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Effects of Health-Related Physical Education Teacher Education on PE Student Teachers' Pedagogical Content Knowledge and on Female Pupils' Health-Related Knowledge and Understanding

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ABSTRACT

The purpose of our study was to investigate a health-related PETE program on two levels: 1) the health-related PCK of PE student teachers participating in the PETE program and 2) the changes in HKU of female pupils participating in the PE lessons developed throughout the PETE program. To study the PCK of the PE student teachers, we conducted a document analysis and examined the PE lesson plans developed during the PETE program. For the investigation of pupils' HKU, a controlled pre-post test was conducted over eight weeks with pupils in an intervention ($n = 113$) and a control group ($n = 61$). The results for PCK showed the PE student teachers' ability to select health-related and competence-based learning tasks. A significant intervention effect with a small effect size was found regarding pupils' HKU. In conclusion, PETE can improve PE teachers' health-related professional competence resulting in higher pupils' HKU.

KEYWORDS

Physical literacy; school-based intervention; pedagogical content knowledge; professional competence; health promotion

Introduction

Physical education (PE) is essential for promoting healthy, physically active lifestyles for children and young people of school age (Messing et al., 2019; Palmer & Behrens, 2017; van Sluijs et al., 2007). As PE teachers may play a key role in encouraging pupils to adopt healthy and physically active lifestyles, effective and targeted health-related physical education teacher education (PETE) is important (Brandl-Bredenbeck & Sygusch, 2017; Hapke et al., 2021). Our study is grounded on the assumption that PE teachers equipped with specific health and physical activity (PA) related professional competencies can significantly enhance these competencies in pupils (Brandl-Bredenbeck & Sygusch, 2017; Hapke et al., 2021; Hunuk et al., 2013). Following scientific models of teachers' professional competence (Baumert et al., 2013; Krauss et al., 2017; Kunter et al., 2013; Shulman, 1986), health-related professional knowledge emerges as a critical factor for health-related competencies and teaching strategies in PETE (Lohmann et al., 2023; Mong & Standal, 2019; Röger-Offergeld et al., 2021; Tinning, 2015). While previous research on health-related PETE has provided valuable

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insights, such as connected health-related beliefs and content-related knowledge of PE (student) teachers (Fane et al., 2019; Harris, 2014; Santiago & Morrow, 2020), only a few studies have focused on the resulting teaching of PE (student) teachers and the pupils' learning success. Thus, our present study aims to offer evidence in this field, as it is crucial in understanding the impact of health-related PETE. In the following, we delve into the aspects that have guided our research interest.

Teachers' professional competence

Teachers' professional competence is often defined based on Shulman (1986), whose criteria are widely used and accepted (Baumert et al., 2013; Blömeke & Kaiser, 2014). According to the generic model of teachers' professional competence, various aspects should be subject to teacher education (Baumert et al., 2013; Kunter et al., 2013). In addition to teachers' beliefs, motivational orientations, and self-regulation, teacher education should, above all, promote the development of teachers' professional knowledge. Two subcomponents of teachers' professional knowledge – content knowledge (CK) and pedagogical content knowledge (PCK) – have been identified as the central categories of a school subject area and must be formulated specifically for each school subject or subject area (Krauss et al., 2017; Kunter et al., 2013).

Concerning PE teachers' health-related professional competence to promote lifelong PA participation in pupils, PE teachers' professional knowledge is also considered an important prerequisite (Hunuk et al., 2013; Kern et al., 2020; Santiago & Morrow, 2020). It is suggested that PE teachers need both – health-related CK and PCK – to implement appropriate goals, content, and teaching didactics in health-related PE (Hapke et al., 2021). However, when it comes to defining the specific professional knowledge that PE teachers need to plan and deliver qualified health-related PE, up until now, there has been little research that refers to a theoretical framework for PE teachers' CK. Even less research exists in relation to PCK (Hapke et al., 2021; Hunuk et al., 2013; Lohmann et al., 2023; Santiago & Morrow, 2020).

Health-related CK of PE teachers

Concerning health-related CK of PE teachers, the concept of Ward et al. (2015) has been largely used. Ward (2009) takes up Shulman's considerations and defines CK for PETE based on the structure and content of various sporting activities, e.g., soccer, track and field: (1) knowledge of the rules, etiquette, and safety, (2) knowledge of technique and tactics, (3) knowledge of errors, and (4) knowledge of instructional representations and tasks. Following Ball et al. (2008), these were further grouped into the knowledge needed to perform a specific sporting activity (Common Content Knowledge, CCK, domains 1 & 2) and the knowledge needed to teach its content (Specialized Content Knowledge, SCK, domains 3 & 4).

For the investigation of the health-related fitness CK of preservice PE teachers, Santiago and Morrow (2020) adopted the CCK concept and examined preservice PE teachers' knowledge e.g., of concepts of fitness (e.g., definitions), of components of HRF (e.g., cardiorespiratory endurance, muscle strength), and of exercise recommendations (e.g., frequency, duration). However, as with some researchers in the U.S., the

focus is mainly on an objective, primarily medically-oriented perspective of health and the prevention of diseases through PE. Generally, a more holistic and salutogenic understanding should be taken as the basis for health promotion (Kickbusch, 2001; WHO, 1997). This is grounded on the salutogenic approach of Antonovsky (1979). In European health-related curricula on PE (e.g., in the Scandinavian countries, Great Britain, and Germany) as well as in Australia, the salutogenetic approach is emphasized (Brandl-Bredenbeck & Sygusch, 2017; Fane et al., 2019; Lohmann et al., 2023; Mong & Standal, 2019; Quennerstedt, 2019). Building on these considerations, Brandl-Bredenbeck and Sygusch (2017) suggest that to foster health-related resources in pupils, PE teachers need profound and salutogenic academic knowledge on the topics of health and PA. Therefore, for PE (student) teachers' health-related CCK, they propose four main topics: knowledge on global (e.g., models of health, the ambivalence of sports), objective (e.g., fitness components like endurance), subjective (e.g., mental wellbeing) and complementary (e.g., nutrition concepts) aspects of health (Brandl-Bredenbeck & Sygusch, 2017; Hapke et al., 2021). Lohmann et al. (2023) confirmed these health-related topics of PE teachers' CCK by conducting a comprehensive literature review on PE teachers' health-related professional competence. In our PETE program, we follow the latter considerations.

Health-related PCK of PE teachers

For *health-related PCK* of PE teachers, Lohmann et al. (2023) found that the term PCK is hardly ever explicitly mentioned in the literature on PE teachers' health-related professional competence. However, they identified various pedagogical-didactical approaches that somewhat focus on health-related PCK. Tinning (2015) divides them into two groups – the instrumentalists' and the educationalists' approach. While the first group believes that PE should primarily direct students on how to promote health-related PA and prevent risk factors and obesity, the second group thinks that PE should have more of an educational purpose and that both teachers and students play a crucial role in determining the purpose, content, and instruction of health-related physical education (Amade-Escot, 2009; Mong & Standal, 2019). Ward and Ayvazo (2016), largely in line with the latter considerations, conceptualize PCK as a construct “that focuses on the act of teaching and the transformation of content knowledge by the teacher into meaningful knowledge for students and student learning” (Ward & Ayvazo, 2016, p. 198). Following Ward et al. (2020), PCK largely refers to the PE teachers' existing SCK. Thus, SCK is the knowledge base for PCK, whereas PCK itself is seen in particular as the ability of the (PE student) teachers to select appropriate learning tasks for the respective learners and teaching situation (Ward & Kim, 2024).

For the present study, we adopt this PCK concept to our context. Following the educationalists' approach, health-related PE and associated learning tasks should encourage critical thinking and involve pupils in co-constructing their own learning to promote their lifelong healthy and physically active lifestyles (Mong & Standal, 2019). Based on these assumptions, our investigation of the PE student teachers' PCK focuses on their ability to select learning tasks characterized by a high degree of openness, situational dependency, and problem-solving orientation (Sygusch et al.,

2022). Health-related learning tasks are embedded in the main characteristics of competence-based teaching, namely cognitive activation, relevance for everyday life, learning structure, and meta-reflection (Hapke et al., 2021; Lohmann et al., 2023). *Cognitive activation* promotes pupils' acquisition and application of knowledge. Challenging learning tasks can help to involve pupils in the learning process. These tasks should incorporate learners' prior knowledge or promote pupils to think about their experiences in PE. *Relevance for everyday life* focuses on topics that are relevant to the pupils. To enable a systematic learning process, PE should also follow features of the *learning structure* that make learning transparent for pupils (e.g., making learning objectives transparent) (Einsiedler & Hardy, 2010). In addition, learners' *meta-reflection* on the learning process, the prerequisites, and the outcomes seems relevant (Einsiedler & Hardy, 2010; Sygusch et al., 2022).

Pupils' health-related knowledge and understanding

One of the key concepts in health-related PE is promoting pupils' *health-related knowledge and understanding* (HKU) (Cale & Harris, 2018; Hapke et al., 2021; Strobl et al., 2020). Following the salutogenic approach, health-related PE should be directed toward promoting pupils' resources, abilities, and knowledge in the name of "learning health" rather than solely the prevention of aspects deemed at risk (Quennerstedt, 2019). In this manner, health-related PE should follow a constructivist perspective of learning by creating meaningful interactions (Zhu et al., 2009). HKU comprises not only the principles of movement and performance, but also the requirements, antecedents, and values of following a physically active lifestyle (Cale & Harris, 2018). HKU covers knowledge on practicing physical activity, exercise, and sports in a healthy way, assessing the health effects of their own sports activities, making healthy choices, and modifying their activities to live healthier (Brandl-Bredenbeck & Sygusch, 2017; Cale & Harris, 2018; Töpfer, 2019). HKU is strongly related to physical literacy, which – besides knowledge and understanding – also comprises a salutogenic and holistic understanding of health, including motivation and confidence, as well as physical competence (Whitehead, 2010). The promotion of HKU is becoming increasingly important in promoting healthy and physically active lifestyles in the school setting, not least as it is associated with increased levels of PA in pupils (Cale & Harris, 2018; Chen et al., 2017; Demetriou et al., 2015; Kulinna et al., 2018; Messing et al., 2019; Ptack & Tittlbach, 2018). For gaining HKU, pupils should learn about objective (e.g., meaning and training of endurance), subjective (e.g., mental health), global (e.g., ambivalence of sports), and complementary health-related aspects (e.g., healthy nutrition) in PE lessons, based on a salutogenic and holistic understanding of health (Ptack & Tittlbach, 2018).

Concerning the investigation of preparing PE teachers to teach various sporting activities, there are several studies examining the effects of PETE on their professional knowledge and pupils' learning success. In particular, the CK or PCK of PE teachers and the influence of CK interventions for PE teachers on their PCK and students' performance in sports-based PE are investigated (Iserbyt et al., 2017; Kim et al., 2018; Ward et al., 2015). In their overview of conceptions and findings concerning PCK, Ward and Ayvazo (2016) found that "most studies have used content representations or instructional tasks derived

from discourse, lesson plans or direct observation of teachers as the primary data sources of PCK” (Ward & Ayvazo, 2016, p. 198). While PE teachers’ sports-related CK and PCK have been investigated quite extensively in recent years, little research has examined PE teachers’ health-related professional competence. Furthermore, existing research on the health-related professional competence of PE teachers is rarely theory-based and focuses primarily on teachers’ health-related beliefs (Fane et al., 2019; Hapke et al., 2021; Harris et al., 2021) and health-related fitness knowledge (HRFK) (Harris, 2014; Kern et al., 2020; Santiago & Morrow, 2020; Santiago et al., 2016). For example, Santiago and Morrow (2020) examined the HRFK of 621 pre-service PE teachers from 68 PETE programs. The results show a mean correct percentage on the test of 61.3% indicating a lack of HRFK of pre-service PE teachers. Most other studies on pre- and in-service PE teachers’ HRFK have similar or even worse results (Castelli & Williams, 2007; Santiago & Morrow, 2020; Santiago et al., 2016). In an analysis of the curricula of 417 health-related PETE programs in the entire territory of the U.S., Ward et al. (2023) come to the conclusion that there is a broad interpretation of what is considered health-related PETE in terms of the curriculum and, accordingly, it cannot be talked about a common PETE curriculum. They see a great need for research and action. Studies on PE teachers’ health-related PCK and students’ learning success are rare. However, they are of great importance for understanding the impact of health-related PETE on teaching and learning outcomes. The present study is to close this research gap.

Purpose of the present study and research questions

Based on the previous considerations, this study follows the educationalists’ approach to health-related PE. We aim to study the effects of the PETE program on two different levels: 1) the health-related PCK of the PE student teachers participating in the PETE program and 2) the changes in the HKU of the female pupils participating in the PE lessons developed by the PE student teachers throughout the PETE program. Our research questions were: How effective is the PETE program regarding a) the PE student teachers’ health-related PCK and b) pupils’ health-related HKU?

Methods

Design

A mixed methods design was used to evaluate the PETE program. We conducted a document analysis to investigate health-related PCK, examining the lesson plans the participating PE student teachers developed during two university PETE seminars. A controlled pretest-posttest study was performed over eight weeks with four secondary school classes each in the intervention and control group using a standardized paper and pencil test to evaluate pupils’ HKU. The pretest (t0) took place in mid-December 2018, and the posttest (t1) in mid-February 2019.

PETE program

The basis of this study was a health-related PE student teachers’ PETE program at the University of Augsburg (see Figure 1). A project-based seminar on “PA and health,” held

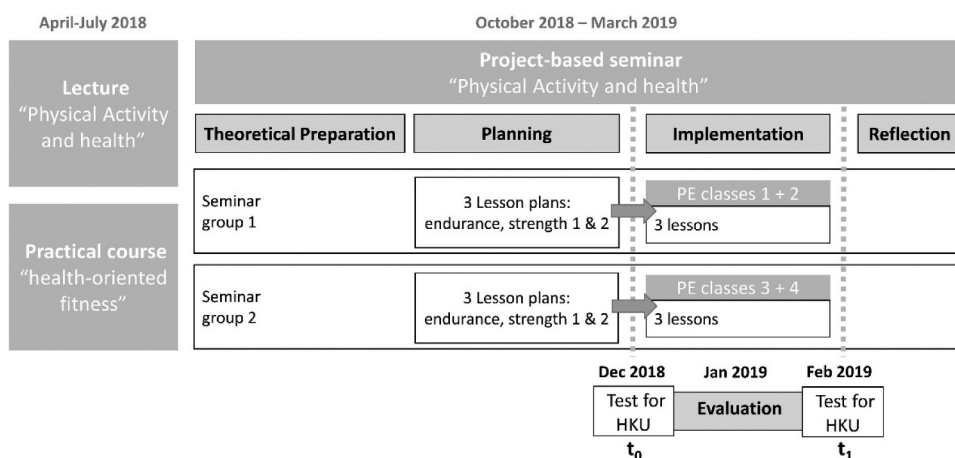


Figure 1. Overview of the PE student teachers' program and the study design.

between October 2018 and March 2019, was the core of this program (main course). The project-based seminar was built on two preparatory courses: lecture "PA and health" and practical course "health-oriented fitness," which took place in the summer semester of 2018 (between April and July 2018).

All teaching courses were based on a salutogenic and holistic understanding of health (alternative approach) to create a basis for the student teachers to help pupils acquire HKU. The lecture covered theoretical topics of CK addressing objective (e.g., endurance), subjective (e.g., mental health), global (e.g., ambivalence of sports), and complementary (e.g., nutrition and sports) health topics (Lohmann et al., 2023). In addition, theoretical aspects of competence-based teaching didactics— *cognitive activation, relevance to everyday life, learning structure, and meta-reflection* (see Introduction) – were included. The practical course involved teaching examples to promote objective (e.g., endurance, strength, flexibility) and subjective (social integration, body image) health resources in PE lessons (CCK), including competence-based teaching didactics (SCK).

The aim of the project-based seminar was to enable the PE student teachers to apply their acquired CCK and SCK to plan, implement, and evaluate appropriate PE lessons for pupils on PA and health. It was mainly practice-based (including joint teaching samples) and was designed to be participatory. That means that although the university lecturer initiated the program, the students were involved in decision-making throughout the seminar and actively participated in all development phases of the PE lessons (planning, implementation, evaluation, and reflection).

In the planning process, student teachers designed the PE lessons with the support of the lecturer. Together, they ensured that the components of CCK and SCK named above were integrated into each lesson. As the implementation phase focused on PE for girls, female PE student teachers of the seminar took the role of teaching.¹ The male student teachers were responsible for the evaluation.

The seminar comprised a total of 14 units. The detailed process with the phases of theoretical preparation, planning, implementation, evaluation, and reflection was structured as follows: In the first half of the teaching units (TU) functioned as a theoretical

preparation. The lecturer’s input, namely goals, contents, and didactics of PE lessons were discussed with the participating student teachers, and priorities were set. In an exchange between the seminars, a basic framework was developed that roughly specified the individual teaching lessons’ goals, contents, and didactics to compare them across the participating PE classes. Ultimately, the aim was, on the one hand, to stimulate mutual learning processes among the student teachers already in the planning phase of the seminar and, on the other hand, to keep the input variability for the outcome measurement as small as possible. In the concrete planning phase (TU 7–10) the lesson plans were finalized and adopted. The 3 PE lessons were implemented in the respective classes (TU 11–13) taking place once a week as part of the regular PE classes. Each lesson lasted 90 minutes. The evaluation phases were set parallel, including testing the pupils (see HKU test). Finally, seminar groups reflected the process and success of the lessons provided (TU 14).

Throughout the PETE program, learner participation (e.g., in the form of teaching samples), higher-order thinking (e.g., in the form of the analysis and discussion of teaching sequences), and critical reflections (e.g., in project-oriented-learning by combining university teaching and teaching experiences in schools) of PE student teachers were fostered.

Participants

As part of the university seminar, two parallel courses were held, each with 12 PE student teachers ($n = 24$). The student teachers were mostly in their third semester and studied an average of 9 semesters. They were between 20 and 24 years old. Approximately 2/3 of the student teachers were female, 1/3 male. The seminar was a mandatory course for all participating students.

The selection of the schools took the form of a deliberate choice by contacting teachers with whom cooperation has already existed by phone or e-mail. In addition, school administrators were asked for permission to participate. To account for the different cognitive abilities of the pupils, two secondary modern classes and two high school classes (7th and 9th grade, respectively) were part of the study.² Each PE teacher participated voluntarily with the corresponding PE class. The total pre-post sample of the pupils in the intervention school included 113 female pupils aged 12–17 years ($M = 13.19$; $SD = 1.18$). In the control school, 61 female pupils were welcomed with an age range of 12–16 years ($M = 13.56$; $SD = 1.27$) (see Table 1). Each of the two parallel university seminars was responsible for two PE classes of the intervention group.

Table 1. Number of students pertaining to intervention or control group.

	Intervention	Control	Total
Total sample	113	61	174
Secondary modern	49	30	79
High School	64	31	95
7 th grade	69	32	101
9 th grade	44	29	73

Measures

Evaluation of health-related lesson plans

The PE student teachers' lesson plans ($n = 6$) were analyzed for health-related PCK. Three lesson plans were submitted in the two seminars (on endurance, strength, and flexibility). Based on the introductions to PCK we examined the lesson plans with regard to the ability of the PE student teachers to select learning tasks characterized by cognitive activation, relevance for everyday life, learning structure, and meta-reflection.

Three researchers independently assessed each PE lesson plan using a questionnaire comprising a quantitative and a qualitative evaluation part in order to grasp PE student teachers' health-related PCK. The quantitative part of the questionnaire consists of 13 items, covering four primary characteristics of competence-based teaching as defined in the Introduction: *cognitive activation*, *relevance for everyday life*, *learning structure*, and *meta-reflection* (Sygusch et al., 2022; see Table 3).

This questionnaire measures the level of competence-based teaching didactics in PE. In addition to previous assessment tools (Ptack, 2019; Sygusch et al., 2020), the number of items was expanded to measure the specific facets of cognitive activation more precisely as it is regarded as a core dimension of competence-based teaching quality (Praetorius et al., 2018). Thus, most items ($n = 10$) relate to *cognitive activation* and measure sub-features such as knowledge acquisition ("The lesson encourages the acquisition of knowledge"), cooperative learning ("The learning tasks are designed in such a way that they stimulate social exchange among the learners") or the incorporation of prior knowledge ("Learning tasks are designed to incorporate learners' prior knowledge"). *Relevance for everyday life* is covered by one item: "The lesson provides an everyday life connection." *Learning structure* is represented by "The lesson provides a clear structure and *meta-reflection* is operationalized by the following item: "The lesson provides opportunities for meta-reflection on learning assumptions, learning process, and learning progress." Each item was rated according to a 4-point Likert scale (Strongly agree [4], Agree [3], Disagree [2], Strongly disagree [1]). If there were noticeable discrepancies between the researchers' ratings (ranging over three or more points on the Likert scale), the individual ratings were consensually validated among the researchers and agreed upon. In addition to this quantitative evaluation part, each researcher was asked to add a short-text qualitative statement based on the questionnaire items. Raters should comment on the lesson's quality with respect to PCK – especially focusing on the content chosen within learning tasks and competence-based teaching didactics.

HKU-test

For measuring pupils' HKU we used a standardized paper pencil test based on the Item Response Theory (Töpfer, 2019). The validated test has been used in previous intervention studies evaluating pupils' development of HKU (Strobl et al., 2020). The test consists of 25 items, including three different item formats: short text (8), single choice (10), and multiple choice (7). The items follow a holistic and salutogenic understanding of health and fitness that integrates global, objective, subjective, and complementary health-related aspects and are derived from current requirements in German PE curricula.

Pupils had 30 minutes time to accomplish the tests providing sufficient time to answer all items without time pressure. Item responses were analyzed according to a code guide (Töpfer, 2019). Reactions to the short-text items had to be rated on a four-point ordinal

scale (0–3). Single and multiple-choice items were ordered dichotomously (0–1). The inter-rater reliability (Kendalls Tau-c) demonstrated a good to excellent level of congruence within the coding process ($\tau = 0.81$). Missing data was treated depending on certain parts of the tests. According to Töpfer (2019) missing data in short text items was assessed as wrong answers (0), indicating that pupils may not be able to respond to an item appropriately. Missing data in single and multiple-choice items was estimated using “plausible values” according to the TAM-package for R (Robitzsch et al., 2021).

The validity of the HKU-test had been proven in a previous study (Töpfer, 2019). The applicability of the Rasch Model (Partial Credit Model) was successfully demonstrated (LR-test: $\text{Chi}^2 = 50.81$; $\text{df} = 40$; $p = 0.12$; Martin-Löf-Test: $\text{Chi}^2 = 321.75$; $\text{df} = 363$; $p = 0.94$). The test showed an acceptable reliability (EAP/PV = 0.79). All items delivered good item fit based on Weighted Mean Square (WMNSQ) within the range of 0.8–1.2.

Data analysis

Evaluation of health-related lesson plans

The quantitative ratings of all three researchers were summarized in a table. The inter-rater reliability (intra-class correlation) proves a very good level of congruence within the rating process (.92) (Koo & Li, 2016). In 15.4% of all ratings, noticeable discrepancies were detected, and researchers agreed on a score through consensual validation. We calculated means (M) and standard deviation (SD) for each lesson plan based on the item scores. With respect to qualitative evaluation, for each lesson plan short-text statements of all three raters were analyzed along the listed items.

HKU-test

The Rasch Model (Partial Credit Model) was used to analyze the quantitative data to estimate the pupils’ responsive behavior values reflecting HKU. Person test parameters were calculated based on the Weighted Likelihood Estimates (WLE) integrated in the TAM-package for R (Robitzsch et al., 2021). Finally, pupils’ HKU scores were transformed into standard values ($M = 500$, $SD = 100$).

Descriptive statistics were calculated for pupil HKU changes between t0 and t1. An analysis of variance (ANOVA) with repeated measures was performed to assess the treatment effect in the intervention group. In addition, to compare effects with those of the control group, we conducted an ANCOVA with HKU at t0 as a covariate and at t1 as the dependent variable. Educational level (e.g., secondary modern versus grammar school) and grade (7th versus 9th grade) represent intersubject factors. Statistical assumptions for the ANCOVA were checked (Field, 2013) and showed no significant problems with kurtosis, skewness, or homogeneity of variance.

Calculated changes in pupils’ HKU between pre-and post-test for each school in the intervention group and their corresponding 95% confidence intervals illustrate the changes in every school. Effect sizes (i.e., Cohen’s d) were calculated for mean differences. To account for the dependency of the pre-post-data, the calculation of d was based on mean differences between HKU at t0 and at t1 divided by the standard deviation of HKU at t0, which was corrected for the correlation between pre-and posttest data (Morris, 2008). All quantitative data analyses were performed using R 3.3.0 and SPSS 26. Significance was set a priori at an alpha value less than .05.

Results

The effectiveness of the PETE program can be viewed on two different levels: (1) PE student teachers' health-related PCK, and (2) pupils' HKU.

Health-related PCK of PE student teachers

Description of the designed health-related PE lessons

During each of the two PETE parallel seminars described above, the participating students developed three PE lessons for pupils on PA and health for each participating class. All lessons were based on a salutogenic and holistic understanding of health. The overall goal of the developed PE lessons was to contribute to the participating pupils' ability to lead an active and healthy lifestyle and to care for their health. Through the programs, participating pupils should (1) understand the potential health benefits of PA and (2) learn how to exercise PA healthily.

To achieve these goals, objective health topics – endurance, strength, and flexibility training – were selected as lesson contents during the planning phase of the seminar, and one lesson for endurance training and two lessons containing strength and balance contents were created. The respective programs included (1) knowledge and understanding of these topics and respective (2) practical forms of exercise. Each lesson was structured: Warm-up, central part, cool-down, and reflection. Various competence-based teaching techniques (relevance for everyday life, cognitive activation, learning structure, and meta-reflection) related to SCK were used in all PE lessons (see below).

For example, the strength and flexibility training unit 1 is outlined in Table 2. At the beginning of the lesson, pupils were asked to move and assume various everyday postures they associate with positive and negative feelings. Then, they reflected on healthy posture and the related potential effects of strength and flexibility training. In the second warm-up exercise, they built on existing knowledge about body muscle groups. They were asked to pin scattered muscle images in the correct locations on a body outline. In the (2) central part, they explored strength training station cards in small groups, presented them to the whole group, and performed them together. In addition, after the (3) cool-down, they discussed the strength training exercises and the muscle groups addressed.

Table 2. Structure of the strength and flexibility training unit 1.

Sequence	Content of the PE lesson
(1) Introduction & Warm-up	(1.1) <i>Active game with music</i> Pupils move in the gym to the music and represent feelings (happy-sad, brave-fearful, etc.) depending on the part of the gym (land of happiness or land of sadness); <i>Afterwards</i>: reflection on healthy postures and potential effects of strength training. (1.2) <i>Active game without music</i> Pupils move in the gym and are asked to pin scattered muscle images in the correct locations on a body outline.
(2) Central Part	(2) <i>Circuit strength training</i> In small groups, pupils receive station cards for strength circuit training. They explore the cards, present the respective exercise to the whole group, and perform them together (with a specified number of frequencies and repetitions).
(3) Cool down & Discussion	(3.1) <i>Dynamic agility exercises</i> Pupils conduct light dynamic agility exercises. (3.2) <i>Discussion</i> Pupils discuss the strength training exercises and the muscle groups they address.

Evaluation of the PE lesson plans concerning health-related PCK

Table 3 shows the results of the quantitative evaluation of the lesson plans. In general, all six lesson plans indicate the application of appropriate learning tasks and therefore student teachers' PCK. *Cognitive activation*, particularly knowledge acquisition, is explicitly addressed in all six lesson plans (item 1) while using knowledge reaches medium values (item 2). The results of items 3 and 4 display that the learning tasks applied by student teachers are, in most cases, challenging and are appropriately missing solution-relevant information. The given learning tasks, in most cases, also seem to incorporate learners' prior knowledge (item 6). Furthermore, the lesson plans appropriately focus on the pupils' reflection of the subject matter (item 10). The results mentioned above especially indicate that lesson plans mostly manage to address relevant learning content in a manner that on the one hand challenges pupils and on the other hand does not overstrain their competencies. Pupils especially receive opportunities to acquire knowledge with respect to the learning content. In addition, relatively good scores were obtained for items related to social exchange (item 8). Almost all lessons follow a clear learning structure (item 11) resulting in high values. In contrast, none of the lesson plans focuses on pupils' meta-reflection (item 13), which would address, for example, pupils' reflection on their learning performance or prerequisite knowledge. Several criteria (items 3, 4, 5, 6, 7, 9, 10, and 12) show large differences among the lesson plans. Lesson plans that address strength-related topics receive higher scores than those that address endurance. This finding also becomes obvious concerning the characteristic relevance for everyday life (12). This can also be seen when comparing the mean scores in the table. A comparison of the two seminar groups shows no apparent differences. The lesson plans differ only slightly in individual points.

With respect to the qualitative evaluation, all six lesson plans show an adequate selection of health-related content concerning the topics of strength and endurance. The raters identify topic-related learning tasks and exercises. For instance, rater 3 indicates that learning tasks focus on "Body awareness: expressing and perceiving feelings; Recognize and classify postures; Assigning muscles; Exploring strengthening exercises and announcing them" (seminar group 2, lesson strength 1). With respect to HKU, the lessons mostly focus on the acquisition of HKU whereas the explicit use of HKU receives only little attention. "In most cases, exercises are given by the teacher and then evaluated. Conscious planning, implementation and evaluation by pupils are not recognizable" (Rater 1, seminar group 1, lesson endurance). The lesson plans are largely adapted to the pupils' development und prerequisites. Several lessons, for instance, explicitly address the pupils' prior knowledge and they provide exercises which pupils can modify according to their physical development. Rater 2: "Existing knowledge is activated and, in some cases, made conscious (importance of muscle groups for posture)" (seminar group 2, lesson strength 1). However, raters remark that the lesson plans barely integrate procedures that explicitly address various levels of competence with respect to an individual and differentiated task work. Furthermore, the lessons did not include opportunities for pupils to reflect on their learning process and learning progress.

Table 3. Evaluation of lesson plans (4-point likert scale with values: strongly agree [4], agree [3], disagree [2], strongly disagree [1]).

	Lesson plans Seminar group 1			Lesson plans Seminar group 2		
	Endurance	Strength 1	Strength 2	Endurance	Strength 1	Strength 2
1) The lesson encourages the acquisition of knowledge .	4	4	4	4	4	4
2) The lesson encourages the use of knowledge .	2	3	2	3	2	2
3) The lesson contains challenging learning tasks .	2	4	4	2	4	3
4) The learning tasks are designed so that solution-relevant information is missing .	2	4	3	2	4	3
5) The learning tasks are designed so that independent learning is possible and necessary .	2	4	3	2	4	3
6) Learning tasks are designed to incorporate learners' prior knowledge .	2	3	4	3	3	3
7) The learning tasks are designed to be fundamentally open-ended .	2	4	3	2	3	3
8) The learning tasks are designed in such a way that they stimulate social exchange among the learners .	2	3	3	3	3	3
9) The learning tasks are designed in such a way that they offer the potential for individual and differentiated task work .	2	2	3	1	2	2
10) The learning tasks are designed in such a way that they encourage the learners to reflect on the subject matter .	2	3	3	3	3	3
11) The lesson provides a clear structure .	4	4	4	3	4	4
12) The lesson provides an everyday life connection .	2	3	4	2	3	4
13) The lesson provides opportunities for meta-reflection on learning assumptions, learning process, and learning progress.	1	1	1	1	1	1
Mean (SD)	2.23 (0.83)	3.22 (0.93)	3.15 (0.90)	2.38 (0.87)	3.08 (0.95)	2.92 (0.86)

HKU of pupils

Table 4 shows that pupils' HKU generally improved across groups, type of school, and grade. Specifically, pupils from intervention schools ($\Delta 19$) improved their HKU more than those from control schools ($\Delta 10$). Regarding intervention schools, pupils from secondary modern schools showed more significant improvements for HKU ($\Delta 23$) compared to high school ($\Delta 14$). Pupils in 7th grade ($\Delta 17$) improved their HKU slightly less than those in 9th grade ($\Delta 22$).

Table 4. Descriptive statistics ($\bar{X}$, SD and Δ for mean differences) for pupils' HKU before (HKU_t0) and after (HKU_t1) the intervention for the total sample of the intervention group (for the total sample and differentiated by educational level and grade) as well as for the control group with adjusted Cohen's d.

	HKU_t0 $\bar{X}$ (SD)	HKU_t1 $\bar{X}$ (SD)	Δ	d
Intervention group ($n = 113$)	485 (87)	504 (90)	19	.24
Secondary modern ($n = 49$)	451 (78)	474 (80)	23	.34
High School ($n = 64$)	512 (85)	526 (91)	14	.18
7 th grade ($n = 69$)	478 (76)	495 (87)	17	.25
9 th grade ($n = 44$)	496 (101)	518 (95)	22	.27
Control group ($n = 61$)	466 (102)	476 (98)	10	.12

After repeated measures ANOVA for the intervention group, there is a significant main effect for change in pre-and post-test scores for the total sample ($F_{1,113} = 6.27$, $p = 0.01$), with a small effect ($d = .24$). The interactions with educational level ($F_{1,113} = 0.170$, $p = 0.68$) and grade ($F_{1,113} = 0.01$, $p = 0.93$) are not significant. While the effect sizes of the pupils at secondary modern school ($d = .34$) and the 7th ($d = .25$) and 9th grade ($d = .27$) are small, that of the high school students ($d = .18$) is not statistically relevant.

Table 5 shows the results of the ANCOVA. There is a significant relation with HKU_t1 for the covariate HKU_t0 and all factors: HKU_t0 ($F_{1,174} = 63.68$, $p = 0.00$, $\eta^2 = .28$), education level ($F_{1,174} = 7.20$, $p = 0.01$, $\eta^2 = .04$) and grade ($F_{1,174} = 5.38$, $p = 0.02$, $\eta^2 = .03$). After adjusting for education level, grade, and the covariate HKU_t0, HKU_t1 of the pupils in the intervention schools is significantly greater in contrast to the control group ($F_{1,174} = 3.88$, $p = 0.05$, $\eta^2 = .02$; small effect) and the difference can be described as small effect. The interactions between group (intervention vs. control group), education level, and grade were not significant, and, because they are not relevant to the present research questions, they are not presented in Table 5.

Table 5. Analysis of covariance (dependent variable: HKU_t1) with factors intervention vs. control group, education level, grade, and the covariate HKU_t0.

	df	F	p	Partial η^2
Covariate				
HKU_t0	1	63.68	.00	.28
Factors				
Education level	1	7.20	.01	.04
Grade	1	5.38	.02	.03
IG vs. CG	1	3.88	.05	.02

Discussion

The purpose of this article was to introduce a participatory PETE program aimed at improving the professional knowledge among PE student teachers concerning PA and health promotion. We investigated the effectiveness of the PETE program at two different levels: (1) We rated the PE lesson plans developed and practically implemented by the participating PE student teachers according to health-related PCK. In addition, (2) we studied changes in pupils' HKU who participated in the PE lessons implemented by the student teachers.

The study underlines the assumption that PETE programs promoting PE student teachers' health-related CK, in general, are suitable for developing PCK (Brandl-Bredenbeck & Sygusch, 2017; Hapke et al., 2021; Lohmann et al., 2023). The PE lessons developed by the participating student teachers are based on a salutogenic and holistic understanding of health with a learning focus on objective learning goals (endurance, strength, flexibility). The lesson plans are broadly consistent with recommendations for competence-based learning in PE (Engelhardt et al., 2023; Ptack & Tittlbach, 2018; Sygusch et al., 2022). Thus, the PE student teachers developed lessons in which they translated general characteristics of competence-based teaching-learning (e.g., cognitive activation) into specific didactical practices (e.g., pupils explored and presented exercises of circuit strength training). These findings are in line with other studies in rather sports-based PE,

which found that improved SCK changes PCK and student performance (Iserbyt et al., 2017; Ward et al., 2015). All planned lessons could be put into practice with pupils. Unlike other intervention studies in this area, lesson plans were not predetermined by the researchers (Volk et al., 2021; Wang & Chen, 2019) but developed in collaboration with PE student teachers. Such participatory methods have been used in previous health-related intervention studies with in-service PE teachers (Strobl et al., 2020).

The participating PE student teachers could apply the specified characteristics (e.g., cognitive activation, learning structure) to their lesson planning. In comparison, in-service PE teachers in other studies had difficulties accepting and applying these relatively new elements of PE didactics (O’Leary, 2014; Ptack, 2019; Strobl et al., 2020). Characteristics of competence-based learning are sometimes seen as contrary to other PE requirements, such as maximizing the amount of movement time (Hastie & Curtner-Smith, 2006; Serwe-Pandrick et al., 2023). In addition, research shows that PE teachers view the gym environment as difficult for reflective discussion (Serwe-Pandrick et al., 2023). In contrast to this, our results indicate that student teachers are mostly capable of integrating reflective and cognitive phases in their lessons. They only struggled to focus on “meta-reflection” in the planned PE lessons.

The PETE program shows how PE student teachers may acquire competencies for planning competence-based PE lessons at the beginning of their professionalization process. The results indicate that the competence-based quality of PE lessons designed and delivered during the present PETE program is relatively high. Accordingly, the PE student teachers in our study, who were at the beginning of their studies, have developed health-related CK and PCK during the PETE program. This is considered a requirement to make the content accessible and understandable to pupils (Ward & Ayzazo, 2016). The outcome data presented above also indicate that the learning process appears to have been successful for both student teachers and pupils. According to Ward et al. (2018), one of the most important benefits of such programs is the perceived confidence of PE teachers when they realize that their personal PCK and CK benefit their teaching practice.

Concerning the pupils’ HKU, the results showed a significant intervention effect with a small effect size. This demonstrates the HKU-strengthening effect of the health-related PE lessons developed by the student teachers during the PETE program. These findings are consistent with other studies that have examined the effects of participating in school-based interventions on pupils’ HKU. Most (79.4%) of the studies reviewed by Demetriou et al. (2015) found significant positive effects on pupils’ HKU. Accordingly, in the present context, the PE lessons developed by the PE student teachers are comparable to those of other lessons often implemented by in-service PE teachers (some of whom are specially trained) (Strobl et al., 2020). The review just mentioned found no influence of an intervention’s content, duration, or frequency in relation to its effects on HKU. Comparing the results of the present study with comparable investigations, however, an effect of the intervention duration emerges. While Strobl et al. (2020) found a medium effect on pupils’ HKU from a school-based health-related in-service participatory intervention of one school year, in the present context, a small effect on pupils’ HKU was found for an intervention duration of three lessons while using the same test instrument. In contrast, Demetriou et al. (2014) found no significant intervention effect after an eight-week health-related PE program on pupils’ HKU with comparable time spent on input to pupils’ HKU. Nevertheless, they identified a tendency for positive effects among the participating girls

that, according to the authors, was not significant due to the small statistical power based on a small sample size. Strobl et al. (2020) also found that girls, and thus the target group of the current study, were more likely to achieve higher scores of HKU than boys.

In the present study, there were only gradual differences in changes of HKU between pupils from the 7th and 9th grades, with a slight advantage for the 9th grade. Demetriou et al. (2015) provide similar results showing a slight tendency for the age of the participating pupils, with adolescents gaining more positive effects on their HKU than children. This was explained by higher levels of cognitive development with growing age and possibly higher learning experience. In contrast, Strobl et al. (2020) discovered a reverse effect, as they found greater HKU improvements among pupils from lower (7th) than upper grades (8th, 9th, and 10th grade), which was initially attributed to lower initial values in the HKU. The related question of adequate health-related cognitive content for different cognitive levels and learning experiences should be further explored in future studies to integrate this into PETE adequately.

Limitations

The present study comprises specific limitations. First, the given sample represents only girls. The results may differ concerning male pupils. Other studies have found gender differences in health-related PE interventions (Demetriou et al., 2015; Strobl et al., 2020). Second, schools were not randomly assigned to the intervention or control group; participation was based on teachers' willingness to take part. However, other intervention studies in the school setting have shown that the criterion of randomization may be challenging to meet, so only few studies have met this standard (Volk et al., 2021). Third, the health-related PCK is only measured at a conceptual level focusing on lesson plans as potential output of PCK. Further video-based evaluation of actual teaching may be helpful to gain more insights into pupils learning and the behavior of PE student teachers in class (Ptack, 2019; Sygusch et al., 2020). Fourth, the present study focused on PE student teachers' health-related professional knowledge concerning PE lessons. A more comprehensive evaluation of PE teachers' health-related professional competence, including other factors (e.g., their health-related beliefs, motivational orientation), would be necessary to paint a complete picture (e.g. Baumgartner, 2022; Lohmann et al., 2023; Santiago & Morrow, 2020). Thus, it was impossible to comprehensively analyze the relationship between PE teachers' professional competence and pupils' HKU. To address this gap, future research should develop and include measures focusing on additional factors of PE teachers' health-related professional competence. Fifth, given the relatively small effect sizes found in the results, it should be noted that the PE student teachers themselves may have made a greater difference than the lesson plans they developed. "New" teachers in a class can alter pupils' learning due to a higher commitment of the new teacher or the pure excitement of pupils having something different in class.

Outlook

With our study, we evaluated the effects of a PETE program in terms of PE student teachers' health-related PCK and pupils' HKU. It demonstrated that PETE could help improve the health-related professional competence of PE (student) teachers and,

ultimately, the HKU of pupils. Therefore, the present study seems to confirm the results of other studies in sports-based PE that health-related PETE positively influences PE (student) teachers PCK and pupils' HKU. However, these effects tend to be on a short-term timeline. Currently, there is no evidence of possible long-term effects of PETE for PE (student) teachers on their subsequent health-related PE on the one hand and long-term effects on changes in the physically active lifestyles of the pupils involved on the other (Hapke et al., 2021). Such associations may only be traced in future longitudinal study designs. In addition, our PETE program focused on health-related CK and PCK of PE student teachers. However, the health-related professional competence of PE teachers also includes aspects such as beliefs, motivational orientations, and self-regulation (Kunter et al., 2013; Lohmann et al., 2023). Future research and PETE programs should also address these aspects of health-related professional competence to provide a comprehensive picture.

Notes

1. This division was made, as in the German federal state of Bavaria (where the PETE program took place). PE classes there are usually segregated by gender and most commonly taught by teachers of the same gender.
2. At the age of 10 or 11, pupils enter secondary school, which in Bavaria is divided into three education levels: Hauptschule, Realschule (secondary modern school), Gymnasium (high school).

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