

Article

The Effects of an Outdoor Learning Program, ‘GewässerCampus’, in the Context of Environmental Education

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Abstract: With education playing a role as a catalyst for change towards a more sustainable world, there is a need to develop educational concepts that enable young people to responsibly take up the challenges of future-proof development. The *GewässerCampus* project is related to environmental education in the context of the ecological dimension of Education for Sustainable Development. This article focuses on evaluating the *GewässerCampus* project by assessing current motivation, ecological knowledge, and environmental values during participation in an outdoor learning program. In total, 231 German pupils of lower and upper secondary level participated in the project. In a quasi-experimental study design, current motivation, pro-environmental and anthropogenic values (Preservation and Utilization), and knowledge were assessed before and immediately after participation in the learning program. The learning activities during the project day led to significant knowledge acquisition. Furthermore, high individual values of the test items for Preservation and low values of the test items for Utilization were obtained. Our results show how important it is to consider the individual teaching and learning requirements of the learner group depending on the grade level, as well as the type of school, when preparing modules for environmental education in the context of sustainable development.



Academic Editor: Trina J. Kilty

Received: 17 March 2025

Revised: 19 April 2025

Accepted: 22 April 2025

Published: 30 April 2025

Citation: Jekel Könnel, E., Geuer, L., Schlindwein, A., Perret, S., & Ulber, R. (2025). The Effects of an Outdoor Learning Program, ‘GewässerCampus’, in the Context of Environmental Education. *Education Sciences*, 15(5), 550. <https://doi.org/10.3390/educsci15050550>

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Keywords: education for sustainable development; environmental education; nature-based learning; field trip; scientific-propaedeutic working methods; environmental values; utilization; preservation; motivation

1. Introduction

Water is a precious resource for humankind, vital to our individual health and essential for life. Since 2010, access to clean water has even been acknowledged as a human right (United Nations, 2010). In 2015, the United Nations (UN) established the Sustainable Development Goals (SDGs), with ‘clean water and sanitation’ (SDG 6) being one of the 2030 Agenda’s seventeen goals (United Nations, 2015, p. 18). However, freshwater resources are finite, and access to clean drinking water remains one of the biggest global challenges to this day (He et al., 2021). Human activities in particular have led to pressures on surface water bodies (Grizzetti et al., 2017; Häder et al., 2020). Common water pollutants include nutrients, plastics, pathogens, chemicals like heavy metals, pesticides, and antibiotics (Houtman, 2010; Schwarzenbach et al., 2006; D. B. Walker et al., 2019). Water pollution can further lead to phenomena such as eutrophication, resulting in the degradation of aquatic ecosystems (Bashir et al., 2020; Carpenter et al., 1998). Climate change, in particular, is exacerbating

the problem (Gosling & Arnell, 2016; Luo et al., 2013). Therefore, with the aim to achieve a good qualitative status of surface water bodies in Europe by 2015, the European Union (EU) proposed the European Water Framework Directive 2000/60EC (European Union, 2000). In order to fulfill the EU standards, the Water Framework Directive is implemented in national guidelines, for example in the Water Ordinance in Germany (Federal Ministry of the Environment, Nature Conservation, Nuclear Safety & Consumer Protection, 2016). However, the ecological status of European surface waters is still unsatisfactory (Wolfram et al., 2021). In 2018, the European Environment Agency published its report on the ecological status of surface water bodies in the EU, which showed that only 40% of all surface water bodies have a ‘good’ or ‘high’ ecological status, and that the overall ecological status has not improved since 2009 (European Environment Agency, 2018, p. 6). Although this topic is of great importance to the world’s population, a considerable number of individuals lack adequate knowledge about aquatic ecosystems (Maniam et al., 2021; McCarroll & Hamann, 2020; Schmid & Bogner, 2018). In particular, the topic is insufficiently addressed in school education, resulting in low levels of water literacy among students (Forbes et al., 2018; LaDue et al., 2021; Sözcü & Türker, 2020). Furthermore, current scientific research and recent discoveries regarding the topic are hardly taken into account in educational practice (Ide, 2016).

With SDG 4 being ‘Quality Education’, education plays a central role in the 17 Sustainable Development Goals of the 2030 Agenda formulated by the UN. Goal 4.7 states that by 2030, all learners should acquire the knowledge and skills necessary for sustainable development, including through education for sustainable development (United Nations, 2015, p. 17). UNESCO launched a program entitled ‘Education for Sustainable Development’, which is in line with the UN’s 2030 Agenda (ESD for 2030). ESD is thereby phrased as a ‘key instrument to achieve the SDGs’ (UNESCO, 2018, p. 26). It describes several competencies that ESD aims to develop in individuals, e.g., critical thinking competency, self-awareness competency, or integrated problem-solving competency (UNESCO, 2018), which are also represented in ‘GreenComp’, the European sustainability competence framework published by the EU in 2022 (European Commission, Joint Research Centre, 2022). In the school context, STEM subjects, in particular, make a fundamental contribution to ESD. Engaging in science subjects allows pupils to develop an understanding that empowers them to take responsibility for present and future ecological and social well-being. In addition, the implementation of ESD in STEM lessons addresses real-world challenges in the classroom and promotes critical thinking skills (Fathurohman et al., 2023). Basic scientific knowledge enables pupils to critically evaluate the complexity of sustainability issues and to actively participate in social decision-making processes (Gropengießer et al., 2022). At the same time, it should be noted that since environmental issues have become a major topic of public opinion, younger generations, in particular, show a deeper awareness of environmental conditions, and actively participate by organizing green movements and engaging with policymakers (Baiardi & Morana, 2021; Calculli et al., 2021; Dimitrova et al., 2021).

The interaction between the increasing environmental awareness of pupils and the demand of the UN creates potential that can be incorporated into didactic concepts. As part of the subject-didactic transfer process for developing educational concepts, a multi-professional team of subject scientists and didacticians have collaborated in the framework of a science outreach project. The result of our project is *GewässerCampus* (German for ‘WaterCampus’), in which pupils carry out photometric water analysis and publish and analyze the results in a web application. The central idea is that pupils create and evaluate a water profile through experiments carried out outdoors at the study site for on-field measurements. *GewässerCampus* differs from existing projects by combining theoretical learning with hands-on scientific analysis and the practical application of analytical methods. A cen-

tral element is the use of a portable photometer, which enables students to actively engage in measuring, analyzing, and interpreting water quality data. This process promotes critical thinking, as students relate their findings to environmental factors and reflect on possible ecological implications. Problem-solving is also a key component, as students troubleshoot measurement issues and apply practical strategies to understand potential causes of water quality changes. While programs like the GLOBE Program focus on contributing to global datasets ([The GLOBE Program, 2025](#)), *GewässerCampus* emphasizes local, practice-oriented learning and supports students through the full scientific process. This combination of practical work, data-based reasoning, and value-oriented reflection fosters essential competencies in Education for Sustainable Development, setting *GewässerCampus* apart from more theory-driven or observation-based initiatives. In addition, one focus of the project is the promotion of scientific-propaedeutic competencies—understood as the ability to comprehend scientific thinking and working methods, and to meaningfully connect theoretical knowledge with practical application. This includes the ability to recognize and apply scientific approaches, to adopt different perspectives, to integrate scientific findings into argumentation, and to develop an understanding of the assumptions, concepts, values, and limitations of science itself.

For this study, individual motivation with regard to the subject of water ecology before the start of a *GewässerCampus* project day, as well as the current level of knowledge on the topic and the environmental values before and after participation in the project day, were evaluated. The project day included an outdoor learning excursion using all didactic materials and methodological approaches developed in *GewässerCampus*.

With the following research aspects, we want to identify the effects of the project with regard to individual knowledge acquisition and environmental values, e.g., Preservation and Utilization of the Two Major Environmental Values Model ([Bogner & Wiseman, 1999](#)), which depend on the participants and their individual motivation, gender, school type, and class level, and which were achieved within the concept of the project day:

- Knowledge acquisition through short-term intervention during a scientific-propaedeutic water investigation.
- Influences on pupils' individual environmental values—Preservation and Utilization—through a short-term intervention in a scientific-educational water investigation.
- Correlations between individual knowledge acquisition and either environmental values or current motivation during the short-term intervention of a scientific-propaedeutic water investigation.

1.1. *GewässerCampus—Water Analysis with a Citizen Science Approach*

While theory-based science lessons only teach the basic principles of scientific processes, their combination with practical elements consolidates knowledge about scientific work and fosters scientific-propaedeutic competencies. Inquiry-based learning, which involves data collection, analysis, and discussion, has been shown to be effective in motivating students ([Ballantyne & Packer, 2002](#)). However, the implementation of practical water quality analysis remains a challenge for conventional teaching, as a suitable toolset and appropriate equipment are required. Hence, simple experimental methods that are precise, easy to learn and use, inexpensive, and robust are needed. *GewässerCampus* provides a toolset to assess the ecological condition of aquatic systems. This toolset is based on photometric methods designed to perform quantitative fieldwork. Instead of complex and expensive laboratory requirements, low-cost photometers make the concept of photometry as an analytical method and the basic design of a complex laboratory photometer comprehensible. With a collection of simple experimental protocols, critical parameters for chemical water quality, such as pH and the contents of phosphate, nitrate, nitrite, am-

monium, sulfate, and dissolved oxygen, can be measured. With these parameter values, chemical water quality indices of nearby waters can be determined by pupils. For this study, a short-term intervention was designed in the form of a project day thematically focusing on water ecology and aquatic ecosystems. The aim of the day was to raise awareness of the quality of local water bodies and to use the theoretical knowledge acquired in the first phase of the project day to perform experiments, analyze the results, and use them to determine the water's quality index. The nature experience and the focus on local water bodies serve as motivation in the context of environmental protection. In addition, *GewässerCampus* enables pupils to publish their self-obtained results as citizen scientists via an open-source web application, and thus embed them in a wider context.

Citizen science (CS) is a concept in which non-professionals and people of the general public participate in scientific research (Shirk et al., 2012; Wiggins & Crowston, 2011). CS projects have become increasingly popular over the last decade, as CS is a useful tool for both data collection and engaging learners (Follett & Strezov, 2015). Especially in the context of monitoring environmental data, it combines ecological research with environmental education (Barbosa et al., 2021; McKinley et al., 2017). In recent years, some studies on water quality monitoring in a CS context have also been published (Nath & Kirschke, 2023; Ramírez et al., 2023; San Llorente Capdevila et al., 2020; D. W. Walker et al., 2021; Zheng et al., 2022). There are already applications of a CS approach for water quality measurement in schools (Araújo et al., 2022b, 2023; D'Alessio et al., 2021), but there is still a lack of interdisciplinary approaches for sustainable implementation in the education system, and a lack of a focus on chemical analysis of parameters for determining water quality.

1.2. Relation Between Outdoor Learning Programs and Individual Motivation

Studies in the field of environmental education show that the success of environmental education approaches depends heavily on authentic, hands-on experiences and direct encounters with nature (Ballantyne et al., 2001; Ballantyne & Packer, 2006; Glaab & Heyne, 2019). Therefore, *GewässerCampus* is inspired by the concept of an outdoor learning program. In contrast to formal education methods in the classroom, outdoor education or outdoor learning programs relocate curricular-based teaching activities to the outdoors (Bølling et al., 2018; Neher-Asylbekov & Wagner, 2023). Outdoor learning programs provide the opportunity for authentic learning with real-life examples, scenarios, and applications of the science content (Ballantyne & Packer, 2002). While formal classroom learning is often theory-driven to teach fundamental principles, outdoor field trips and excursions have been reported to reinforce and strengthen knowledge acquired in the classroom (Ballantyne & Packer, 2002; Gal, 2023; Lin & Schunn, 2016; Morag & Tal, 2012; Vennix et al., 2018). Various reviews published in recent years describe the value of field trips for environmental learning (Behrendt & Franklin, 2014; DeWitt & Storksdieck, 2008; Kola-Olusanya, 2005; Mann et al., 2022; Schmäing & Grotjohann, 2022). Behrendt and Franklin (Behrendt & Franklin, 2014), for example, have summarized the advantages of experiential learning in the outdoors for pupils' cognitive and motivational skills. Outdoor learning programs are increasingly incorporated by educators, particularly in environmental education (Brookes, 1989; Fančovičová & Prokop, 2011; Hill, 2013). The learning experience in nature allows pupils to apply theoretical knowledge in the field, discover issues, and undertake problem-solving and decision-making within a real-world setting (Ballantyne & Packer, 2002). It has been shown that one of the most effective ways to reach pupils with an environmental message is to provide them with learning experiences in the environment.

1.3. Relations Between Important Drivers of Sustainable Development: Knowledge Acquisition and Environmental Values

A well-studied and frequently used method for measuring environmental values is the Two Major Environmental Values Model (2-MEV), developed by Bogner and Wiseman (Bogner & Wiseman, 1999). The instrument has been used in several international investigations within different population groups (Bogner, 1999; Bogner et al., 2015; Nyberg et al., 2020) and independent research groups (Boeve-de Pauw & Van Petegem, 2013; Braun et al., 2018; Nkaizirwa et al., 2023; Regmi et al., 2019), confirming its validity and reliability. The model is available in 33 languages and has been applied in various teaching formats, both in traditional classroom teaching and outdoor scenarios (Bogner, 2018). The 2-MEV model consists of two higher-order factors, Preservation and Utilization. Preservation refers to a preference for the conservation and protection of nature. Utilization measures a preference for exploitation of nature and overuse of natural resources. With these two values, Preservation and Utilization, it is possible to determine the individual importance of environmental protection and simultaneously recognize the necessity of using natural resources. Educational modules in school lessons have been shown to have an influence on pupils' environmental values, as well as on their knowledge gain (Schneiderhan-Opel & Bogner, 2020). Various studies have therefore investigated the relationship between knowledge acquisition and environmental values in environmental education (Barbosa et al., 2021; Boeve-de Pauw & Van Petegem, 2011; Fremerey & Bogner, 2015; Nkaizirwa et al., 2023; Roczen et al., 2014; Thorn & Bogner, 2018). Short-term interventions have already proven to be sufficient to achieve knowledge acquisition (Schmäing & Grotjohann, 2022; Schneiderhan-Opel & Bogner, 2020). In contrast, a long-term educational approach is usually required to achieve a change in environmental values (Bogner, 1999). Both the acquisition of knowledge and environmental values have an influence on environmentally friendly behavior, which is of great importance for environmental education research and ESD. Bogner et al. investigated the relation between knowledge acquisition and environmental values several times. They found positive correlations between pro-environmental values of learners and the inclusion of different environmental topics in their education (Baierl et al., 2021; Schneiderhan-Opel & Bogner, 2020, 2021a; Schumm & Bogner, 2016; Stöckert & Bogner, 2021; Thorn & Bogner, 2018).

2. Materials and Methods

To carry out the field study, a project day was designed using the materials developed within the framework of the *GewässerCampus* project, which includes a field trip to a body of water. The materials include a teaching concept for the project day with all the necessary teaching documents, such as worksheets, documents with supporting information, and questionnaires prepared for the field study to investigate the research questions. For the field trip, each participating school received an experimental kit containing all the necessary consumables for the photometric water analysis experiments to be performed by the pupils. The participating pupils attended lower- and upper-level secondary schools. Understanding the complexity of an ecosystem using the example of an aquatic ecosystem is one of the learning objectives of the project day. Other objectives include learning about important parameters for water quality, independently analyzing a parameter in a water sample using a protocol, and using the data from the water analysis to reach a conclusion about the ecological state of the water, to name but a few. In the following section, the content and design of the project day, the characteristics of the participants, and the research instruments used are described in detail.

2.1. Content and Design of Learning Program

The central theme of the *GewässerCampus* project day is the photometric analysis of a water body performed by pupils in a citizen science context. The structure of the project is therefore similar to the procedure for investigating a scientific question in the context of water analysis, and thus enables the integration of scientific-propaedeutic competencies. The project day centers on an outdoor excursion, during which a body of water is examined using photometric methods. The excursion is prepared and followed up theoretically in short blocks, and covers a total time frame of five hours (one regular school day, from 8 a.m.–1 p.m.), in which 20 min is scheduled for the outward journey and 20 min for the return journey between the school and the water body. Structurally, the project day is divided into three phases, which are shown in the structural overview in Figure 1: the preparation phase, the practical phase, and the post-processing phase.

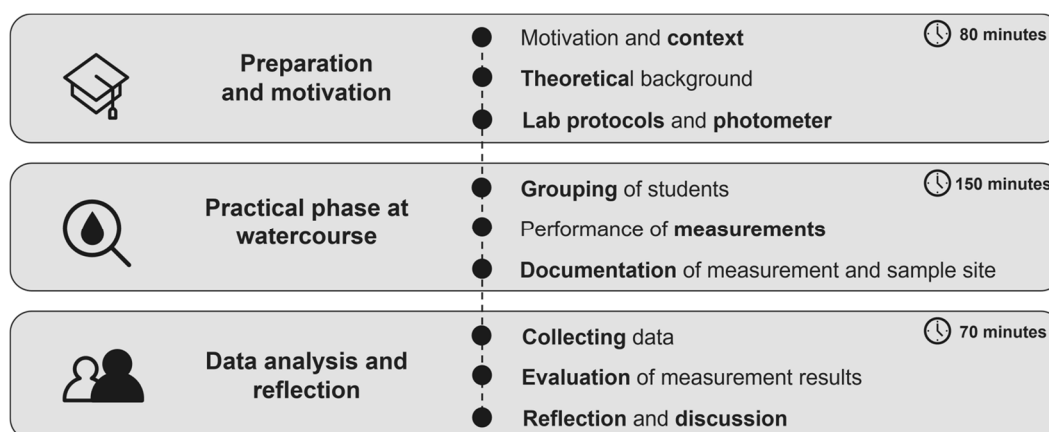


Figure 1. Structural overview of project day conducted.

In the preparation phase, the motivation and context of the project day are conveyed with the introductory question, ‘How clean are our local waters?’. The pupils learn how to assess the cleanliness of water bodies, and which characteristic parameters are decisive for water quality. The concept of a water quality index for the assessment of water quality is presented using the BACH-Index (Bach, 1980) as an example of a water quality index. The BACH-Index was chosen as a multiplicative index for assessing water quality based on chemical parameters such as temperature, pH, and concentrations of ammonium, nitrate, and phosphate. It combines these values into a single score to classify chemical water quality. In preparation for the practical phase, the pupils learn how to use the developed didactically prepared and portable *GewässerCampus* photometer (desklab gUG (haftungsbeschränkt), Schriesheim, Germany) as a measuring device for outdoor water analysis by using the illustrated instructions. During this phase, the pupils also familiarize themselves with the illustrated step-by-step protocols (see Supplementary Materials) for the sampling and the treatment of the water sample with reagents. After dividing the pupils into groups and taking a short break, the class moves on to the outdoor phase with the practical analysis of a water body. The provided experimental kit is taken by the class to the water body of interest. An overview of the experimental kit is shown in Figure 2.

The experimental kit contains a class set of eight portable photometers (desklab gUG, Schriesheim, Germany) and other materials required for carrying out the experiments. These include the necessary reagents, as well as consumables and waste containers. For each parameter to be investigated, the required materials are arranged in colored, labeled boxes to provide a clear overview of the materials. Each of these parameter boxes is available in multiple versions, and contains sufficient materials and reagents for analyzing

the parameter several times. In addition, the experimental kit contains group-specific flow charts and worksheets on which the pupils can record their measurement results. Back in the classroom, the data analysis takes place in the post-processing phase. Here, the collected data are used for the calculation and classification of the water quality index for the specific water body. Furthermore, the results are discussed with the teacher and compared in plenary. Also, a short report of the investigated water body's condition is written by each group.



Figure 2. Photo and overview of the *GewässerCampus* experimental kit.

The project day can be carried out if the topic of water analysis has already been taught in class. However, this is not a mandatory requirement. The implementation of the project day is suitable in the subjects of biology, chemistry, or in similar optional or special subjects. In biology, it ties in with the topic of ecology. Specifically, a chemical–physical water analysis is carried out, which can be supplemented by biological quality determination or geomorphological water structure analysis. In the subject of chemistry, the project day offers the opportunity to carry out practical detection methods using photometry as an analysis method for various parameters, using water as an application example. By focusing the teaching unit on the integration of scientific-propaedeutic working methods, the pupils acquire skills in this area, e.g., using varied forms of presentation when processing the measured values, critically assessing and interpreting the data from the measurements, and answering hypotheses.

2.2. Participants

In total, our sample consisted of 231 pupils (Mage = 16.38, 46.1% female (F), 50.4% male (M), 1.3% diverse (D)) from eight schools (104 pupils from 3 integrated comprehensive schools (ICSs) and 127 pupils from 5 grammar schools (GSs)) in Rhineland-Palatinate (Southwest Germany). Of these, 113 pupils from the lower secondary level (LS; grade: 8 to 10) and 117 pupils from the upper secondary level (US; grade: 11 to 13) participated. The Federal Ministry of Education and Research (FMER) describes a grammar school (in German: *Gymnasium*) as a ‘school type that covers both lower secondary level and upper secondary level (grade: 5 to 13 or 5 to 12) and provides an in-depth general education leading to the general higher education entrance qualification’ ([Federal Ministry of Education & Research, 2025](#)). An integrated comprehensive school covers the lower secondary level, ‘whereby the pupils are placed in courses according to the level of proficiency

in a number of core subjects, but taught together as a year group in all other subjects' ([Federal Ministry of Education & Research, 2025](#)). The teachers registered their school classes for participation in the project day '*GewässerCampus* with Evaluation'. Pupils' participation in the study was voluntary. For pupils under the age of 14 ($N = 6$), written consent from parents or legal guardians was required. The 'Aufsichts- und Dienstleistungsdirektion' (ADD) of the federal state of Rhineland-Palatinate has given its approval under the ethical requirements for intervention studies.

2.3. Procedure and Instruments

Our study design comprised a pre- and post-questionnaire in paper-and-pencil format. All treatment groups completed the test twice: in the morning before participation (T_0) and immediately after (T_1) participation in the project day. The respective teachers were responsible for conducting the surveys and the project day with evaluation. In order to ensure the consistency of the process, participation in a previous online training session was mandatory for the participating teachers. In addition to the training, the teachers were given written guidelines with a detailed program schedule. The program schedule can be viewed in the Supplementary Information. Teachers were also asked to document any deviations from the schedule, special incidents, and the amount of time required to identify any differences in the execution of the project day between the treatment groups and to be able to draw conclusions in the discussion on this basis. Pre- and post-tests were conducted in the classroom and lasted approximately 20 min. At all test time points, the variables of knowledge and environmental values were analyzed. To avoid bias, the items at the post-test were randomly reordered. The variable current motivation was investigated only at test time T_0 .

An ad hoc questionnaire with 12 dichotomous true-or-false statements (similar to ([Schneiderhan-Opel & Bogner, 2021a, 2021b](#))), of which 6 were true and were 6 false, was used to assess the pupils' knowledge values. The questions were evenly divided into 'background knowledge of water quality parameters', 'practical knowledge of water quality investigation or photometry', and 'knowledge of water quality indices'. For each statement, the answer options were 'True', 'False', and 'Don't know', and to respect the voluntary nature of participation, 'No answer' could also be selected. Three examples of the knowledge test's items are shown in Table 1. To maintain the content validity of the knowledge scale, the items were consistent with the specific learning objectives, as well as with the state curriculum. In addition, the scale was scored by experts within the work group. Cronbach's alpha was calculated to assess the reliability of the internal consistency of the knowledge questionnaire. At all test time points, Cronbach's alpha was good to excellent ($T_0 = 0.828$, $T_1 = 0.912$). In general, scores above 0.7 are considered to be acceptable ([Tavakol & Dennick, 2011](#)).

Environmental values were assessed using the Two Major Environmental Values Model (2-MEV) ([Bogner, 2018](#)) with its two dimensions, Preservation and Utilization of nature. Cronbach's alpha was calculated at both test time points, before (T_0) and immediately after (T_1) participation, to assess the reliability of internal consistency. Except for the values at T_0 , Cronbach's alpha reached acceptable levels (Preservation: $T_0 = 0.646$, $T_1 = 0.715$; Utilization: $T_0 = 0.616$, $T_1 = 0.756$). The slightly lower alpha values at T_0 , which were below the generally accepted threshold of 0.7, can be attributed to the limited number of items, the moderate sample size, and the use of a program-specific questionnaire, all of which may have influenced internal reliability. The Questionnaire on Current Motivation (QCM) ([Rheinberg et al., 2001, 2021](#)) was used to assess current motivation. It consists of four scales (fear of failure, interest, probability of success, challenge) with a total of 18 items. To assess the reliability of internal consistency, an acceptable Cronbach's alpha was found

at test time T_0 ($T_0 = 0.750$). An overview of the pre- and post-study structure of the project day can be found in Figure 3.

Table 1. Three examples of knowledge test (KN) items, with the correct answers emphasized in italics.

Item No.	Wording
KN 1	The agricultural use of soils and over-fertilization can cause increasing nitrate pollution in water bodies. (a) <i>True</i> (b) False (c) Don't know (d) No answer
KN 2	During the measurement, the photometer shows the concentration of the analysed substance on the display. (a) <i>True</i> (b) <i>False</i> (c) Don't know (d) No answer
KN 3	Phosphate promotes the growth of algae in a body of water and is largely responsible for the eutrophication of a body of water. (a) <i>True</i> (b) False (c) Don't know (d) No answer

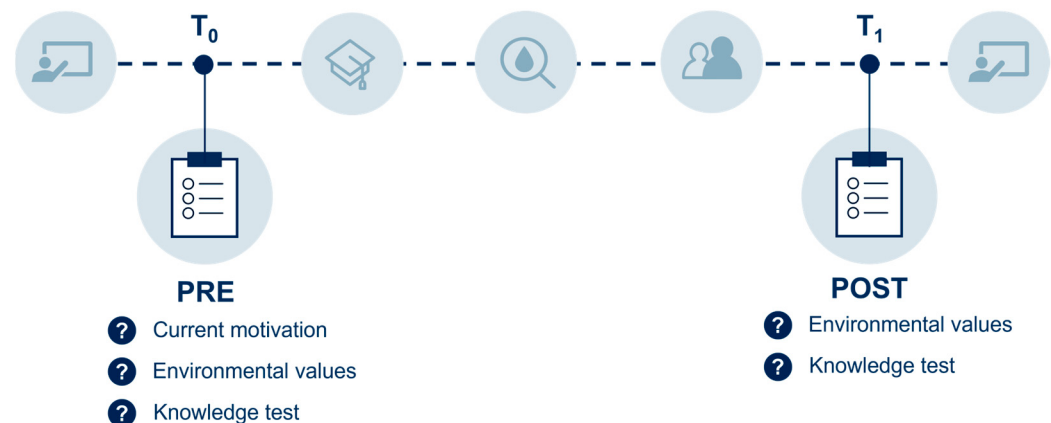


Figure 3. A structural overview of the pre- and post-study procedure during the conducted project day. T_0 marks the time when the pre-questionnaire was filled out, and T_1 when the post-questionnaire was filled out.

2.4. Statistical Analysis

IBM SPSS 28 (28.0.1.1, IBM, Armonk, NY, USA) was used for all statistical analyses. The analysis of knowledge acquisition was performed using the knowledge score, which was defined by the number of correct answers. For analysis of the Likert scales for '2-MEV' and 'QCM', the means values were calculated and compared, and additionally, subgroups defined for this purpose (grade level, gender, type of school) were analyzed. To determine the effects of the intervention on knowledge and environmental scores, the differences between the test times were determined using *t*-tests. A grouped *t*-test was used to define and compare subgroups (grade level, gender, school type). A *t*-test determines the extent to which mean values of two dependent samples are different, and whether this difference is statistically significant. The distribution of the test statistic *T* follows a theoretical *T*-distribution whose shape differs depending on the degrees of freedom.

In order to examine correlations between the variables under investigation—knowledge, environmental attitudes, and motivation—a Bravais–Pearson correlation analysis was used.

3. Results

The following chapters first present the results before and after the intervention, followed by an analysis of the correlations between knowledge acquisition, environmental values, and motivation. Detailed data and full numerical values underlying the presented results are available from the authors upon reasonable request.

3.1. Before Intervention—Knowledge Acquisition, Environmental Values, and Motivation

At the start of the intervention, the participants in the entire sample achieved a knowledge score (max. 12) of $M_{T0} \pm SD = 3.980 \pm 2.439$, as shown in Figure 4A at T_0 . In a t -test for independent variables, the sample was grouped according to the variable ‘school type’ with participants from comprehensive schools (ICSs) vs. participants from grammar schools (GSs). It was found that participants from ICSs at T_0 achieved a significantly lower knowledge score than participants from GSs ($M_{ICS/T0} \pm SD = 3.400 \pm 2.046$; $M_{GS/T0} \pm SD = 4.460 \pm 2.633$; $t_{\text{school type}} (229) = -3.336$, $p < 0.001$, $r = 2.387$). With regard to the knowledge score at T_0 , no significant differences were found in the respective t -test for the grouping variables ‘grade level’ (GL), ‘lower secondary school’ (LS) vs. ‘upper secondary school’ (US) ($t_{GL} (228) = -1.250$, $p = 0.015$), and ‘gender’ (G) ($t_G (220) = -0.646$, $p = 0.557$).

As shown in Figure 4B, the participants’ individual environmental values, Preservation and Utilization, showed an average mean value of $M_{P/T0} \pm SD = 3.628 \pm 0.622$ for Preservation and of $M_{U/T0} \pm SD = 1.959 \pm 0.533$ for Utilization. In the gender comparison of male vs. female, significantly higher Preservation values were observed for female participants ($M_{PF/T0} \pm SD = 3.800 \pm 0.572$; $M_{PM/T0} \pm SD = 3.459 \pm 0.592$; $t_{PG} (220) = 4.360$, $p < 0.001$, $r = 0.583$). In contrast, the male participants showed significantly higher Utilization values ($M_{UF/T0} \pm SD = 1.762 \pm 0.467$; $M_{UM/T0} \pm SD = 2.154 \pm 0.527$; $t_{UG} (220) = 5.842$, $p < 0.001$, $r = 0.499$). For the grouping variables ‘grade level’ and ‘school type’, no significant differences in the t -test were found.

Regarding the assessment of the participants’ current motivation based on the QCM, the sample showed an average level of interest of $M_{T0} \pm SD = 4.202 \pm 1.176$, as shown in Figure 4C. Using a t -test of independent variables for the grouping variable ‘grade level’, a significant difference was found for the variable ‘interest’: participants in lower secondary school showed a significantly higher level of interest than participants in upper secondary school ($M_{LS/T0} \pm SD = 4.371 \pm 1.143$; $M_{US/T0} \pm SD = 4.067 \pm 1.175$; $t_{USGL} (228) = 1.992$, $p = 0.024$, $r = 1.159$). No significant differences were found in the t -test for the grouping variables ‘gender’ and ‘school type’. As a further subscale analysis of current motivation, it was also determined that the sample could be described as having a probability of success of $M_{T0} \pm SD = 5.395 \pm 1.220$ and a challenge of $M_{T0} \pm SD = 4.289 \pm 1.119$. Furthermore, for the grouping variable ‘school type’, a significantly lower probability of success ($M_{ICS/T0} \pm SD = 5.140 \pm 1.310$; $M_{GS/T0} \pm SD = 5.600 \pm 1.105$; $t (229) = -2.916$, $p = 0.002$, $r = 1.168$) and significantly higher challenge ($M_{ICS/T0} \pm SD = 4.526 \pm 1.064$; $M_{GS/T0} \pm SD = 4.095 \pm 1.130$; $t (229) = 2.963$, $p = 0.002$, $r = 1.101$) were found for participants at ICSs. For the grouping variables ‘gender’ and ‘grade level’, no significant differences in the t -test were observed. The entire sample showed a fear of failure of $M_{T0} \pm SD = 2.050 \pm 1.142$. Moreover, a t -test of independent variables on the grouping variable ‘gender’, male vs. female, showed a significant difference in the variable of fear of failure: female participants showed a higher fear of failure than male participants ($M_{F/T0} \pm SD = 2.293 \pm 1.218$; $M_{M/T0} \pm SD = 1.822 \pm 1.022$; $t (220) = 3.124$, $p = 0.001$,

$r = 1.120$). For the grouping variables ‘school type’ and ‘grade level’, no significant differences in the t -test were observed.

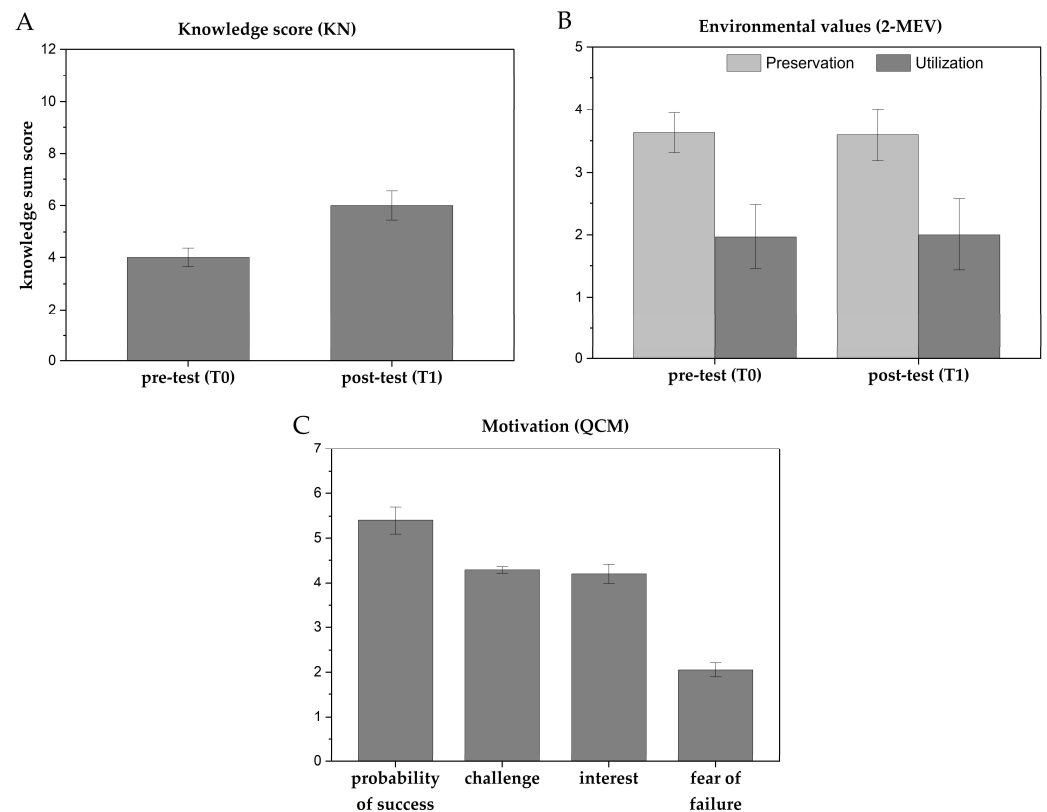


Figure 4. (A): Environmental values, Preservation and Utilization, measured using the Two Major Environmental Values Model (2-MEV) before (T_0) and after intervention (T_1). (B): Knowledge sum scores measured before (T_0) and after intervention (T_1). (C): Current motivation measured using the Questionnaire on Current Motivation (QCM) with its four scales (fear of failure, interest, probability of success, challenge) before intervention (T_0). The error bars show 95% CI.

3.2. After Intervention—Knowledge Acquisition and Environmental Values

An unpaired t -test showed a significant difference in the knowledge score between the times of testing before the intervention (T_0) and after the intervention (T_1), $t(220) = -12.185$, $p < 0.001$, $r = 3.064$. The mean values of the knowledge score after the intervention (T_1) were $M_{T1} \pm SD = 6.490 \pm 3.320$, as can be seen in Figure 4A at T_1 . Thus, the sample showed an average change in knowledge of $M_{T0} \pm SD = 0.534 \pm 0.5451$ more correct answers after intervention (T_1). In a t -test for independent variables for the grouping variable ‘gender’, it was found that female participants answered significantly more answers correctly than male participants at the time of testing T_1 ($M_{F/T1} \pm SD = 6.990 \pm 2.778$; $M_{M/T1} \pm SD = 6.040 \pm 3.712$; $t(221) = 2.072$, $p < 0.020$, $r = 3.229$). In a gender-specific comparison of the number of correct answers before (T_0) and after (T_1) the intervention, significant differences were found for both females ($t(107) = -11.167$, $p < 0.001$, $r = 2.841$) and males ($t(109) = -6.531$, $p < 0.001$, $r = 3.182$). Thus, both genders showed a significant increase in correct answers as a result of the intervention, with females generally (at T_0 and T_1) answering more answers correctly on average. Similarly to at T_0 , participants at comprehensive schools showed a significantly lower number of correct answers for the grouping variable ‘type of school’ at T_1 ($M_{ICS/T1} \pm SD = 4.770 \pm 2.956$; $M_{GS/T1} \pm SD = 7.810 \pm 2.975$; $t_{\text{school type}}(219) = -7.550$, $p < 0.001$, $r = 2.964$) and a significantly lower change in knowledge ($M_{ICS/T1} \pm SD = 0.206 \pm 0.477$; $M_{GS/T1} \pm SD = 0.786 \pm 0.449$; $t_{\text{school type}}(221) = -9.294$, $p < 0.001$, $r = 0.462$) compared to participants at grammar schools. A school type-specific

comparison of the number of correct answers before (T_0) and after (T_1) the intervention showed significant differences for participants from ICSs ($t(95) = -4.755, p < 0.001, r = 2.833$), as well as for participants from GSs ($t(124) = -12.799, p < 0.001, r = 2.956$). Participants from both types of schools achieved a higher knowledge score after the intervention, although in general (for T_0 and T_1), the participants from ICSs answered fewer items correctly on average. In contrast, no significant differences were found for the grouping variable 'grade level' at T_1 with regard to the knowledge score at T_1 . In a grade level-specific comparison of the number of correct answers before (T_0) and after (T_1) the intervention, significant differences were found for the lower secondary school ($t(110) = -7.904, p < 0.001, r = 3.302$), as well as for the (German) upper school ($t(108) = -9.454, p < 0.001, r = 2.827$). Participants from both grades showed a higher knowledge score after the intervention than before the intervention.

No significant differences for the environmental values (2-MEV) of Preservation and Utilization were found between the time of testing before (T_0) and after intervention (T_1), with $t_P(220) = 1.132, p = 0.129, r = 0.411$ and $t_U(220) = -0.976, p = 0.165, r = 0.510$, respectively, as shown in Figure 4B. The mean values for Preservation and Utilization after the intervention were $M_{P/T1} \pm SD = 3.597 \pm 0.634$ and $M_{U/T1} \pm SD = 2.003 \pm 0.660$. Corresponding to the time of testing before intervention T_0 , the results of time T_1 regarding individual environmental values are similar in terms of gender-specific comparison. Significantly higher Preservation values were observed for female participants ($M_{PF/T1} \pm SD = 3.802 \pm 0.503$; $M_{PM/T1} \pm SD = 3.406 \pm 0.629$; $t_{PG}(211) = 5.038, p < 0.001, r = 0.572$). In contrast, the male participants showed significantly higher Utilization values, ($M_{UF/T1} \pm SD = 1.739 \pm 0.465$; $M_{UM/T1} \pm SD = 2.257 \pm 0.717$; $t_{UG}(211) = -6.201, p < 0.001, r = 0.609$). Furthermore, no significant differences were found after intervention T_1 for the grouping variable 'school type' or for the variable 'grade level'. Since a change in knowledge but no change in environmental values were found in the post-state, further research questions and correlations were examined to relate the change in knowledge to the pre-states of variable environmental values and motivation. Correlations between the post-state of knowledge and the pre-state of environmental values (2-MEV) and motivation (QCM) are shown and discussed in the following section.

3.3. Correlation Between Knowledge Acquisition and Environmental Values

In terms of knowledge acquisition, there was a positive correlation between the number of correct answers at test time T_0 and the change in knowledge during the intervention ($r = 0.282, p < 0.001, n = 223$). This positive correlation between the change in knowledge and the number of correct answers was also evident at the test time T_1 ($r = 0.544, p < 0.001, n = 221$). This led to the following correlation: the higher the number of correct answers at both test times T_0 and T_1 , the higher the change in knowledge during the intervention. On the environmental values scale, a Pearson correlation test showed a negative correlation between the subscales Utilization and Preservation at both times of testing, before ($r_{T0} = -0.245, p < 0.001, n = 231$) and after intervention ($r_{T1} = -0.289, p < 0.001, n = 221$). The results of the correlation can therefore be used to define the following context: 'The higher the Preservation, the lower the Utilization'. A correlation analysis of the entire sample between the environmental values of the subscale Preservation at test time T_0 and the knowledge score at test time T_1 showed a positive correlation ($r = 0.260, p < 0.001, n = 221$). The higher the Preservation at T_0 , the higher the number of correct answers at T_1 . In this context, it should be highlighted that for the grouped correlation analysis in relation to 'school types', a positive correlation could also be observed for both investigated 'school types', ICSs and GSs ($r_{ICS} = 0.356, p < 0.001, n = 96$; $r_{GS} = 0.193, p = 0.031, n = 125$). Furthermore, a positive correlation was found between the Preservation

subscale and the knowledge score at test time T_1 . The result of this correlation is that the higher the Preservation after the intervention (T_1), the higher the knowledge score after the intervention (T_1).

3.4. Correlation Between Knowledge Acquisition and Motivation

A Pearson correlation test between the subscale 'interest' at T_0 and the knowledge score at T_0 ($r_{T_0} = 0.265$, $p < 0.001$, $n = 231$) and T_1 ($r_{T_1} = 0.246$, $p < 0.001$, $n = 221$) showed positive correlations. This led to the following result: the higher the interest, the higher the number of correct answers at both test times. There were also positive correlations between the 'probability of success' and the knowledge score observed at T_0 ($r_{T_0} = 0.254$, $p < 0.001$, $n = 231$) and T_1 ($r_{T_1} = 0.312$, $p < 0.001$, $n = 221$). A further positive correlation was found between the 'probability of success' and 'change in knowledge' ($r = 0.160$, $p = 0.017$, $n = 223$). This led to the following relationship being established: the higher the individual probability of success, the higher the number of correct answers after the intervention, i.e., the higher the change in knowledge.

4. Discussion

The results of our study indicate that our concept and the materials of the one-day learning program of the *GewässerCampus* project day are effective in increasing knowledge about aquatic ecosystems and water investigations. The participants showed an increase in knowledge from T_0 to T_1 . This is consistent with the results of previous studies on different educational environments and learning approaches to environmental education. Schneiderhan-Opel and Bogner (Schneiderhan-Opel & Bogner, 2021a), for example, reported an increase in knowledge acquisition between pre- and post-test in an outdoor learning module focusing on forests. The same authors found similarly positive results regarding the increase in knowledge directly before and after the intervention for an outdoor learning experience on the topic of freshwater supply (Schneiderhan-Opel & Bogner, 2021b). With regard to knowledge acquisition, it should also be noted that participants with a high level of prior knowledge were able to achieve a higher change in their knowledge as a result of the intervention. This finding is based on previous studies, in which the effects of prior knowledge on learning success have already been described (Schneiderhan-Opel & Bogner, 2021a, 2021b). Contrary to the assumptions of the current media hype about sustainability and environmental protection, participants belonging to the climate generation, and the close link to the content of the curriculum, it is surprising that the level of knowledge on the topic of aquatic ecosystems and water studies before the intervention was very low: the pretest resulted in an average knowledge level of 3.98 correct answers out of a total of 12 possible correct answers. This indicates corresponding deficits in prior knowledge on the topic of aquatic ecosystems and water studies. Despite longer and more intensive contact time in STEM lessons and learning modules on ecosystems and water bodies anchored in the curriculum, participants in the upper secondary school were not able to significantly differentiate themselves from those in the lower secondary school in terms of their prior knowledge. The differences in the knowledge values between the participants of both types of schools can be attributed to the different structures of the curricula, learning situations, and prerequisites at the grammar school and the comprehensive school. A significant increase in knowledge could also be observed among participants of the comprehensive school after the intervention compared to at T_1 , which indicates a positive learning effect as a result of the intervention. However, this observed higher level of knowledge was still relatively low, as the participants only answered half of the test questions correctly on average: in the post-test, the average knowledge level was 6.49 correct answers out of a total of 12 possible correct answers. This could be due to the one-day format of the

program, which may not provide enough time to increase in-depth knowledge or practical application. Extending the program to multiple sessions could potentially increase engagement and knowledge. The lower level of knowledge acquisition at comprehensive schools can be attributed to the previously established differences in the comparison of school types. In addition, the suitability of the current concept for classes at comprehensive schools should be discussed and prioritized. Optimization steps for specific school types should be considered as part of the further development of the concept. For example, the preparation phase could be extended, and content could optionally be prepared in advance by the teacher to reduce the amount of learning content in the structure of the project day. Likewise, optimizations towards a modular program are possible in order to simplify the structure of the day and give teachers the opportunity to reduce the didactic load so that the amount of content can be adapted to the learning group, or a focus can be placed on specific content or parameters. The one-day project was effective in achieving cognitive learning effects. However, the sample did not show any significant change in environmental values. This result is not unexpected, as a long-term change in environmental values through participation in a single learning program is a rather unrealistic goal. Within the construct of the environmental values scale, the anchored definition of a negative correlation between the Preservation subscale and the Utilization subscale was shown: participants with a high level of Preservation showed a lower level of Utilization. However, it should be noted that the Preservation scale is already associated with a social desirability bias (Oerke & Bogner, 2013). It has already been confirmed that participants tend to choose responses that they consider socially acceptable or desirable, rather than those that reflect their actual attitudes. This leads to high values in the Preservation subscale, and causes a so-called ceiling effect. This tendency is also confirmed by the parallels between our sample and the results of Liefländer and Bogner, as well as Schneiderhan-Opel and Bogner (Liefländer & Bogner, 2018; Schneiderhan-Opel & Bogner, 2021b), as the participants already achieved high Preservation scores before the intervention, leaving little space for improvement. The gender-specific comparison showed that women had higher environmental conservation scores than men, with the latter reporting higher environmental use. These correlations extend existing findings from the literature (Zecha, 2011). Our results suggest that ongoing and in-depth engagement with environmental issues is necessary to achieve a lasting impact on participants' values. The literature emphasizes that in order to achieve effective and long-term changes towards environmentally friendly values, long-term learning sessions that last for several days are required, or pupils must be regularly exposed to nature-based environmental learning (Bogner, 1998). Accordingly, the duration of the project day can probably be used to account for the lack of further development of environmental values. Although *GewässerCampus* is a short-term intervention, such programs can act as important catalysts for longer-term engagement with environmental topics. By offering hands-on experiences and fostering initial curiosity and motivation, they may spark a lasting interest in ecological issues that extends beyond the duration of the project day. Therefore, it would be interesting to see future studies that examine the long-term effects of environmental learning programs over a longer time period and explore how short, targeted learning formats might lay the groundwork for sustained behavioral or attitudinal change—especially when complemented by follow-up activities or embedded within broader educational strategies. Andrew Brookes (2004), for example, takes a critical look at concepts of outdoor learning in his work and emphasizes the long-term, comprehensive development process of skills, whereby outdoor learning programs are a supplement to this. However, in general, out-of-school approaches are considered suitable for promoting environmental values (Kuo et al., 2019). The heterogeneity of learning backgrounds, the content of the

program, the duration of the learning program, and the intensity of interaction with the natural environment are key factors for their success.

The analysis of the data on current motivation showed that participants of lower secondary level had a significantly higher level of interest compared to upper-secondary-level participants. This could be due to various factors, such as different curricula, pedagogical approaches, or individual development of competencies. Therefore, as part of the further development and optimization of the *GewässerCampus* concept, it is necessary to create learning situations on the topic that are suitable for the target group and age group, and thus to develop measures to promote interest in the relevant target group. In general, an average interest with a mean value of $M_0 \pm SD = 4.2024 \pm 1.176$ was determined. This indicates an overall moderate level of interest among the participants. It would be interesting to analyze this further in order to identify possible factors influencing the pupils' interest and to develop appropriate strategies to increase interest. In this regard, studies also show that pupils are more interested in topics such as climate change, and that environmental topics in the context of cause–effect relationships and action-related aspects attract a lot of interest (Höhnle et al., 2023). It is noticeable that topics with a local reference achieve significantly lower interest values than topics that have a global background. For the future design of the motivating introduction to the *GewässerCampus* project day, a specific reference to the global level could be discussed, which would then lead onto the topic of aquatic ecosystems and water bodies in the local area. In addition, significant differences in the probability of success depending on the type of school were identified. It was found that the probability of success of participants from comprehensive schools was lower than that of participants from grammar schools. In conclusion, it can be stated that the topics and tasks of the project day had a negative impact on the probability of success of participants from comprehensive schools. Optimization steps are also necessary in the future in order to give all pupils the chance and opportunity to complete the tasks of the *GewässerCampus* project with motivating prospects of success. Another interesting result was that female participants showed a significantly higher fear of failure compared to male participants. These gender-specific differences in terms of fear of failure could be due to social, cultural, or psychological factors. This finding was already confirmed in 1999 (Köller et al., 1999), who found that female pupils have a higher fear of failure than males.

The linear positive correlation between environmental values and knowledge found in the present study is partially compatible with results from the existing literature (Schneiderhan-Opel & Bogner, 2021b) and earlier findings. Participants with high Preservation scores performed better on the knowledge test (pre-test and post-test) than those with lower Preservation scores. Most studies focusing on secondary pupils have consistently found this positive linear relationship between retention and content knowledge, which has been demonstrated for classroom and outdoor learning approaches (Fremerey & Bogner, 2015; Schumm & Bogner, 2016; Thorn & Bogner, 2018). The present study thus once again confirms the assumption of a positive correlation between retention and knowledge in a learning program with secondary pupils. Additional factors that could influence cognitive learning and were not measured in this study should also be noted.

In this study, a positive correlation was found between interest in participating in the project day on the topic of water and the acquisition of knowledge. Participants with a high level of interest at T_0 showed a higher level of knowledge acquisition through the intervention. This positive correlation was also evident in participants with a high probability of success and a high level of knowledge at T_0 . This initial increased knowledge base presumably enabled the participants to better assess the expected success in advance. Furthermore, it was shown that people who had a high level of knowledge at the beginning of the study tended to have a higher level of knowledge acquisition. This indicates that

existing prior knowledge not only influences the assessment of success, but also has a positive influence on the process of knowledge acquisition itself. There was also an interesting result in relation to the change in knowledge. Participants who showed a clear change in their level of knowledge tended to have a higher probability of success. This suggests that a prospect of success in advance can have a positive impact on knowledge acquisition. These findings underline the importance of interest, probability of success, prior knowledge, and knowledge change in an integrative context, which could be explored in more depth in further discussions and research approaches.

4.1. Limitations

However, limitations must be taken into account when interpreting the results. There is a potential bias in the results in relation to the recruitment of school classes through random sampling, as the pupils were not randomly selected for the study. Schools were randomly selected regionally, and teachers enrolled their classes to participate in the project. The total sample size of 231 pupils is quite large, but a larger sample size is needed to ensure a representative distribution of the target population, i.e., all German pupils of lower and upper secondary level. Moreover, there was an uneven distribution across school types, with 127 pupils from grammar schools and 104 from comprehensive schools, which may have influenced group-specific comparisons, and should be considered a limitation.

Additionally, the lack of a control group presents a limitation in terms of isolating the specific impact of the *GewässerCampus* intervention. While the observed changes in motivation, knowledge, and values strongly suggest the positive influence of the field trip, incorporating a control group in future studies would allow for a more rigorous evaluation of the intervention's effects by controlling other external factors. Since this study is based on a single case, the findings should be viewed as exploratory and may not be readily generalizable. Future research across diverse regions and educational contexts is necessary to confirm and extend these results. Consequently, to confirm our assumptions, further studies are needed with an increased number of participants of different age groups, as well as from the two school types, to determine exactly how environmental values influence environmental learning through the *GewässerCampus* framework. Due to the multifactorial influence on the learning process, it is difficult to evaluate the effectiveness of learning environments. Rickinson et al. (2004) identified three factors that affect learning in natural environments: program factors, participant factors, and location factors. In addition, prior experience or knowledge, motivational or demographic characteristics of the learners, and the location itself, in particular, the learners' degree of familiarity with the natural environment, are considered factors (Rickinson et al., 2004). From this, and considering the so-called novel field trip phenomenon (Falk et al., 1978), we derive the following basis for interpretation. As the outdoor learning environment and learning tasks are fundamentally different from those in the classroom, pupils are easily distracted by the unfamiliar environment and learning conditions outdoors (Boeve-de Pauw et al., 2019). Recent studies show that a high degree of novelty in the environment can significantly affect learning (Boeve-de Pauw et al., 2019). This could explain the observed low increase in knowledge. The reason for this is that the participants were not familiar with the waterfront environment as a natural learning environment or as an extracurricular learning environment. In combination with the cognitive learning activities, the participants were therefore cognitively overloaded and could not fully explore the potential of the learning environment.

4.2. Future Directions

Although knowledge was acquired during the implementation of the project day, we believe that a higher level of knowledge could be acquired if the project were extended

to cover several days or a series of lessons. In addition to intensifying learning content and the overall topic of environmental education, this would enable the teacher to arouse a higher level of interest among pupils in advance. At the same time, an extension to a long-term intervention could increase knowledge transfer and allow more time to include other important aspects of environmental education, in order to achieve a detectable impact on environmental values. In a study by Araújo et al. (2023), an intervention as part of a citizen science education project on coastal water quality was also able to foster a more positive attitude towards environmental problems, and also showed good indicators for the project's contribution to behavioral change among participating students. The authors also emphasize that its actual impact can only be measured in a longitudinal study (Araújo et al., 2022a, 2023). Also, a temporal extension would allow for a more intensive integration of the citizen science approach. This would also intensify the focus on the scientific-propaedeutic methodology which is anchored in the project. Future studies could also explore how active participation in data collection and publication through citizen science affects students' sense of agency and engagement. Investigating these aspects could offer valuable insights into how such involvement fosters ownership of learning processes and encourages deeper environmental commitment. As clear differences were observed between the participants of the two school types, grammar school and comprehensive school, regarding knowledge acquisition, the content should be more specific to the school types, and thus be offered according to the diverse learning types. The significantly higher fear of failure in connection with significantly higher knowledge acquisition among female participants compared to male participants indicates the necessity to further expand the promotion of girls in STEM subjects. To further investigate the effect of different learning environments on knowledge acquisition, it is necessary to add a treatment group that only experiences the classroom learning environment, and compare the results to a treatment group that experiences the out-of-school environment with a field trip using the *GewässerCampus* material. Furthermore, an additional retention test a few weeks after intervention (T_2) in the two different treatment groups could show the effectiveness of the developed materials and outdoor learning environment in terms of long-term knowledge retention, as was similarly investigated by Schneiderhan-Opel and Bogner (2021a). In addition to quantitative measures such as retention tests, initial pilot interviews with teachers have shown the value of qualitative methods. We plan to expand these approaches by including student interviews to gain deeper insights into perceptions and attitudes toward the *GewässerCampus* experience. The developed material (see Supplementary Materials), particularly the *GewässerCampus* experimental kit, as well as the online portal for the documentation of measurement values, will be further available to teachers for future water analysis field trips with their school class. In addition, the teaching materials on aquatic ecosystems developed in this project and used in this study are publicly available to teachers. With the aim of further integrating the *GewässerCampus* project into the various curricula in the education system, we would like to orient our research work towards aspects of action research in the future. For this purpose, appropriate phases for reflecting on successes and failures in the context of regular workshops with participating teachers are possible, which can also be used as a tool for both support and discussion. In the context of these workshops, the project can be further developed in the context of these workshops, the project can be further developed through action research by collaboratively sharing and refining ideas for implementation and problem-solving together with the participating teachers. Teachers should see themselves in the role of researchers in order to improve the curriculum and make it more relevant to real problems in the community. In 1994, Schreuder (1994) published such a concept for the enhancement of an environmental

education program, which also dealt with the integration of water body research into the curriculum.

In summary, we will further investigate the following research questions, which connect with and extend upon the available results:

- How does a multi-day or long-term intervention in the context of the *GewässerCampus* project influence the knowledge acquisition and environmental awareness of students compared to a one-day project?
- How does the integration of the citizen science approach into environmental education projects influence the motivation and scientific understanding of students?
- Does an outdoor learning environment have a long-term impact on students' knowledge in the field of ecological education compared to a traditional classroom setting, and how does the novelty of the outdoor environment influence this effect?
- Which specific adaptations of the teaching content are necessary to meet the different learning needs of students from different school types (grammar school vs. comprehensive school)?

5. Conclusions

The contribution of this study was to identify effects in terms of individual knowledge acquisition and environmental values (Preservation and Utilization), which were directly related to the participants and their individual motivation, gender, school type, and grade level, in the context of the conception and design of the *GewässerCampus* project day. Regarding knowledge acquisition through the *GewässerCampus* intervention, our results confirm that even a short-term, one-day intervention with hands-on, outdoor learning activities can promote environmentally relevant knowledge. The scientific-propaedeutic water investigation at a local body of water successfully increased pupils' subject-specific knowledge and provided authentic, meaningful learning experiences. We also observed that participation influenced pupils' environmental values to a limited extent. While significant changes were not universally found, pupils with already-high environmental values benefited more strongly from the intervention, suggesting the importance of value-based differentiation in environmental education. Furthermore, our data support a correlation between environmental values and individual knowledge acquisition: students with higher situational motivation and more pronounced pro-environmental values demonstrated stronger learning outcomes. This highlights the importance of addressing individual learning needs and adapting educational formats to suit diverse learner profiles. In summary, our results confirm the potential of one-day outdoor learning programs to promote environmentally relevant knowledge. The motivational approach with hands-on activities and authentic learning experiences at the local water body led to success in learning about the topic of water ecosystems and water analysis in a critical sustainability context and through a scientific-propaedeutic approach. The findings complement previous studies that consider nature experiences as a key factor in promoting motivation, cognitive learning, and a pro-environmental attitude (Drissner et al., 2010; Schneiderhan-Opel & Bogner, 2021a, 2021b; Wiegand et al., 2013). Furthermore, the results constitute a meaningful milestone in the comparison of the German school types of comprehensive schools and grammar schools. In this context, it was emphasized how important it is to consider the individual teaching and learning needs of learners depending on their grade level and type of school when creating learning programs for environmental education in the context of sustainable development. Due to the heterogeneity within the school types, it is therefore advisable to optimize the concept of the project day according to the needs of the target group. The reasons for the differences in performance between the groups of pupils were varied, but there is a connection with the resources and materials provided in the concept. Further-

more, our results show that pupils with high environmental values benefited the most from participating in the learning activities and performed better than their peers. The learning program thus appealed better to those participants who already held environmentally friendly values.

The results underline and emphasize the importance of considering the impact of learning prerequisites, the conservation of diverse learning content in a one-day project structure, and the developmental duration and dependencies of environmental values on learning when planning didactic and methodological approaches to environmental education. Educational approaches have a responsibility to promote pupils' pro-environmental values, which have been shown to have a positive impact on environmental learning. Therefore, educational institutions have a responsibility to promote awareness of outdoor learning and facilitate more frequent field trips. For this, *GewässerCampus* represents a milestone in allowing nature-based learning environments to become part of school practice. The *GewässerCampus* project encourages pupils to achieve the SDGs in terms of ESD competencies, broadening the learning experience and enabling pupils to practice critical thinking and develop scientific-propaedeutic skills.

Supplementary Materials: The following supporting information can be downloaded at the links provided: Protocols: <https://desk-lab.de/docs/?query=&selection=54> (accessed on 23 February 2024); *GewässerCampus*-Online-Portal: <https://app.gewaessercampus.de> (accessed on 23 February 2024); Experimental Kit: <https://mv.rptu.de/fgs/biovt/lehre/lehrkraefte-und-schuelerinnen/ilab-forscherkisten-1> (accessed on 23 February 2024); Practical Guide: <https://desk-lab.de/docs/?query=&selection=54> (accessed on 23 February 2024).

Author Contributions: Conceptualization: E.J.K., L.G., A.S., S.P. and R.U.; methodology: E.J.K., L.G., A.S. and S.P.; software: A.S. and S.P.; validation: E.J.K., L.G., A.S. and S.P.; formal analysis: E.J.K. and L.G.; investigation: E.J.K. and L.G.; resources: A.S., S.P. and R.U.; data curation: E.J.K., L.G., A.S. and S.P.; writing—original draft preparation: E.J.K. and L.G.; writing—review and editing: A.S., S.P. and R.U.; visualization: E.J.K.; supervision: R.U.; project administration: A.S., S.P. and R.U.; funding acquisition: A.S., S.P. and R.U. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the German Federal Environmental Foundation (DBU), grant number 35811-01.

Institutional Review Board Statement: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The questionnaire and methodology for this study were approved by the Institutional Review Board of Aufsichts- und Dienstleistungsdirektion Rheinland-Pfalz (protocol codes AZ 124/16 and 125/16; 4 May 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors are grateful to desklab for the very enriching exchange during the project. Also, the authors would like to thank all participating pupils and their teachers for their time and effort. We are grateful to Alena Otteny for help in data processing. We would like to thank Jonas Drotleff und Noah Wach for their input in the development of the online portal which was used as part of the *GewässerCampus* project day.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

EU	European Union
UN	United Nations
SDG	Sustainable Development Goal
ESD	Education for Sustainable Development
STEM	Science–Technology–Engineering–Mathematic
QCM	Questionnaire of Current Motivation
2-MEV	Two Major Environmental Values Model
CS	Citizen science
GS	Grammar school (in German: Gymnasium)
ICS	Integrated comprehensive school (in German: integrierte Gesamtschule)
G	Gender
GL	Grade level
US	Upper secondary school
LS	Lower secondary school

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