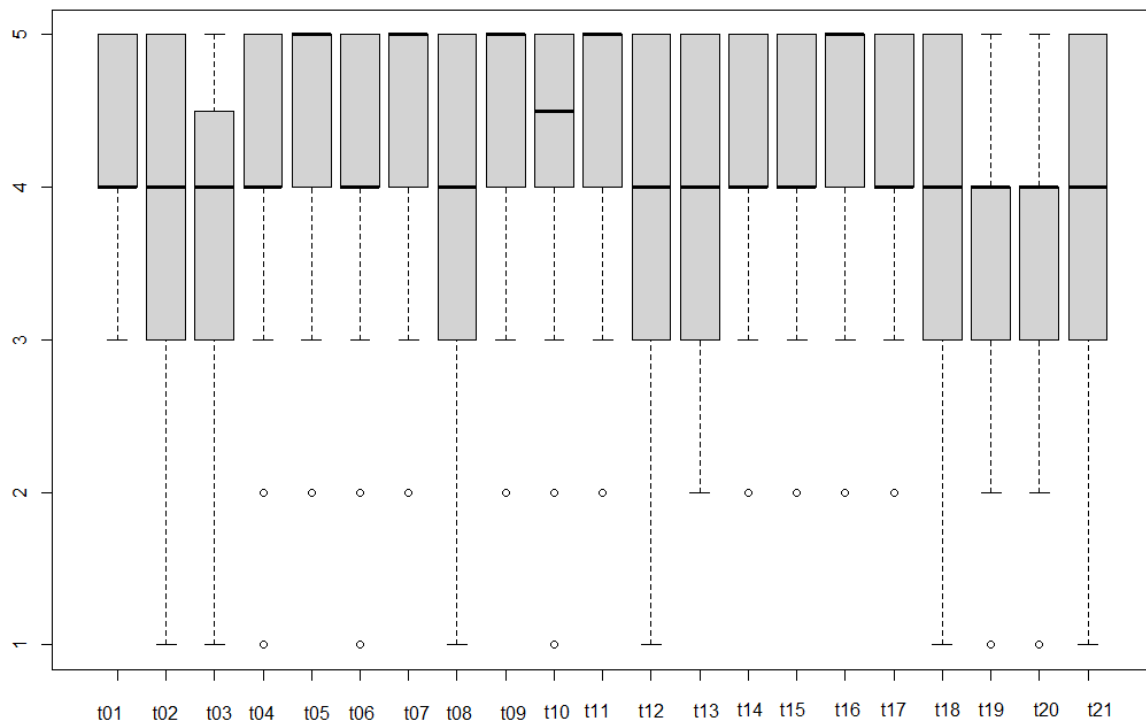


Figure 15. Importance for topics by item.

Box 5. Items for topics.

T1 = diversity of values, cultures and living conditions
 T2 = globalization of religious and ethical models
 T3 = history of globalization
 T4 = goods from all over the world
 T5 = agriculture and food
 T6 = health and disease
 T7 = education
 T8 = globalized leisure
 T9 = protection and use of natural resources
 T10 = opportunities and dangers of technological progress
 T11 = global environmental change
 T12 = mobility and urban development
 T13 = globalization of economy and work
 T14 = demographic structures and developments
 T15 = poverty and social security
 T16 = peace and conflict
 T17 = migration and integration
 T18 = good governance
 T19 = development cooperation and its institutions
 T20 = global governance
 T21 = communication in a global context

4.7. Study Course and ESD Competencies

Overall, ESD competencies were assessed more highly by more advanced pre-service teachers. A U-curve characterizes the correlation between semester number and competence (see Figure 16). Students enter university with high confidence in their competencies, get less confident during the first semesters, and then gain confidence again, finally exceeding the entrance level. There was neither a correlation between assigned importance and semester number nor between importance and individual modules.

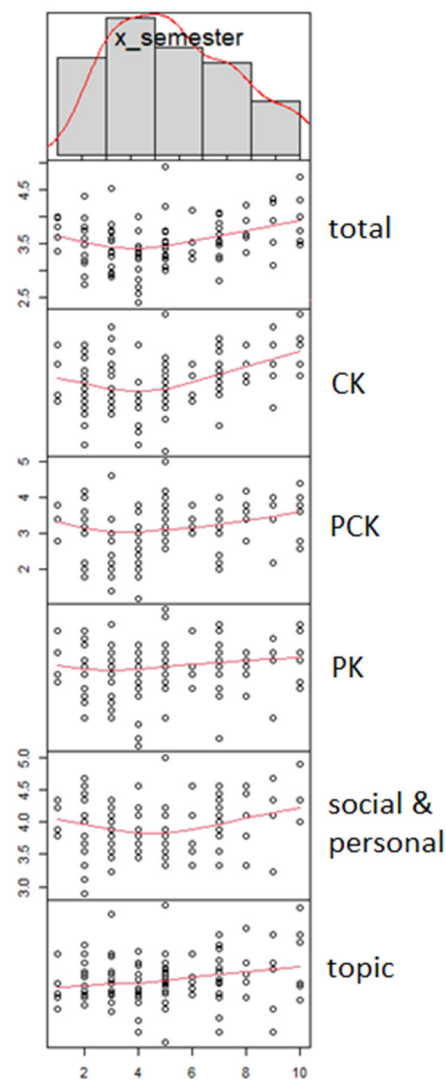


Figure 16. Semester course.

General ESD competence correlated only with some individual modules (see Table 1). Out of all modules, the school practice had the most significant impact on ESD competence ($p < 0.001$); the fieldwork also correlated significantly ($p < 0.01$). Its correlation (0.33) underlines the importance of the school practice to the assessed competence, which was higher than the correlation between semester number and competence (0.21). The modules with explicit ESD references (e.g., nature-society) did not relate to general ESD competence.

Table 1. Subdiscipline’s correlation with ESD competence * p -value < 0.05 ** p -value < 0.01 *** p -value < 0.001 .

	Human	Physical	Nature-Society	Didactics	ESD Reference	Fieldwork	School Practice	Semester Number
Total	**	*		**		**	***	*
CK	*	**		***		**	***	**
PCK				**		**	*	
PK	**						*	
Social and Personal							*	
Topic	**	*	*		**	**	*	

The individual competence dimensions were correlated differently to the different modules. CK was impacted most strongly and correlated to all modules but nature-and-society and modules with ESD reference (see Table 1). In detail, didactics and school practice impacted CK most significantly and physical geography and fieldwork more significantly than human geography. On the other hand, the ESD topics were more robustly correlated to human geography, modules with ESD reference, and fieldwork, but also correlated to physical geography, nature-society, and school practice. PCK, PK, and social and personal competence linked to fewer modules. PCK was influenced by didactics, field, and school practice only. PK correlated to the school practice and the human geography modules taken. The social and personal competencies were impacted only by the practical experience in school.

5. Discussion and Conclusions

5.1. How Confident Are Pre-Service Geography Teachers in Their Professional Competence Regarding ESD?

Pre-service geography teachers are generally very confident in their ESD competencies. These results align with previous research, attesting that geography teachers are highly familiar with all ESD dimensions [46]. The competencies with the highest marks (system thinking, problem-orientated thinking, change of perspective, and empathy) are ranked as very important by most experts [38].

Regarding the dimensions, the pre-service teachers are most confident in their CK and social and personal competencies and least satisfied with their PK. CK is reflected in a knowledge dimension included in many ESD models [11,34–36,47–49]. Surveys on the ESD competence of pre-service teachers from different disciplines show lower results in the knowledge dimension [49–53]. Our high results in the content knowledge assessment connect to intervention studies results [11,47,49] and suggest an impact of higher education in geography on the pre-service teachers' ESD competence assessment.

5.2. How Important Are Specific Competencies to Them?

Pre-service geography teachers assign very high importance to ESD competence. The given importance is above the competence level but correlates. This connects to empirical findings [50,51]. Nonetheless, problem-solving-oriented thinking is the only competence pre-service teachers feel highly competent in and rank with the highest importance. These results reflect the central role system thinking has in German geography education [52–55]. The other competencies with the highest level of importance assigned (dynamics and interdependencies of global processes, agriculture and food, education, protection and use of natural resources, global environmental change, peace and conflict, problem-solving-oriented thinking, and development of assessment skills among learners) have high and medium competence levels assigned. All dimensions are similarly highly ranked in importance. Women assign higher importance to ESD competencies than men. This result connects to previous findings [56].

5.3. How Does the Course of Studies Connect to Self-Assessed Competence?

The course of studies is positively connected to the self-assessed ESD competences. The importance pre-service teachers assign to ESD competence is constantly high, independent of semester number and modules finished. Our results show that active learning environments in a disciplinary setting affect the competence assessment more strongly than formally integrating ESD into the curriculum. The modules with an explicit SD reference in the module description only affect the assessed competence level regarding the ESD topics; the practical modules, school practice, and fieldwork correlate positively in general. The didactic modules yield higher impacts on CK than human and physical geography, which might be explained by the integrated perspective on the subject the didactics of Marburg pursue [57].

Regarding the competence dimensions, we see that the semester number only impacts the assessed CK and ESD topics strongly and, possibly due to this influence, streamlines the assessment of these competencies. Intervention studies show that PCK and PK are more difficult to promote in a purely academic setting [47,49]. In our study, the PCK assessment is influenced by didactics, fieldwork, and school practice only. PK assessment is only positively correlated to school practice and, surprisingly, to human geography. As social science teachers promote the social dimension of ESD more strongly than natural science teachers [58], pre-service teachers with a solid connection to human geography might feel more engaged with pedagogical ESD tasks. Overall, PK was assessed very heterogeneously, and we assume that these results reflect pre-service teachers' prerequisites from outside the university [59]. Regarding the social and personal competence assessment, we see an impact of practical experience only, highlighting the importance of the practical experience described in the literature [13,47,49].

The U-curve describing the competence assessment over the semester number can be explained by pre-service teachers overestimating their competencies in the beginning of their studies. After experiencing challenges and possibly failures, they adjust their competence assessment. Finally, when they become established, the assessed competencies rise and exceed the entrance level.

5.4. Limitations

To ensure a coherent analysis, we included complete questionnaires only. This proceeding might have led to a bias toward positive results by selecting the more motivated students. Unfortunately, the incomplete questionnaires were too fragmented for well-founded statements as to whether a bias exists.

The students self-assessed their competencies. This method is valid for comparative statements as students can usually tell which part they are more competent in and which part they are less competent in [60]. It is questionable whether the pre-service teachers' competence is as high as experts would assess [20]. Rothland argues that pre-service teachers overestimate their competence at the beginning of the school practice and their development during the practice [61]. Their self-assessment is driven by an illusionary self-concept that is perceived as ideal [61]. Under this argumentation, the competence assessment in this study might depict the pre-service teachers' idealized self-concept.

Our analysis of the impact of the modules is based on the formal module description only. The module descriptions have been in place for some time: long enough to surpass different instructors. We did not assess how much ESD is included in the syllabus of practical teaching by the individual instructors. Neither did we assess the attitudes the individual instructors have towards ESD.

5.5. Conclusions

Our results show an impact of geography education on professional ESD teaching competence assessment. However, this impact is neither very high nor does it encompass all competence dimensions. We see a connection to the importance the pre-service teachers assign to the competencies. How the pre-service teachers want to be might, thus, be a factor in the competence assessment. However, the pre-service teachers integrate some dimensions of ESD competence more strongly into their self-concept than others. This study revealed the blind spots of geography teacher education regarding ESD: PK, PCK, and social and personal competencies.

The claim that higher education should foster all ESD teaching competencies alike might be too strong. A differentiation of PCK according to the consensus model [62] might help develop a hierarchy of skills that must or can be developed during higher education. While we can argue that PK and PCK are left to be developed in the practical phase of teacher education, that higher geography education has no general impact on social and personal competencies, not even in the self-concept, is not satisfying.

Exploring the potential of different geography modules to meet this need shows the benefit of practical modules. Adjusting specialized theoretical modules smoothly to foster competencies to teach ESD thus seems challenging. A strong focus on research and project-based learning might be critical to integrate ESD adequately into geography education. Such methods successfully improve geographic [63] and ESD competence [10,42,64]. Scientific and research skills are also the most mentioned learning skills in geographic ESD concepts [65].

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Appendix A

Box A1. Survey structure.

- (1) ESD-specific competencies [38]
 - a. self-assessment of competence level
 - b. importance assigned to competencies
 - c. classify items to CK, PCK, PK (Shulman (1986))
 - d. expected phase to gain proficiency level (higher education / ongoing career)
 - e. self-assessment of social and personal competencies
- (2) ESD-specific topics [40] KMK/BMZ (2016)
 - a. self-assessment of knowledge
 - b. importance assigned to knowledge
 - c. self-assessment of capability to prepare a lesson for topic
- (3) socio-demographic data

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