Enhancing subject-specific interests through interdisciplinary teaching units

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Abstract

Due to its constructivist nature, interdisciplinary teaching appears ideal for increasing students' interests in subjects (Brassler, 2020; Kramer & Wegner, 2021). Although many argue in favor of a more comprehensive implementation of interdisciplinary teaching in schools, many practical barriers arise during the realization that need to be resolved following the design-based research approach (DBR) (Kramer & Wegner, 2022b). Especially at the upper secondary school level, implementation seems to be difficult. The question arises of how interdisciplinary instruction can be usefully implemented in the upper grades. As a first potential solution, interdisciplinary project days were developed in the subject combination of biology and physical education and evaluated with the help of an initial study. The prototypes developed increased both students' situational interests and their perceptions of the utility value of the subjects involved (Kramer & Wegner, 2021; 2022a). However, the implementation process could be optimized, as it currently depends on reducing other school subjects. Therefore, following the iterative cycle of DBR, a new prototype was developed involving interdisciplinary units within the regular subject lessons.

The second prototype was empirically evaluated with a control-group design. In contrast to the first prototype, only descriptive trends were found, indicating that the interdisciplinary units trigger situational interest and stabilize individual interest. However, this cannot be supported statistically. Due to a high data dropout, the sample size should be increased, and the trends should be further investigated. In terms of practical feasibility, the second prototype has an advantage as it does not require any cancellation of subject lessons. However, implementing a second subject may reduce the time available for subject-specific content.

Keywords

Interdisciplinary Education, Subjective task values, Interest Development, Design-based research

Introduction

In today's society, we encounter numerous transformative challenges that require adaptations to new demands across various levels, including politics, economy, and society (Stentoft, 2017). To cope with the transformative needs, interdisciplinary competencies such as problem-solving skills, critical thinking, or collaboration are increasingly relevant apart from professional expertise (Stentoft, 2017; Ye & Xu, 2023). The importance of these factors extends beyond adult education and should be emphasized in schools (Wang et al., 2020). The effective promotion of those competencies is a central characteristic of interdisciplinary education (Labudde, 2014; Ye & Xu, 2023). These approaches are, therefore, becoming increasingly important in international education systems (European Council, 2018; KMK, 2023; Wang & Song, 2021; Ye & Xu,

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2023). In upper secondary school, there is a special emphasis on providing interdisciplinary instruction to students. This approach aims to familiarize individuals with scientific inquiry and assist them in building connections between the fundamental principles of various disciplines (KMK, 2023). When implementing these teaching scenarios in upper secondary grades, an organizational problem arises. Due to the elective course system in Germany, the courses are composed of different students. Therefore, two courses to be combined do not have the same student population (Kramer & Wegner, 2022b). Thus, the implementation of interdisciplinary projects in upper grades is quite challenging, which leads to a difficult question for educators and professionals in this field: How can interdisciplinary education be usefully implemented within upper secondary school? (Kramer & Wegner, 2022b).

The project "Sport-Bio-logisch!" examines this problem and focuses on an interdisciplinary approach within the methodological framework of design-based research. The project aims to develop and empirically examine interdisciplinary teaching units combining biology and physical education for the upper school as possible solutions to the problem. After preliminary research in terms of a systematic literature review, a first prototype solution was created. However, upon evaluation, it was found that the prototype does not fully meet the demands of schools, and further development is required (Kramer & Wegner, 2020, 2021, 2022a, 2022b). Consequently, the project is currently evaluating a second prototype. On the research level, student attitudes are surveyed including their interests in both subjects. This paper presents a comparison of the results of the second prototype with the first study, focusing on the development of student interest. Additionally, we discuss the practicality of implementing the prototype in upper secondary schools. Focusing on the development of interest as a partial aspect of the project, the present study is placed in the overall context of the project, making the methodological approach of design-based research transparent.

Interdisciplinary Education

Interdisciplinary education encompasses various models, resulting in a range of associated terms (Weinberg & Sample McMeeking, 2017; Ye & Xu, 2023). A highly divergent picture of definitions emerges, making discourse in research and practice difficult (Kramer & Wegner, 2020). However, the central ideas of the different conceptual forms can be found in Klein and Newell's (1996) definition. They describe interdisciplinary instruction as "a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession" (Klein & Newell, 1996, p. 3). The main focus is on a particular issue or inquiry that is being addressed in instruction (Kramer & Wegner, 2020). The issue should be relevant, multifaceted, and multifactorial so that at least two disciplines need to be equally involved in the development of solutions (Caviola et al., 2011; Labudde, 2003). Integrating preexisting knowledge from the respective disciplines is fundamental to this process (Weinberg & Sample McMeeking, 2017). Consequently, interdisciplinary education builds on the basic knowledge acquired in the subjects, rather than being seen as an alternative to subject teaching.

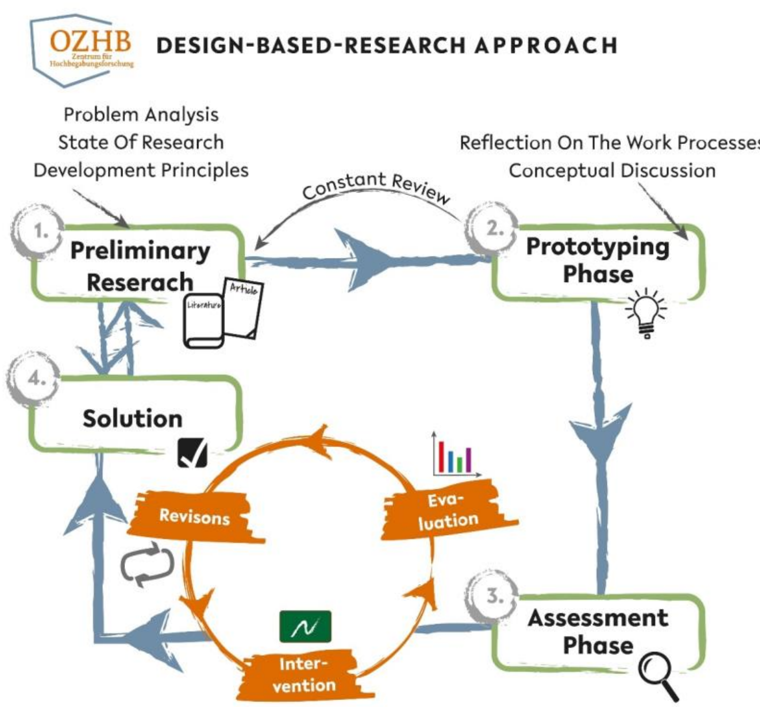
Accordingly, problem orientation and a moderate constructivist approach are constituting characteristics of interdisciplinary teaching (Brassler, 2016; Brassler & Dettmers, 2017). During instruction, students engage with an authentic and complex problem that requires the perspectives of at least two subjects to reach a solution. To adequately address issues in a particular field, students must utilize their existing knowledge and experiences while also actively expanding upon this foundation by considering diverse perspectives. This takes place in contexts relevant to the students (Labudde, 2008).

Encouraging students to recognize the boundaries of subject disciplines, and to interconnect relevant content of these to develop answers to complex problems in collaborative settings, is one way to foster 21st-century generic competencies (Wang & Song, 2021; Ye & Xu, 2023). There are profound arguments that support endeavors to increase interdisciplinary education. It is argued that interest is increased since learning takes place in meaningful contexts and students gain individual access to the subject matter (Labudde, 2014). The argument can be strengthened by scrutinizing specific subject combinations, such as those in the fields of biology and physical education (PE). PE has the unique attribute of experience. Engaging in physical activities can provide students with first-hand experiences that deepen their understanding of biological concepts (Ukley et al., 2013). Conversely, biology allows them to explain practical phenomena in sports (Ukley et al., 2013). Integrating PE makes it possible to establish personally relevant contexts. These postulated benefits are often based on theoretical considerations or experiential reports from teachers and students (Applebee et al., 2007; Kramer & Wegner, 2020; Stentoft, 2017). There seems to be limited empirical evidence of the positive effects of interdisciplinary education (Kramer & Wegner, 2020). Nevertheless, the implementation has become increasingly popular, leading to organizational issues at the upper secondary level.

Design-based Research

The project "Sport-Bio-logisch!" intends to address this problem by following the three phases of the design-based research approach, to which a fourth phase "solution" has been added (Reinmann, 2017; Schmiedebach & Wegner, 2021, see Figure 1). The project will be presented along the different phases of the iterative cycle with a focus on the evaluation of the second prototype (see also Figure 1).

Figure 1: Expanded DBR Cycle of the OZHB



The cycle consists of a preliminary review to capture the current state of research and practice (Schmiedebach & Wegner, 2021). This is followed by the development of a prototype as a potential solution to the initial problem, which is examined in the iterative assessment phase consisting of intervention, evaluation, and revisions. Ideally, this iterative process results in a recommended solution to the initially posed problem. Related theories are also refined and new ones are created (Schmiedebach & Wegner, 2021).

The focus of this article is to assess the research and findings related to the second DBR cycle. However, to give a complete picture of the project, a brief overview of the first cycle is also provided. Table 1 (see Appendix) summarizes the project's development phases according to the DBR approach.

Preliminary research

Initially, a systematic literature review was conducted to identify the current state of research on interdisciplinary education in the subject combination of biology and PE. A total of 14 studies were found in the period from 2000 to 2019 (Kramer & Wegner, 2020). It was found that few concepts have been developed and scientifically tested for upper grades. The research focused on students' knowledge acquisition and activity levels. There has been limited research on the impact of interdisciplinary interventions on affective-motivational levels (Kramer & Wegner, 2020). Consequently, there seems to be a lack of empirical support for the promotion of interest through interdisciplinary education as postulated by the theoretical discourse. This, in turn, led to the research focus on investigating the development of interest (Kramer & Wegner, 2020). From a research perspective, the findings of the study can serve as indicators for promoting the use of prototypes in schools.

Excursus: Interest

In order to comprehend how interdisciplinary education can promote interest, it's important to delve into the concept of interest as such.

The construct "interest" is described as an "interactive relation between an individual and certain aspects of his or her environment (e.g., objects, events, ideas)" (Hidi & Harachiewicz, 2000, p. 152). It can be understood as a psychological stage but also as a motivational disposition (Renninger & Hidi, 2017). Within a psychological dimension, interest is characterized by heightened attention, increased concentration, and effort during an engagement (Renninger & Hidi, 2017). Two forms of interest can be differentiated as motivational dispositions, depending on a temporal determinant (Renninger & Hidi, 2017).

Individual interest can be defined as a time-stable dispositional preference for engaging with a particular topic or subject area regardless of occurring difficulties (Ainley et al., 2002). Individual interest is not limited to one area of interest. A person may possess a whole network of different individual interests that are highly specific to particular subject areas or, more generally, to new phenomena (Ainley et al., 2002). Individual interests are tied to positive attitudes toward the object of interest (Ainley et al., 2002).

In contrast, situational interest is determined by its temporal limitation. It is caused by an external trigger that attracts the person's attention (Krapp, 2002). The associated emotions can be both positive and negative (Ainley et al., 2002). Situational interest can either decrease or develop into a more stable form (Ainley et al., 2002; Hidi & Renninger, 2006).

Consequently, interest as a motivational disposition is highly variable and can be influenced externally. In a heterogeneous class, students have different dispositions, though they can be transferred into the same psychological state (Renninger & Hidi, 2017). How interest develops from situational interest to individual interest can be explained by Hidi & Renninger's four-phase model of interest (2006, see Figure 2).

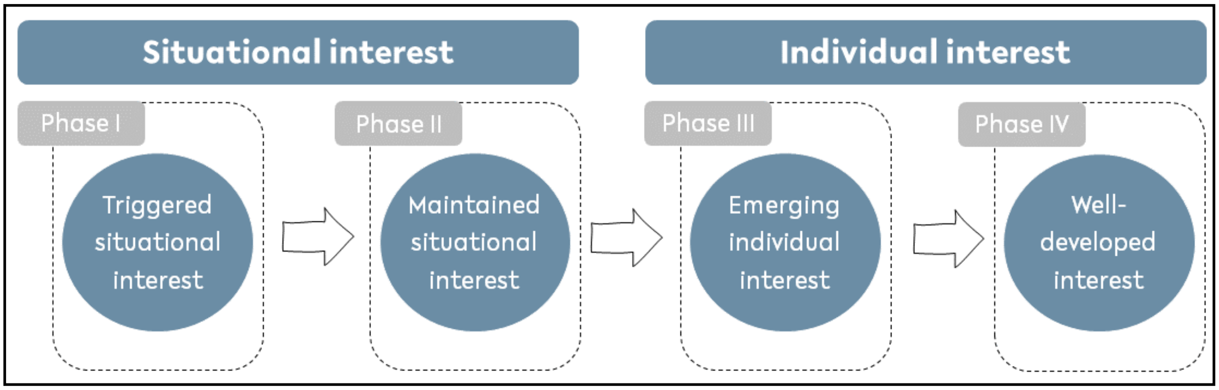


Figure 2: Illustration of the four-phase model of interest development by Hidi & Renninger (2006)

The first two phases can be assigned to situational interest. In the "triggered situational interest" phase, interest is induced by an external trigger. This can be, for example, a phenomenon or an experiment. If the trigger is perceived as individually important, it can lead to further engagement with the topic. This transition to a "maintained situational interest" usually requires external support, such as a teacher explaining the relevance of the object to the student's life or their academic development. A stable value conception, basic prior knowledge, and a positive attitude towards the topic can lead to a development of so-called "emerging individual interest." Students with individual interests follow their own questions about the content and look up additional information. Here, too, external influence can help to consolidate individual interests, especially when problems arise. If such problems do not lead to a decrease in interest and the students continue to work on the subject matter, their individual interest can be described as “well-developed.” Although the phase has a high degree of autonomy, interest can also be positively influenced by external sources (Wigfield & Cambria, 2010).

While the model suggests a linear development of interest, the different stages of interest do not necessarily imply a ranking. For instance, in a school context, situational interest appears to have great importance in getting the attention of individuals who are not yet interested in the topic (Hidi & Harackiewicz, 2000). However, it is important to support these initial situational interests to ensure that students remain engaged with the subject matter for an extended period of time, rather than only capturing their attention for a single moment (Wigfield & Cambria, 2010). Maintained interest in the subject matter is crucial for students to stay motivated and continue learning in future lessons (Wigfield & Cambria, 2010). Further individual interest is also desirable to increase students' interest in a subject and to generate excitement about the related academic fields and associated jobs.

Interests develop as a part of the interaction between a person and the contexts they engage with (Wigfield & Cambria, 2010). Thus, interest can be promoted or diminished by the individual and by the environment (Wigfield & Cambria, 2010). The initial two phases and the shift toward the third phase can be affected by external factors, both positively and negatively. This makes them ideal opportunities for creating and maintaining interests through instruction. Between the first two and between the second and the third phases, value conceptions constitute a crucial factor to strengthen the initially triggered interest and to transfer it into a more stable form. In this context, Schiefele (2009) highlights that the promotion of interest depends on three factors. First, the content must be meaningful. In addition, it should have a practical application to the reality of the student's lives and, ideally, be connected to existing interests (Schiefele, 2009).

Promoting interest in school is crucial as it improves the quality of learning through increased engagement and attention (Steidtmann et al., 2023). Furthermore, interest affects motivation, academic achievement, and later career choices (Schiefele, 2009; Canning & Harackiewicz, 2019). Although interest is highly relevant, declining interest is observed over the course of students' time at school. This has been found especially for science subjects including biology (Holstermann & Bögeholz, 2007; Löwe, 1987; Prokop et al., 2007; Potvin & Hansi, 2014; Vlckova, Kubiatko & Usak, 2019; Wegner & Schmiedebach, 2020) but also for PE (Bös et al., 2006; Potvin & Hasni, 2014).

Throughout one's lifetime, differing interests may arise, providing potential explanations for the decline. At first, students display a general curiosity towards various subjects. However, over time, they tend to develop a specific interest in particular subject areas and topics (Wigfield, 2010). This is a natural process bolstered by course selection in the upper secondary classes. The change in teaching methods from a holistic approach during primary education to a subject-specific approach during secondary education (Tröbst et al., 2016) constitutes another potential reason for the decline of student interest. Holistic approaches enable teaching to become close to students' everyday experiences, making it meaningful (Tröbst et al., 2016). In subject-specific courses, it is challenging to address everyday experiences and related issues from a single disciplinary perspective. Constructivist and problem-based instruction, meanwhile, can promote interest because they combine interest promoting factors (Schiefele, 2009). The questions associated with the problem trigger situational interest (Harackiewicz et al., 2016). If the problem is complex enough and several connecting questions arise, situational interest can be stabilized (Harackiewicz et al., 2016). Problem-based and constructivist instruction has the potential for students to access their own prior experiences and actively construct new knowledge based on phenomena and questions to be solved (Wegner & Kramer 2022a). Interdisciplinary education combines both approaches and, therefore, theoretically provides a good basis for promoting interest in the participating disciplines.

Prototype I

Based on the central practical problem of how interdisciplinary education can be usefully implemented in the upper school, as well as the systematic review of interdisciplinary education projects in the subject combination of science subjects and PE, a first prototype was developed. The requirements for the prototype were usability in upper grades, the subject combination of PE and biology, and an orientation to the central definition of interdisciplinary education. As potential prototypes for the assessment phase, one-day workshops on various topics were developed. One of the developed workshops is called "learning through movement" and will be described briefly as it is the basis of both assessment phases (see Table 1 in Appendix).

The intervention begins with a practical coordination exercise. In this exercise, students throw two balls in the air, cross their hands, and catch the balls again. The resulting question "Why do we have such a problem with this coordinative task?" can be answered from the perspectives of biology and physical education. At first, different brain areas and their role in creating a movement are investigated. The primary focus is on the executive functions, which are located in the frontal lobe. Through psychological tests and additional sports exercises, the students learn about the executive functions in more detail and how they influence not only the execution of the initial exercise but also other actions in everyday life. Finally, practical sports training that improves executive functions is developed and tested. In addition, the training's effects on the brain will be worked out. The unit closes with a reference back to the initial question. A more detailed description of the intervention can be found in Kramer, Großecosmann & Wegner (2022).

Since interdisciplinary education is considered to have a positive influence on interest development due to its constructivist and problem-oriented approach, the effects of the interdisciplinary prototype on interest development were investigated. A quantitative instrument was used to examine situational interest and subjective task values in a pre-post design. The subjective task value consisting of intrinsic value, utility value, attainment value, and cost are predictors of sustained interest (Acee et al., 2018; Tibbetts et al., 2015) and are defined as follows:

> The "intrinsic value" of a task is the enjoyment derived from the task itself (Eccles et al., 1983). It is often referred to as interest or interest value (Steinmayr & Spinath, 2010).
>
> The "utility" of a task refers to its relevance for achieving future goals. The task may have purely functional characteristics and need not correspond to any intrinsic value. Therefore, it may have some extrinsic characteristics (Eccles et al., 1983).
>
> The "attainment value" of a task is determined by its relevance to one's personal and social identity. If the task challenges and addresses traits important to one's self-esteem, its "attainment value" is considered high. This depends on the affirmation of personally significant character traits (Wigfield & Eccles, 2020).
>
> The "cost" of a task is described by the effort and time a person has to invest in dealing with the task (Wigfield & Eccles, 2020).

In the study, we utilized the assessment tool developed by Steinmayr and Spinath (2010). This tool associates subjective task values with entire school subjects instead of individual tasks and consists of items that can be rated by the students on a rating scale. Since intrinsic value combines the dimensions of situational and individual interest (Wigfield & Cambria, 2010), the construct was divided in "situational intrinsic value" according to Wegner (2009) and "intrinsic value" according to Steinmayr and Spinath (2010).

Assessment phase I

In the first cycle, the concepts were piloted in school classes, evaluated in terms of their feasibility, and conceptually adapted. In the second cycle, the concept named "learning through movement" (Kramer, Großecosmann & Wegner, 2022; Kramer & Wegner, 2021) was tested as a day workshop with 75 students from upper secondary classes. The evaluation was conducted using the quantitative test instrument, initially without the intrinsic value subscale since no effect on individual interest can be assumed for short-term interventions. Mixed ANOVAs showed a significant positive effect of the interdisciplinary intervention on the situational intrinsic value in biology and PE and on the utility value of the two individual subjects (Kramer & Wegner, 2021). The attainment value of the two subjects showed no significant change. These first empirical results show positive effects of interdisciplinary instruction on the interest development. A first situational interest could be increased. In addition, the utility value indicates that the students recognized a value in the thematic examination for their lives, indicating further engagement with the discipline. Consequently, the results hint at the fact that the first phase of triggered interest can be evoked and stabilized through interdisciplinary education.

Solution I

From a research perspective, this first prototype is suitable for implementation at the upper secondary level. Project days are ideal for carrying out interdisciplinary instruction in a chosen combination of subjects. However, this is at the expense of other subjects whose lessons are cancelled for the duration of the project. Consequently, the frequency of interdisciplinary projects in the form of project days or weekly workshops is limited. As a result, the prototype did not provide an ideal solution to the problem in the field, and the DBR cycle has been repeated to develop a second prototype.

Prototype II

During a second DBR cycle, the preliminary review was not required. A new prototype was developed based on the limitations of the first prototype. The main criticism was the reduction of other subject lessons and consequently rather limited feasibility in schools. The new prototype had to be implementable in regular school settings without affecting other subjects and their organizational frameworks. As described at the beginning, course selection within upper grades severely limits the coordination of interdisciplinary education between two subject teachers, since their courses are attended by different students. Consequently, the new prototype had to be feasible in one course. Its content was based on the workshop of the piloted first prototype "learning through movement" (Kramer, Großecosmann & Wegner, 2022; Kramer & Wegner, 2021). The workshop phases were divided into single lessons in order to obtain completed lessons for the school. A total of 10 lessons were designed. If necessary, the entire teaching unit can be conducted in one subject. Practical PE elements were designed to be held in a classroom, eliminating the need for a gymnasium.

The test instrument was also slightly adapted. In addition to a follow-up survey to investigate long-term effects (six to eight weeks), the test instrument was supplemented by the "intrinsic value" of Steinmayr & Spinath (2010), which, in addition to the "situational intrinsic value," rather measures individual interest. All items could be rated on a six-point rating scale. The test instrument was examined for internal consistency. Table 2 (see Appendix) shows the results of the analysis. All subscales of the test instrument were found to be acceptable.

Assessment phase II

In the second assessment phase, the first evaluation phase was skipped. Instead, the prototype was directly accompanied by the test instrument. Only minor didactic adjustments were made (e.g., using material with clearer task instructions, additional support materials), which were based on feedback from the students and teachers, but did not change the content or methodology of the lessons.

Hypotheses

Following the theory of interest development, the prototype was examined with regard to the question: How do interdisciplinary teaching units in biology and PE influence the students' interest development? For that purpose, the following hypotheses were formulated:

> Through its problem-based and constructivist approach, interdisciplinary education provides a theoretically well-suited basis for promoting initial situational interest (Harackiewicz et al., 2016). Therefore, the following hypotheses were formulated:
>
> H1: The "situational intrinsic value" of biology is rated higher after the intervention than before the intervention.
>
> H2: The "situational intrinsic value" of PE is rated higher after the intervention than before the intervention.

Following Scheifele's (2009) argumentation that problem-based approaches combine all three prerequisites to promote interest, students might experience the subject as relevant to their lives and practical issues through interdisciplinary education as a problem-based approach. The study of the first prototype already showed an increased utility value for both subjects, which confirmed the assumption for the first prototype (Kramer & Wegner, 2021). Accordingly, it was hypothesized:

> H3: The "utility value" of biology is rated higher after the intervention than before the intervention.
>
> H4: The "utility value" of PE is rated higher after the intervention than before the intervention.

The attainment value relates to personal and social identity. When those character traits are addressed, the attainment value also increases. Since character traits are not directly addressed in the intervention it was assumed:

> H5: The "attainment value" of biology will not change throughout the intervention.
>
> H6: The "attainment value" of PE will not change throughout the intervention.

Interest can be promoted through interdisciplinary projects (Labudde, 2014, Schiefele, 2009). Although the second prototype is conducted over a longer period of time, it is still comparatively short in terms of the temporal dimension of interest development. Therefore, the interventions were not expected to foster the development of individual interest. For this reason, the following hypotheses were stated:

> H7: The "intrinsic value" of Biology will not change throughout the intervention.
>
> H8: The "intrinsic value" of PE will not change throughout the intervention.

Sample

The unit was offered at schools in the region of Bielefeld University. The teachers responded voluntarily to participate in the project. A control group was requested at all participating schools. Since both biology and PE courses participated in the intervention, the respective control course consisted of a parallel course. Unfortunately, it was not possible to survey a control course at every school.

A total of 505 students participated in twelve intervention courses and seven control courses. Due to the exclusion of individuals who attended only one of the two testing points, only 107 individuals could be examined for the intervention group and 49 individuals for the control group. The large data dropout can be attributed to the effects of the COVID-19 pandemic. Due to a significant increase in data dropout, the follow-up analysis was not considered. Therefore, further studies are needed to investigate long-term effects.

Method

The four scales were checked for outliers. Only minor deviations were found, which, upon closer analysis of the cases, did not justify exclusion. The data were examined using a mixed ANOVA, in which "group" (intervention and control group) was examined as a between-subjects effect in addition to the temporal main effect. The mixed ANOVA was calculated in SPSS 29. In addition, a power analysis was performed by using G-Power to determine the appropriate sample size. Results show that for the interaction effects, a sample of 212 students would have been needed to reveal medium interaction effects. The mixed ANOVA with 156 probands can only reveal strong interaction effects. Nevertheless, a mixed ANOVA was chosen as a robust test procedure. The results must be interpreted in the context of the power analysis.

Results

The results of the mixed ANOVAs are presented following the order of our hypotheses. The results of the Mauchly test are omitted as only two measurement points were examined.

Situational intrinsic value

Starting with biology, Levene's test confirmed homogeneity of variances (t0: $p = .78$; t1: $p = .211$). The mixed ANOVA revealed a main effect of “time” with medium effect size ($F(1,143) = 9.99$, $p = .002$, partial $\eta 2 = .065$). Mean scores increased throughout the intervention from $M = 2.77$ ($SD = 1.29$) to $M = 3.1$ ($SD = 1.32$). However, no interaction effect between “time” and “group” was found ($F(1,143) = 0.583$, $p = .277$). On a descriptive level, it appears that the mean score of the intervention group increased more (t0: $M = 2.84$, $SD = 1.28$; t1: $M = 3.12$, $SD = 1.27$) than the mean score of the control group (t0: $M = 2.63$, $SD = 1.33$; t1: $M = 2.81$, $SD = 3.22$; see figure 3).

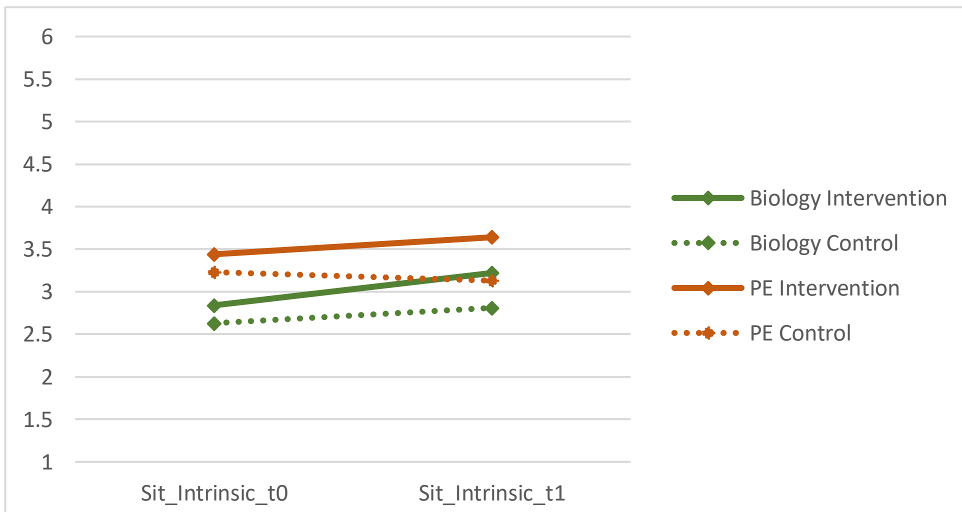


Figure 3: Mean values of the construct “situational intrinsic value” for biology and PE over the intervention period, divided into an intervention group (PE n=104, biology n=102) and a control group (n=47, n=43, respectively).

Looking at the results for PE, the homogeneity of the error variances was confirmed by Levene's test (t0: $p = .123$; t1: $p = .835$). Neither a main effect of “time” ($F(1,149) = 0.25$, $p = .621$) nor an interaction effect between “time” and “group” could be found ($F(1,149) =$

2.03, p = .157). Descriptively, the mean scores show that the intervention group rated the construct higher after the intervention (t0: M= 3.44, SD= 1.19. ; t1: M= 3.64, SD= 1.26; see figure 3), while the control group's "situational intrinsic value" for PE decreased slightly (t0: M= 3.23, SD= 1.39; t1: M= 3.13, SD= 1.26; see figure 3).

For PE, the homogeneity of variances could also be confirmed (Levene's test, t0: p = .376; t1: p = .059). No main effect of "time" (F(1,146) = 0.01, p = .940) could be found. Furthermore, no interaction effect was discovered between "time" and "group" (F(1,146) = 0.09, p = .593).

Utility value

Levene's test revealed that equal variances could be assumed for the scale "utility value" in biology (t0: p = .554; t1: p = .676). Results of the mixed ANOVA showed no main effect of "time" (F(1,153) = 0.267, p = .606). Descriptive data analysis showed that the mean score of the intervention group increased slightly over the intervention (t0: M= 3.41, SD= 1.22; t1: M= 3.51, SD= 1.26). Meanwhile, the control group's mean score decreased (t0: M= 3.19, SD= 1.13; t1: M= 3.01, SD= 1.29). However, the mixed ANOVA did not suggest a significant interaction between "time" and "group" (F(1,153) = 3.21, p = .075).

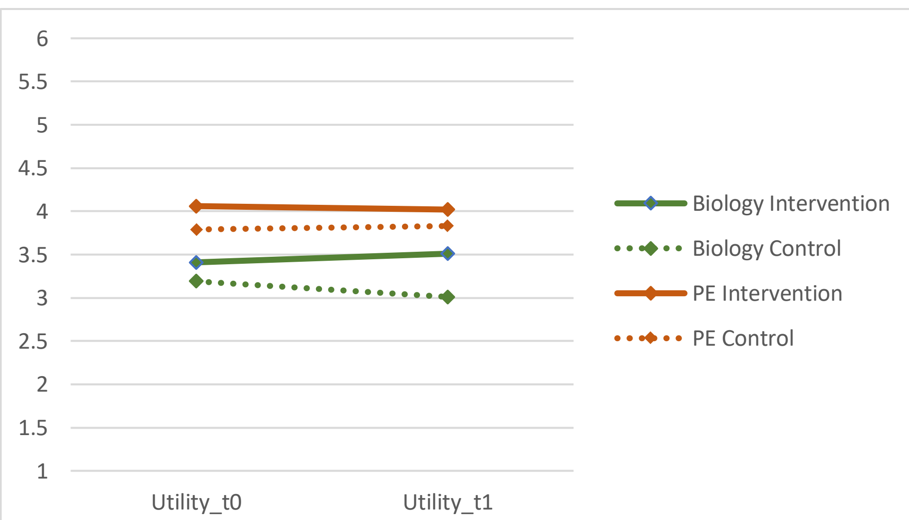


Figure 4: Mean values of the construct "utility value" for biology and PE over the intervention period, divided into an intervention group (PE n=102, biology n=107) and a control group (n=46, n=48, respectively).

Attainment value

Looking at the "attainment value" results regarding PE, Levene's test showed equal variances (t0: p = .499; t1: p = .808). The mean decreased over time (t0: M = 3.93, SD = 1.39; t1: M= 3.78, SD= 1.39). However, the mixed ANOVA revealed no main effect of "time" (F(1,147) = 2.14, p = .146) and no interaction effect between "time" and "group" (F(1,147) = 0.13, p = .599).

For PE equal variances could be assumed based on Levene's test (t0: p = .356; t1: p = .876). As in biology, the mean value for the "attainment value" decreased over the course of the intervention period. This was more prominent in the control group (t0: M = 4.68, SD = 1.39; t1: M = 4.30, SD = 1.26) than in the intervention group (t0: M = 4.77, SD = 1.19; t1: M = 4.62, SD = 1.32). A main effect of "time" was found (F(1,152) = 12.82, p ≤ .001, partial η2 = .078) with medium effect size but no interaction effect between "time" and "group" (F(1,152) = 0.92, p = .113).

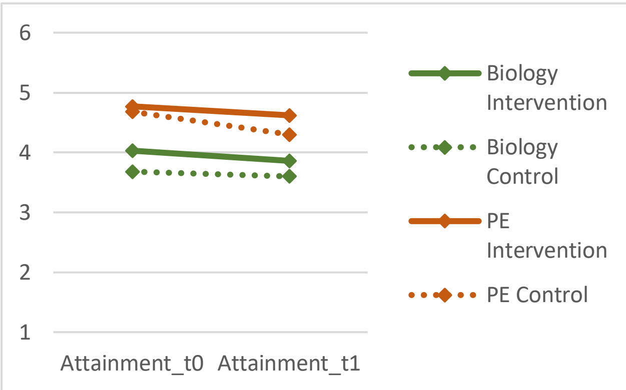


Figure 5: Mean values of the construct "attainment value" for biology and PE over the intervention period, divided into an intervention group (PE n=105, biology n=104) and a control group (n=49, n=45, respectively).

Intrinsic value

For biology, Levene's test showed homogeneity of variance (t0: p = .905; t1: p = .527). Descriptively, the mean of the intervention group remained stable (t0: M = 3.72, SD = 1.34; t1: M = 3.73, SD = 1.40), while the mean of the control group decreased slightly (t0: M = 3.74, SD = 1.30; t1: M = 3.53, SD = 1.35). Based on the mixed ANOVA results, there were no significant differences observed for both the main effect of "time" (F(1,150) = 2.11, p = .149) and the interaction effect between "time" and "group" (F(1,150) = 2.68, p = .104).

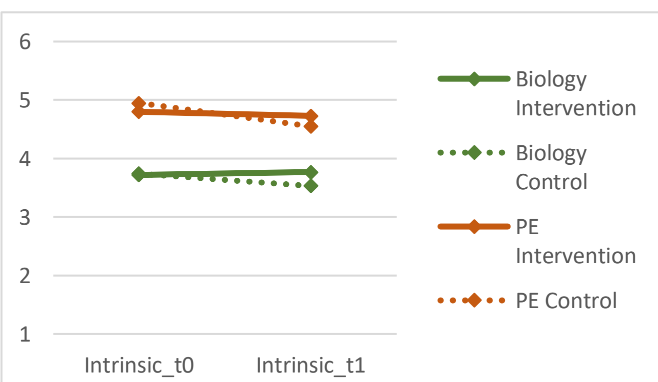


Figure 6: Mean values of the construct "intrinsic value" for biology and PE over the intervention period, divided into an intervention group (PE n=105, biology n=105) and a control group (n=48, n=47, respectively).

The data for PE showed homogeneity of variances (Levene's test, t0: p = .356; t1: p = .876). The mixed ANOVA revealed a main effect of "time" with a medium effect size (F(1,151) = 13.56, p ≤ .001, partial η2 = .082). In addition, an interaction effect between "time" and "group" with small effect size was found (F(1,151) = 6.73, p = .010, partial η2 = .043). The mean scores of the control group (t0: M = 4.95, SD = 1.17; t1: M = 4.55, SD = 1.19) decreased more in comparison to the intervention group (t0: M = 4.8, SD = 1.21; t1: M = 4.73, SD = 1.21).

Discussion

The results showed barely any differences between the intervention and the control group, which strongly limits the interpretation regarding the effects of the intervention. Only for the construct "intrinsic value" a significant interaction effect between "time" and the "group" could be found for PE. After the intervention, the intrinsic value of the control group decreased, while students in the intervention group maintained stable attitudes towards it. It appears that the intervention had a stabilizing effect on individual interest. Hypothesis H8 can be accepted, as the measurement for the intervention group remained constant. Although no interaction effect could be reported for biology, thus confirming H7, the descriptive data showed a similar trend. The acceptance decreased only in the control group. Accordingly, the data indicated a stabilization of already existing individual interests in the participating subjects. The data also highlight that an external influence could have a positive effect on the stages of individual interest (Wigfield & Cambria, 2010). Simultaneously, the main effect of "time" for biology and the descriptive data of PE showed a decrease in individual interest over the intervention period, confirming the assumptions of a decreasing interest over the school career (among others, Potvin & Hasni, 2014).

The scale “situational intrinsic value” showed a significant main effect of “time” only for biology. Unfortunately, due to the missing interaction effect, it was not possible to draw any conclusions regarding the effectiveness of the intervention. Descriptive data showed a slightly higher increase in the mean scores in the intervention group. In PE, although there was no main effect of time, a trend was evident through the descriptive data. Compared to biology, there was a higher increase in mean scores in the intervention group compared to the control group. The trend suggested that interdisciplinary interventions could raise situational interest in the subjects. Looking at the items' wording in the context of the duration of the intervention, the scale might display a maintained situational interest, since it asks for the last lessons of the subject and not just for a specific situation. Thus, the initial problem and the interdisciplinary work on the posed question could slightly increase or at least stabilize situational interest (Harackiewicz et al., 2016). However, for now, the hypotheses associated with the scale (H1 & H2) must be rejected.

Regarding the utility value, neither hypothesis (H3 & H4) was confirmed for the second prototype. The trend in biology indicated that the subject combination with PE could lead to an increase in the utility value for biology (Labudde, 2014). The practical application of biological concepts increased students’ perceptions of the relevance of biology for their own future. However, further analysis is needed to strengthen these assumptions. The utility value regarding PE, meanwhile, remained relatively constant. Explaining the biological principles did not seem to lead to an increased sense of utility for PE. The stabilization of the intrinsic value and the increase in situational intrinsic value could not be explained by an increase in utility value.

The attainment value relates to the student’s personal and social identity. The hypothesis that the attainment value is not addressed by the intervention and does not change could be confirmed (H5 & H6). A main effect of “time” was found regarding PE, but no interaction effect between “time” and “group.” Only descriptive data indicated an effect of the intervention. The results suggested that the intervention was closer to the students’ perceptions, keeping their attainment value and intrinsic value stable instead of decreasing.

The observable trends could currently not be fully supported through closer statistical analysis. Nevertheless, they indicated a positive influence. As already mentioned in the method chapter, the current sample size only reveals strong interaction effects. Therefore, the sample size should be expanded and recalculations should be made.

Limitations

Unfortunately, the impact of COVID-19 resulted in a small sample size and made a follow-up survey unattainable due to significant dropouts. Both, a larger sample and a follow up survey, need to be considered in future studies in order to investigate long-term effects of the interventions and to detect small to medium effects by mixed ANOVA.

Additionally, there was a difference in the subject matter taught in the control group compared to the intervention group. While it would be ideal to control this, it is challenging in interdisciplinary settings. Since two subjects were combined, the students in the control group needed to be taught in PE and biology. To ensure consistency in content for the interdisciplinary project, coordination of lessons in both subjects is necessary. At the same time, however, this would lead to a reduced form of interdisciplinary education, which in turn negates the control function of the control group. Particularly in the context of design-based research, the chosen research methodology should be improved and refined.

Solution II

The second prototype needs to be evaluated based on two different dimensions. From a practical standpoint, the teaching unit can be more seamlessly integrated into the daily school routine when compared to the first prototype. However, it is important to mention that this prototype cannot be implemented without limitations. The curriculum must provide adequate time resources available for interdisciplinary projects. It must be noted that the integration of a second subject reduces the time available for the other. Despite this, teachers can teach interdisciplinary education in their subject and no other subject teaching is eliminated. Based on current research regarding interest development, a one-day intervention is the preferred option because it increases the situational intrinsic value and utility value for both subjects, which is not yet confirmed for the second prototype. In addition to the development of interest, however, other research issues such as evaluating the process characteristics of moderate constructivism need to be included in the discussion.

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References

Acee, T. W., Weinstein, C. E., Hoang, T. V., & Flaggs, D. A. (2018). Value Reappraisal as a Conceptual Model for Task-Value Interventions. *The Journal of Experimental Education*, 86(1), 69–85. https://doi.org/10.1080/00220973.2017.1381830

Ainley, M., Hidi, S., & Berndorff, D. (2002). Interest, learning, and the psychological processes that mediate their relationship. *Journal of Educational Psychology*, 94(3), 545–561. https://doi.org/10.1037/0022-0663.94.3.545

Applebee, A. N., Adler, M., & Flihan, S. (2007). Interdisciplinary Curricula in Middle and High School Classrooms: Case Studies of Approaches to Curriculum and Instruction. *American Educational Research Journal*, 44(4), 1002–1039. https://doi.org/10.3102/0002831207308219

Bös, K., Brochmann, C., Eschette, H., Lämmle, L., Lanners, M., Oberger, J., Opper, E., Romahn, N., Schorn, A., Wagener, Y., Wagner, M., & Worth, A. (2006). *Gesundheit, motorische Leistungsfähigkeit und körperlich-sportliche Aktivität von Kindern und Jugendlichen in Luxemburg – Eine Untersuchung für die Altersgruppen 9, 14 und 18 Jahre. Abschlussbericht zum Forschungsprojekt*. Luxembourg: SCRIPT.

Brassler, M. (2016). Interdisciplinary Problem-Based Learning—A Student-Centered Pedagogy to Teach Social Sustainable Development in Higher Education. In W. Leal Filho & P. Pace (eds), *Teaching Education for Sustainable Development at University Level*. World Sustainability Series (pp. 245–257). Springer, Cham.

https://doi.org/10.1007/978-3-319-32928-4_17

Brassler, M. (2020). Interdisciplinary Teaching and Learning — Theory, empirical Results, and practical Implications. *ICERI2020 Proceedings*, 9342–9351. http://doi.org/10.21125/iceri.2020.2072

Brassler, M., & Dettmers, J. (2017). How to Enhance Interdisciplinary Competence—Interdisciplinary Problem-Based Learning versus Interdisciplinary Project-Based Learning. Interdisciplinary *Journal of Problem-Based Learning*, 11(2).

https://doi.org/10.7771/1541-5015.1686

Canning, E., & Harackiewicz, J. (2019). Utility Value and Intervention Framing. In K. Renninger & S. Hidi (Eds.), *The Cambridge Handbook of Motivation and Learning* (Cambridge Handbooks in Psychology, pp. 645–662). Cambridge: Cambridge University Press. https://doi.org/10.1017/9781316823279.027

Caviola, H., Kybutzs-Graber, R., & Locher, S. (2011). *Wege zum guten fächerübergreifenden Unterricht. Ein Handbuch für Lehrpersonen*. hep.

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75–146). San Francisco: Freeman.

European Council (2018). *Council recommendation of 22 May 2018 on key competences for lifelong learning* [EB/OL]2018-05-23. Available at: http://data.consilium.europa.eu/doc/document/ST-9009-2018-INIT/EN/pdf

Harackiewicz, J. M., Smith, J. L., & Priniski, S. J. (2016). Interest matters: The importance of promoting interest in education. *Policy Insights From the Behavioral and Brain Sciences*, 3, 220–227. https://doi.org/10.1177%2F2372732216655542

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the Academically Unmotivated: A Critical Issue for the 21st Century. *Review of Educational Research*, 70(2), 151–179. https://doi.org/10.3102/00346543070002151

Hidi, S., & Renninger, K. A. (2006). The Four-Phase Model of Interest Development. *Educational Psychologist*, 41(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4

Holstermann, N., & Bögeholz, S. (2007). Interesse von Jungen und Mädchen an naturwissenschaftlichen Themen am Ende der Sekundarstufe I. *Zeitschrift Für Didaktik Der Naturwissenschaften*, 13, 71–86.

Klein, J., & Newell, W. (1996). Advancing interdisciplinary studies. In J. Gaff and J. Ratcliff (Eds.), *Handbook of the Undergraduate Curriculum* (pp. 393–395). Jossey-Bass: San Francisco.

KMK (Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland) (2023). *Vereinbarung zur Gestaltung der gymnasialen Oberstufe und der Abiturprüfung*. Bonn: KMK.

Kramer, N. & Wegner, C. (2020). Fächerübergreifender Unterricht im Fächerverbund Naturwissenschaften und Sport. Darstellung eines systematischen Reviews. *HLZ –Herausforderung*

Lehrer*innenbildung, 3(1), 689–715. https://doi.org/10.4119/hlz-2544

Kramer, N., & Wegner, C. (2021). Giving Meaning to the Subject: The Influence of Interdisciplinary Interventions on the Subjective Task Values of Biology and PE. *Global Education Review*, 8(4), 41–57.

Kramer, N., & Wegner, C. (2022a). Gemäßigt konstruktivistische Prozessmerkmale fächerübergreifenden Unterrichts im Fächerverbund Sport und Biologie. *German Journal of Exercise and Sport Research,* 52(1), 148–158. https://doi.org/10.1007/s12662-021-00769-9

Kramer, N., & Wegner, C. (2022b). Untrennbar getrennt: Design-Based Research als Forschungsansatz für fächerübergreifenden Unterricht. *inter- und transdisziplinäre Bildung*, 1, 117–126.

Kramer, N., Großecosmann, A. M., & Wegner, C. (2022). Lernen durch Bewegung - Gehirnjogging durch ein Training der exekutiven Funktionen. *Sportunterricht,* 71(7), 315–320.

Krapp, A. (2002). Structural and dynamic aspects of interest development: Theoretical considerations from an ontogenetic perspective. *Learning and Instruction*, 12, 383–409.

Labudde, P. (2003). Fächerübergreifender Unterricht in und mit Physik: eine zu wenig genutzte Chance. *PhyDid A, Physik Und Didaktik in Schule Und Hochschule*, 2(1), 48–66.

Labudde, P. (2008). *Naturwissenschaften vernetzen, Horizonte erweitern*. 1. Aufl.. Seelze-Velber: Klett Kallmeyer.

Labudde, P. (2014). Fächerübergreifender naturwissenschaftlicher Unterricht – Mythen, Definitionen, Fakten. *Zeitschrift für Didaktik der Naturwissenschaften*, 20, 11–19. https://doi.org/10.1007/s40573-014-0001-9

Löwe, B. (1987). Interessenverfall im Biologieunterricht. *Unterricht Biologie*, 124, 62–65.

Potvin, P., & Hasni, A. (2014). Analysis of the Decline in Interest Towards School Science and Technology from Grades 5 Through 11. *Journal of Science Education and Technology,* 23(6), 784–802. https://doi.org/10.1007/s10956-014-9512-x

Prokop, P., Tuncer, G., & Chudá, J. (2007). Slovakian students' attitudes toward biology. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(4), 287–295. https://doi.org/10.12973/ejmste/75409

Reinmann, G. (2017). Design-based Research. In D. Schemme & H. Novak (Hrsg.), *Gestaltungsorientierte Forschung – Basis für soziale Innovationen. Erprobte Ansätze im Zusammenwirken von Wissenschaft und Praxis* (S. 49–61). Bielefeld: Bertelsmann.

Renninger, K. A., & Hidi, S. (2017). *The Power of Interest for Motivation and Engagement* (1st ed.). New York: Routledge. https://doi.org/10.4324/9781315771045

Schiefele, U. (2009). Situational and individual interest. In K. R. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school.* Educational psychology handbook series (pp. 197–222). New York: Routledge. 197–222.

Schmiedebach, M., & Wegner, C. (2021). Design-Based Research als Ansatz zur Lösung praxisrelevanter Probleme in der fachdidaktischen Forschung. *Bildungsforschung,* 19(2), 11.

Steidtmann, L., Kleickmann, T., & Steffensky, M. (2023). Declining interest in science in lower secondary school classes: Quasi-experimental and longitudinal evidence on the role of teaching and teaching quality. *Journal of Research in Science Teaching,* 60(1), 164–195. https://doi.org/10.1002/tea.21794

Steinmayr, R., & Spinath, B. (2010). Konstruktion und erste Validierung einer Skala zur Erfassung subjektiver schulischer Werte (SESSW). *Diagnostica*, 56(4), 195–211. https://doi.org/10.1026/0012-1924/a000023

Stentoft, D. (2017). From saying to doing interdisciplinary learning: Is problem-based learning the answer? *Active Learning in Higher Education*, 18(1), 51–61. https://doi.org/10.1177/1469787417693510

Tibbetts, Y., Canning, E., & Harackiewicz, J. M. (2015). Academic Motivation and Performance: Task Value Interventions. *International Encyclopedia of the Social & Behavioral Sciences*, Second Edition, 37–42. https://doi.org/10.1016/B978-0-08-097086-8.26078-9

Tröbst, S., Kleickmann, T., Lange-Schubert, K., Rothkopf, A., & Möller, K. (2016). Instruction and Students' Declining Interest in Science: An Analysis of German Fourth- and Sixth-Grade Classrooms. *American Educational Research Journal* 53(1), 162–193. https://doi.org/10.3102%2F0002831215618662

Ukley, N., Gröben, B., Wegner, C., & Spintzyk, K. (2013). Fächerübergreifender Unterricht: Allgemeindidaktische Erwartungen. Fachdidaktische Anschlussmöglichkeiten. Beispielhafte Umsetzungsmöglichkeiten im Fach Sport. In A. Gogoll & R. Messmer (Hrsg.), *Sportpädagogik zwischen Stillstand und Beliebigkeit. 25. Jahrestagung der dvs-Sektion Sportpädagogik vom 7. bis 9. Juni 2012 (S. 139–152)*. Magglingen: Bundesamt für Sport BASPO.

Vlckova, J., Kubiatko, M., & Usak, M. (2019). The Perception of Biology by Czech Lower Secondary School Students. *Eurasia Journal of Mathematics, Science and Technology Education*, 15(5), 1–12. https://doi.org/10.29333/ejmste/105277

Wang, HH., Charoenmuang, M., Knobloch, N. A., & Tormoehlen, R. L. (2020). Defining interdisciplinary collaboration based on high school teachers' beliefs and practices of STEM integration using a complex designed system. *IJ STEM Ed*, 7(3), 1–17. https://doi.org/10.1186/s40594-019-0201-4

Wang, Z., & Song, G. (2021). Towards an assessment of students' interdisciplinary competence in middle school science. *International Journal of Science Education*, 43, 693–716.

Wegner, C. (2009). *Entwicklung und Evaluation des Projektes "Kolumbus-Kids" zur Förderung begabter SchülerInnen in den Naturwissenschaften*. Bielefeld: Universität Bielefeld.

Wegner, C. & Schmiedebach, M. (2020). Interest in biology: Grade-dependent differences and benefits of participating in out-of-school interventions. *International Journal of Research in Education and Science* (IJRES), 6(3), 427–434. https://doi.org/10.46328/ijres.v6i3.1051

Weinberg, A. E., & Sample McMeeking, L. B. (2017). Toward Meaningful Interdisciplinary Education: High School Teachers' Views of Mathematics and Science Integration. *School Science and Mathematics*, 117, 204–213. https://doi.org/10.1111/ssm.12224

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review*, 30(1), 1–35. https://doi.org/10.1016/j.dr.2009.12.001

Wigfield, A., & Eccles, J. S. (2020). 35 years of research on students' subjective task values and motivation: A look back and a look forward. In A. J. Elliot (Ed.), *Advances in motivation science*. Volume 7 (pp. 161–198). Academic Press.

Ye, P., & Xu, X. (2023). A case study of interdisciplinary thematic learning curriculum to cultivate "4C skills." *Frontiers in Psychology*, 14, 1080811. https://doi.org/10.3389/fpsyg.2023.1080811

Appendix

Table 1: Development phases of the project “Sport-bio-logisch!” along the DBR approach.

DBR cycle	Phasen	Realization in the context Interest Development	Source
First DBR cycle	Preliminary Research	A systematic literature review was conducted	Kramer & Wegner, 2020
	Prototyping phase I	Interdisciplinary one-day workshops were developed A test instrument was determined	Kramer, Großecosmann & Wegner, 2022 Kramer & Wegner, 2021
	Assessment phase I	The one-day workshop “learning through movement” was investigated regarding its effects on the interest development	Kramer, Großecosmann & Wegner, 2022 Kramer & Wegner, 2021
	Solution I	The first prototype was assessed	Kramer & Wegner, 2021; 2022b
Second DBR cycle	Prototyping phase II	The one-day workshop “learning through movement” was transformed into a teaching unit The test instrument was adapted	Part of this article
	Assessment phase II	The teaching unit was investigated regarding its effects on the interest development	
	Solution II	The second prototype was assessed	

Citation: Kramer, Niklas, & Wegner, Claas. (2024). Enhancing subject-specific interests through interdisciplinary teaching units. *Global Education Review*, 11 (1), 55-75.

Table 2: Internal consistencies, example items, and the number of items in the respective subscales of subjective task values (situational intrinsic value, utility value, attainment value, intrinsic value) depending on the individual subject and measurement time, modified and extended according to Steinmayr & Spinath (2010) and Wegner (2009).

Subscale	Example item (insert specific subject)	Number of items	Subject and measuring time	Cronbach's Alpha
Situational intrinsic value	The last hours of …really interested me.	3	biology (t0)	0,932
			biology (t1)	0,930
			PE (t0)	0,827
			PE (t1)	0,895
Utility value	… is useful for my future	3	biology (t0)	0,883
			biology (t1)	0,909
			PE (t0)	0,863
			PE (t1)	0,835
Attainment value	It is important for me to be good at …	3	biology (t0)	0,928
			biology (t1)	0,942
			PE (t0)	0,938
			PE (t1)	0,941
Intrinsic value	I enjoy …	3	biology (t0)	0,922
			biology (t1)	0,925

			PE (t0)	0,900
			PE (t1)	0,892