Efficacy of Outdoor Environmental Education

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A Cross-National Comparative Research Study Investigating Nature Connectedness, Environmental Attitudes, Knowledge and Behavior

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I. Short Summaries

In order to give the reader a broad overview of the performed research project there will be a longer German as well as a short English summary given before the project will be described in detail.

1 Zusammenfassung

Sowohl in der aktuellen wissenschaftlichen Praxis als auch im gesellschaftlichen Diskurs stellen Umweltfragen eines der zentralen Themen unserer Zeit dar. So gehören Biodiversitätsverlust, Abholzung und Klimawandel zu den beinahe alltäglichen Schlagworten in den Nachrichten. Allesamt werden auch durch anthropogenen Einfluss bedingt bzw. verstärkt. Hinter diesem Gesichtspunkt erscheint die Stärkung positiver Mensch-Natur-Beziehungen wichtiger denn je. Nicht zuletzt deshalb gewann die Umweltbildung, welche heute in der Bildung für nachhaltige Entwicklung (BNE) verankert ist, innerhalb der letzten Jahrzehnte in der formalen und informellen Bildungsbranche an Bedeutung. Besonders außerschulische Umweltbildung vermag es, sowohl kognitive als auch affektive Prozesse bei Kindern anzustoßen (Boyle, et al., 2007; Fuller, Edmondson, France, Higgitt, & Ratinen, 2006). So kann außerschulische Umweltbildung den Wissenszuwachs von Schülerinnen und Schülern[1] fördern und sie mit der Inspiration und den Fähigkeiten, die für umweltgerechtes Handeln entscheidend sind, ausstatten (Dillon, et al., 2006; Hope, 2009).

Voraussetzung für einen selbstbestimmten, verantwortungsbewussten Umgang mit der Natur ist die Fähigkeit, sich an der Entwicklung einer zukunftsfähigen Gesellschaft zu beteiligen. Zeitgenössische Umweltbildung zielt darauf ab, Motivation und Einstellungen zu fördern sowie eine grundlegende Wissensbasis zu schaffen (IUCN, UNEP, & WWF, 1991; Potter, 2010). Ein positiver Naturbezug und positive Umwelteinstellungen stellen die Grundlage für aktiven Umweltschutz dar. Direkte Naturerfahrungen können verstärkend wirken und gelten somit als eine didaktische Möglichkeit, die Motivation für Umweltschutz zu festigen (Kaiser, Roczen, & Bogner, 2008). Allerdings sind Einstellungen dynamisch und verändern sich im zeitlichen Verlauf. Dadurch gilt es für jede umweltbildnerische Maßnahme das adäquate Alter zu ermitteln (Ernst & Theimer, 2011). Auch Umweltwissen gilt als Grundlage für umweltgerechtes Handeln, da die sinnliche Erfahrung allein es nicht vermag

[1] Im Sinne einer besseren Lesbarkeit wird fortan nur die maskuline Form „Schüler“ verwendet, wenngleich selbstverständlich beide Geschlechter angesprochen sind.

ökologische Zusammenhänge verständlich zu machen. Hierzu bedarf es Sachinformationen (Frick, Kaiser, & Wilson, 2004; Liefländer, Bogner, Kibbe, & Kaiser, 2015). Allerdings führt Fachwissen allein nach heutiger Erkenntnis ebenfalls nicht zur Entwicklung von Haltungen und Werten, welche ein Bewusstsein generieren und es letztlich vermögen unser Handeln zu beeinflussen (Barr S. , 2003; Finger, 2010; Leiserowitz, Kates, & Parris, 2005; Stern P. , 2000; Trumbo & O´Keefe, 2001). Aktuell erkennt die biologiedidaktische Forschung drei Wissenstypen als wesentlich für die Genese von umweltfreundlichem Handeln an. Fakten-, Handlungs- und Effektivitätswissen gelten als erforderlich, um Schülerinnen und Schüler zu umweltgerechtem Handeln zu befähigen (Frick, Kaiser, & Wilson, 2004).

Diverse Studien mit Schülern bestätigen den positiven Einfluss von außerschulischen Umweltbildungsprogrammen auf Umwelteinstellungen, -wissen oder –verhalten (Bogner, 1998; Dettmann-Easler & Pease, 1999; Ernst & Theimer, 2011). Nichts desto trotz diagnostiziert die Bildungsforschung auch immer wieder eine Kluft zwischen Wissen und Handeln (Ernst & Theimer, 2011; Gifford & Sussman, 2012; Kollmuss & Agyeman, 2002), die bislang nicht geschlossen werden konnte.

Bis heute sind altersbasierte Unterschiede bei Schülern bezüglich ihrer Naturverbundenheit und Umwelteinstellungen nicht hinreichend untersucht. Auch ist die nötige Dauer der Naturerfahrungen, die es braucht, um signifikante Veränderungen bewirken zu können, noch nicht ausreichend erforscht. Zudem ist auf Grundlage der durchgeführten Literaturrecherche bislang keine Studie bekannt, die Umwelteinstellungen, -wissen und –handeln von Kindern verschiedener Regionen der Erde mit einer weiten Altersspanne innerhalb eines einzigen Evaluationssettings untersucht und Daten auf internationaler Ebene erhoben und ausgewertet hat. Die gezielte Integration der drei Umweltwissensarten in ein solch globales Umweltbildungsprojekt bedeutet hierbei eine bislang nicht untersuchte zusätzliche Herausforderung.

Die vorliegende Arbeit schließt diese bestehenden Forschungslücken, indem sie all jene Variablen mit einbezieht, die einen nahezu vollständigen Eindruck der Effektivität von Umweltbildung in verschiedenen Weltregionen, Sozialisationen und Altersklassen zulässt und ferner den Einfluss zahlreicher externer Faktoren beleuchtet. Dabei wird ein einzigartiges, multifaktorielles Evaluationsdesign angewandt.

Das Gesamtforschungsprojekt ist in drei Teilstudien untergliedert, die jeweils andere Schwerpunkte verfolgen und sich in Forschungsfragen, Stichproben und dem Design unterscheiden. Die Studie umfasst insgesamt 1454 Schüler aus Bangladesch, Malaysia, Deutschland und Singapur, die alle an dem Umweltbildungsprojekt „Global denken, lokal

handeln – wir schützen unsere Umwelt!“ bzw. “Think global, act local – we protect our environment!“, teilgenommen haben.

So wird in der Publikation „Connecting students to nature – how intensity of nature experience and student age influence the success of outdoor education programs“ (Braun & Dierkes, 2016), das Naturbewusstsein von Grund- und Mitteschstufenschülern aus Singapur untersucht und Veränderungen aufgrund der Teilnahme an dem Umweltbildungsprogramm erforscht. Das Alter der Schüler und die Interventionsdauer gelten dabei als exogene Variablen. Um der prominenten Annahme, der Grad der Naturverbundenheit sinke mit steigendem Alter (Bruni & Schultz, 2010; Ernst & Theimer, 2011; Wells & Lekies, 2006), nachzugehen, wurde die Stichprobe in vier Altersgruppen von sieben bis 18 Jahren eingeteilt.

Die Publikation „Fostering changes in attitude, knowledge and behavior: demographic variation in environmental education effects“ (Braun, Cottrell, & Dierkes, 2017) untersucht sowohl Ausgangswerte als auch mögliche Veränderungen von Umwelteinstellungen, -wissen und –handeln von Schülern der Primar- und Sekundarstufe aus Bangladesch, Malaysia, Deutschland und Singapur infolge eines eintägigen Umweltbildungsprogrammes. Anders als bisherige bekannte Studien bezieht die vorliegende Variablen mit ein, die bislang nicht hinreichend analysiert wurden. Zu diesen, Umwelteinstellungen, -wissen und –handeln beeinflussenden, Prädiktorvariablen zählen das Wohnsitzland sowie Nationalität, Alter, Geschlecht und die ländliche bzw. städtische Prägung der Lebensumgebung. Diese Studie zeichnet sich zudem durch ihr international angelegtes Design aus, welches in dieser Form bisher kein zweites Mal bekannt ist.

Schließlich wird in der Publikation „Evaluating Three Dimensions of Environmental Knowledge and Their Impact on Behaviour“ (Braun & Dierkes, 2017) der Schwerpunkt auf die drei Dimensionen von Umweltwissen, System-, Handlungs- und Effektivitätswissen, gelegt und untersucht, inwiefern die einzelnen Wissensdimensionen untereinander und in Bezug zu Umwelthandeln korrelieren. Des Weiteren wird am Beispiel zweier Stichproben aus Singapur und Deutschland vergleichend geprüft, wie sich die einzelnen Dimensionen aufgrund der Teilnahme an einem eintägigen Umweltbildungsprogramm verändern.

Die Naturverbundenheit wurde mit Schulz’ INS-Skala (Inclusion of Nature in Self) (2002) gemessen. Das dichotome 2-MEV-Modell (Two Major Environmental Values) (Johnson & Manoli, 2011) diente der Messung der Umwelteinstellungen. Da die Skala zur Erhebung des Umweltwissens auf das Programm zugeschnitten sein muss, wurde eigens eine Skala verfasst, geprüft und später nochmal im Hinblick auf die Untersuchung der drei Wissensdimensionen erweitert. Das Umwelthandeln wurde mittels einer auf der Grundlage

von Bögeholz (1999) basierenden selbst erstellten Skala gemessen. Die Skalen waren in einen Fragebogen eingebettet, der entsprechend dem Pre-, Post-, Follow-up-test Design, eine Woche vor der Intervention sowie im direkten Anschluss und 6 Wochen danach eingesetzt wurde. Die Kontrollgruppen bestanden aus Parallelklassen, die nicht am Projekt teilnahmen, aber Klassenunterricht zu den jeweiligen Themen erhielten.

Die Ergebnisse der Studien bestätigen den positiven, fortwährenden Effekt außerschulischer Umweltbildung bezüglich der Entwicklung der untersuchten Variablen. So wurde sowohl nach der Teilnahme am eintägigen als auch nach dem fünftägigen Umweltbildungsprogramm eine signifikante Verstärkung des Naturbezugs festgestellt, wohingegen die Kontrollgruppen keine messbare Veränderung zeigten. Allerdings war der Effekt in jener Experimentalgruppe, die am fünftägigen Programm teilnahm, deutlich stärker als beim eintägigen Programm. Die stärkste Resonanz zeigten Schüler zwischen sieben und neun Jahren. Das bestätigt die Signifikanz der Interventionsdauer sowie die des Schüleralters.

Umwelteinstellung, -wissen und –handeln wurden durch das Umweltbildungsprogramm ebenfalls positiv verstärkt. Das Wohnsitzland sowie die städtische bzw. ländliche Prägung der Wohngegend stellten sich als die stärksten Einflussfaktoren, was das Vorhandensein sowie die Entwicklung der untersuchten Variablen angeht, heraus. Die Entwicklung des Umwelthandelns allerdings schien nicht verändert durch die außerschulische Erfahrung. Die Kontrollgruppen zeigten ähnliche Veränderungen in ihrem aktiven Einsatz für die Umwelt. Der internationale Vergleich zeigt die komplexen Zusammenhänge und Abhängigkeiten einzelner externer Umgebungsbedingungen. So scheint der Wohlstand eines Landes mit all seinen politischen Konditionen als bestimmender Faktor auf den Erfolg von Umweltbildungsprogrammen zu wirken.

Die Probanden zeigten schwache Ausgangsniveaus bezüglich aller drei Wissenstypen Fakten-, Handlungs-, und Effektivitätswissen. Die Teilnahme am Umweltbildungsprogramm bewirkte einen signifikanten Zuwachs jedes Wissenstyps, wobei der Anstieg des Effektivitätswissens am größten war. Ebenfalls beim Umweltverhalten zeigte sich eine signifikant positive Veränderung nach der Intervention. Die gemessenen Korrelationen zwischen den einzelnen Wissenstypen und dem Umwelthandeln waren aber nur schwach. Die Ergebnisse zeigen die Wichtigkeit einer effektiven Integration der drei Wissenstypen in Umweltbildungsprogramme bzw. Unterrichtseinheiten. Die Daten machen deutlich, dass Faktenwissen als Grundlage fungiert, auf der Handlungs- und wiederum Effektivitätswissen basieren. Es ist der Ausgangpunkt, ohne den Handlungs- und wiederum Effektivitätswissen nicht generiert werden können. So bedarf es zuerst Wissen über Ökosysteme bzw. natürliche

Phänomene, um auf diesem Faktenwissen Handlungsoptionen zu deren Schutz erarbeiten zu können. Hieraus kann dann Effektivitätswissen abgeleitet werden, indem die Wirksamkeit der verschiedenen Schutzmaßnahmen vergleichend erörtert wird.

Die Wirksamkeit des durchgeführten Umweltbildungsprojektes in seinen abgewandelten Formen kann im Hinblick auf die positive Veränderung von Naturbezug sowie Umweltwissen, -einstellung und –handeln auf Grundlage der Studienergebnisse bestätigt werden. Es wurde deutlich, dass Unterrichtsszenarien, die direktes und positives Naturerleben zulassen, die Mensch-Natur-Beziehung deutlich intensivieren können. Weiter wird die Wertschätzung der Natur positiv beeinflusst und daraus hervorgehendes, vorsätzliches Handeln zum Schutz der Umwelt bewirkt. Vor allem weil sich Umwelteinstellungen im Laufe des Lebens verändern, darf Umweltbildung nicht nur einzelne Jahrgangsstufen adressieren. Vielmehr sollte sie ein Kontinuum bilden, das von früh an in die Schulpraxis integriert wird und somit die in der frühen Kindheit am stärksten verankerte Naturverbundenheit und positive Umwelteinstellungen über die Jahre erhält und weiter intensiviert. Auf erworbenem Grundlagenwissen wird in einem zweiten Schritt komplexeres ökologisches Wissen aufgebaut sowie bewusstes Handeln geübt und reflektiert.

Die im Rahmen dieser Untersuchung gewonnenen Daten haben gezeigt, dass Wissenszuwachs durchaus durch Unterricht im Klassenraum erreichbar ist. Aber um den Zielen der Bildung für nachhaltige Entwicklung Rechnung zu tragen und ganzheitliche Aspekte, die das Bewusstsein und Handeln beeinflussen, anzusprechen, verlangt es authentische Naturerfahrungen, die über reine Wissensvermittlung hinausgehen. Es braucht Zeit für die Begegnung mit der Natur. Multisensorische Zugänge intensivieren das Erleben. Das durchgeführte Umweltbildungsprogramm verbindet die kognitive mit der affektiven Ebene und führt dadurch zu einem ganzheitlichen Zugang zur Natur, der in einem intensivierten Wissen sowie einem Bewusstsein und er Bereitschaft für aktiven Umweltschutz resultiert.

Die wertschätzende Verbindung zur Natur kann nur durch positive Erfahrungen im Freien verstärkt werden. Wissen ist wichtig, um ökologische Zusammenhänge zu verstehen und umweltverträgliche Handlungsweisen zu entwickeln. Es ist jedoch kein Garant für aktiven Umwelteinsatz. Hierzu bedarf es einer positiven Einstellung zur Natur. Denn „Ich schütze nur, was ich liebe. Ich liebe nur, was ich kenne. Ich kenne nur, was ich wahrnehme. Ich nehme nur wahr, was für mich eine Bedeutung hat. …und diese Bedeutung vermitteln Erwachsene den Kindern“ (Knauer & Brandt, 1995, S. 14).

2 Summary

In light of today`s environmental problems supporting positive human-nature-relationships is more important than ever. Contemporary environmental education aims to foster motivation and attitudes as well as a fundamental knowledge base to enable a self-determined, responsible interaction with nature (IUCN, UNEP, & WWF, 1991; Potter, 2010). Positive nature connectedness and environmental attitudes count as basis for active environmental protection. Direct nature experience is considered as didactical possibility to strengthen the motivation to do so (Kaiser, Roczen, & Bogner, 2008). Attitudes change in the course of a lifetime and so age can play an important role concerning the efficacy of environmental education programs (Ernst & Theimer, 2011). Also environmental knowledge is deemed a basis of environmental behavior. Sensual experiences alone do not lead to an understanding of ecological contexts (Frick, Kaiser, & Wilson, 2004; Liefländer, Bogner, Kibbe, & Kaiser, 2015). Research in didactics of biology considers system, action-related and effectiveness knowledge as a central condition for the genesis of environmental behavior (Frick, Kaiser, & Wilson, 2004). According to the latest research isolated expertise doesn`t lead to the development of values and attitudes which affect our acting (Barr S. , 2003; Finger, 2010; Leiserowitz, Kates, & Parris, 2005).

To this day age-based differences in students' nature connectedness and environmental attitudes are not examined sufficiently. Further, the necessary duration of nature experiences has not been verified. So far there is no study known that investigates environmental attitudes, knowledge and behavior of children from different world regions and that collects and evaluates data on an international basis. The integration of the three knowledge dimensions in such a global environmental education project is an additional unapproached task. The present research closes these remaining research gaps by including variables that offer a nearly complete impression of the efficacy of environmental education in different regions, socializations and age groups on an international level. This way, the influence of a comprehensive environmental education program concerning nature connectedness, environmental attitudes and knowledge dimensions gets examined and references regarding eventual alterations in environmental behavior are made. Thereby, traditional and so far unexplored possible influencing factors are paramount. The study includes 1454 students from Bangladesh, Malaysia, Germany and Singapore that participated in the environmental education project "Think global, act local – we protect our environment!" respectively "Global denken, lokal handeln – wir schützen unsere Umwelt!".

Schulz' INS scale (Inclusion of Nature in Self) (2002) served as tool for measuring nature connectedness. Environmental attitudes were measured using the 2-MEV-Model (Two Major Environmental Values) (Johnson & Manoli, 2011). A scale for collecting environmental knowledge data was developed autonomously and later modified regarding the three knowledge types. For measuring environmental behavior a scale was developed according to Bögeholz (1999). All scales were part of a questionnaire that was implemented in the form of a pre-, post-, follow-up-test. Students from the respective parallel classes who didn`t participate in the project but received lessons covering the same topic served as control cohorts.

The results confirm positive effects of extracurricular environmental education regarding the development of the examined variables. After participating in the one-day as well as the five-day program significant increases of nature connectedness could be measured whereas the control cohorts didn`t show measurable alterations. Yet, the five-day intervention also caused sustained changes. Children in the age between seven and nine years showed the strongest variations.

Concerning demographic influencing factors for environmental attitudes, knowledge and behavior country of residence and rural-urban differences emerged as the most powerful influencing factors. They were the most influential determinants for predicting baseline values as well as alterations of the examined variables due to the educational measure. Solely the development of environmental behavior direct nature experiences seems to be insignificant given that the control cohorts showed a similar change in their engagement for the environment. By international comparison the complex concatenation of diverse factors just as the welfare of a nation, their general political system or the specific educational conditions determine the success of environmental education programs.

Data shows that system knowledge is the basis for action-related and effectiveness knowledge. All knowledge dimensions increased through the intervention. Effectiveness knowledge showed the largest increase. Also environmental behavior has positively changed. Yet only weak correlations between the single knowledge dimensions and behavior could be detected. In summary, the implemented educational project was successful regarding the promotion of nature connectedness as well as environmental attitudes, knowledge and behavior. Within the scope of this work the results will be discussed with regard to their importance for the scholar environmental education as well as the didactical research.

II. Research Project

In this part the research project will be explained in detail. The reader will get information about the aims and the scope of the study as well as the applied methods. Further, the findings obtained will be presented and discussed with regard to their scientific and educational relevance.

1 Theoretical Background

Stimulating a profound awareness about the human impact on the environment is more important than ever since the world is facing steadily increasing environmental threats possibly caused through anthropogenic actions. Since the younger generation will shape the world`s future most intensely it seems necessary to address children and young adults when trying to increase environmental literacy. For a global prevention of environmental issues it is important to deepen people's connection to nature, increase environmental knowledge, promote positive attitudes and motivate individuals to engage in nature conservation (Potter, 2010; UNEP, 2005). Theoretically grounded environmental education interventions imply to be an adequate tool for pursuing this goal. This research examines the efficacy of a singular outdoor environmental education program with regard to possible shifts in primary and secondary school students` nature connectedness, their levels of environmental attitudes, knowledge and behavior. Thereby, each of the three sub studies investigates a different prioritization that will subsequently be explained.

1.1 Leading questions and study aims

The overall scope of this research was global in nature and included students from four different countries in Asia and Europe. Each sub study was presented in a publication that addresses a specific scientific problem.

Publication A: Connecting students to nature – how intensity of nature experience and student age influence the success of outdoor education programs

This publication (Braun & Dierkes, 2016) examines baseline values and the impact of an outdoor environmental education program on Singaporean primary and secondary school students' nature connectedness with regard to program duration and participant age. In order

to investigate the prominent assumption that the degree of nature connectedness declines with rising age (Bruni & Schultz, 2010; Ernst & Theimer, 2011; Wells & Lekies, 2006) participants were divided into four age groups from seven up to 18 years of age.

Further, it is broadly suggested that nature connectedness depends on nature experience (Kals, Schumacher, & Montada, 1999; Nisbet, Zelenski, & Murphy, 2009; Schultz, 2002). Still, there exists no definite notion of a necessary length of this experience. So, the intervention was realized in two lengths: one-day and five-days. This way it was tried to find the necessary extent for positive shifts towards a stronger nature connectedness.

Publication B: Fostering changes in attitude, knowledge and behavior: demographic variation in environmental education effects

This study (Braun, Cottrell, & Dierkes, 2017) examines baseline differences and the effects of a singular one-day outdoor educational program on environmental attitudes, knowledge and behavior among primary and secondary school students educated in Bangladesh, Germany, Malaysia and Singapore. Other than most studies so far this research employed a combination of yet insufficiently explored variables (country of residence, age, nationality, sampling year, gender and urban/ rural habitation) as predictor variables for the existence and the development of environmental attitudes, knowledge and behavior. Also, this research follows an international approach that couldn`t been found previously. Research indicates that knowledges counts as a precondition for environmental attitude and behavior (Frick, Kaiser, & Wilson, 2004; Gifford & Sussman, 2012). We believe that the web of influencing factors is way more complex and therefore invented this unique multi-factorial, large-scale design.

Publication C: Evaluating Three Dimensions of Environmental Knowledge and Their Impact on Behaviour

Following the results of Frick, Kaiser and Wilson (2004) that relate to adults this research extends this field of research by evaluating the development of three environmental knowledge dimensions of secondary school students after participation in a singular 1-day outdoor education program to review their suggestions (Braun & Dierkes, 2017). Only this way the results can matter for educational research and school practice. The three knowledge types *system, action-related* and *effectiveness knowledge* of students educated in Germany

and Singapore were assessed in a cross-national approach. Correlations between single knowledge dimensions and behavior changes due to the participation in the outdoor environmental education intervention were examined. This way, this study is unique in evaluating the development of the three environmental knowledge dimensions system, action-related and efficiency knowledge among secondary school students after participation in a singular outdoor educational intervention. Further, it widens the scope to an international level.

1.2 Nature Connectedness

Nature connectedness is the extent to which individuals perceive nature as part of their own identity (Schultz, 2002). Individuals who feel connected to nature are the ones most likely to take stewardship for natural environments (Clayton, 2003; Dunlap, Van Liere, Mertig, & Jones, 2000; Nisbet, Zelenski, & Murphy, 2009). Therefore, nature connectedness counts as motivation for nature protection (Frantz, Mayer, Norton, & Rock, 2005; Kaiser, Roczen, & Bogner, 2008; Kals, Schumacher, & Montada, 1999). Positive nature experiences and time spent in natural surroundings can intensify the way individuals relate to nature (Schultz, 2002). Janssen (1988) developed a model which emphasizes the importance of nature experiences as a foundation for cognitive ecological understanding as well as nature awareness and the motivation for proactive environmental behavior (see Figure 1). Hence, the educational program developed in the frame of this study does not only focus on knowledge acquisition but involves the emotional tier of direct nature encounter as well.

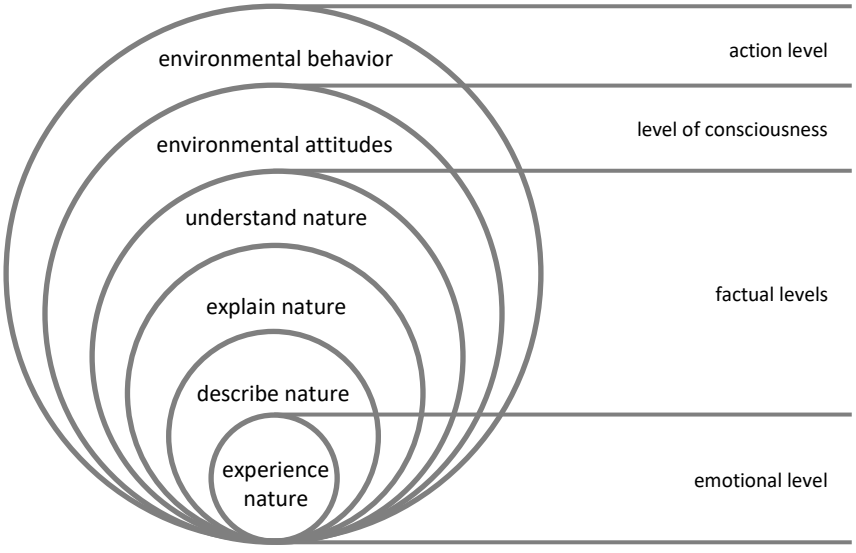

Figure 1: Connection between nature experience and environmental behavior. Source changed after Janssen (1988).

Research suggests that current environmental issues can be related to a disconnection between humans and nature (Jordan, 2009; Tacey, 2000). Hence, a re-connection between humans and nature is of enormous importance. Since the younger generation will be the one to actively design world`s future it seems logical to address children and young adults when trying to evoke a more environmental friendly lifestyle. An environmental education program which is both scientifically sound and addresses the needs of the learners, therefore, is a suitable instrument to stimulate nature connectedness.

So far, research does not yield a complete clarification concerning the development of nature connectedness over time. Bruni and Schultz (2010) could prove that children aged ten to eleven demonstrate a significantly higher nature connectedness than college students. Liefländer, Fröhlich, Bogner and Schultz (2012) found that students aged 9 to 10 show a considerably stronger nature connection compared to students aged 11 to 13.

Further, the necessary length of such educational programs has not sufficiently been determined yet. Research lacks studies to directly compare environmental education programs that differ in duration. So far it was found that the degree of being connected with nature could not clearly be affected by participation in a one-day program (Kossack & Bogner, 2012) whereas a four-day program achieved positive shifts (Ernst & Theimer, 2011).

The connection between individual and nature can be depicted by the “inclusion of nature in self” (INS) scale by Schultz (2002). This scale considers the inclusion of nature into the self-concept of individuals and uses seven different graphics to determine the individually perceived feeling of being interconnected with nature. Psychometric quality criterions for this scale have been approved (Schultz, Shriver, Tabanico, & Khazian, 2004) independently.

1.3 Environmental Attitudes

Besides nature connectedness, environmental attitudes are considered a further important predictor for environmental behavior. The two most prominent theories for explaining the relation between attitude and behavior are Ajzen`s theory of planned behavior (TPB) (1991) and the value-belief-norm theory (VBN) by Stern (2000). Pro-environmental attitudes are reliant on various factors such as age, gender, cultural backgrounds, experience, rural-urban residences, knowledge etc. (Gifford & Sussman, 2012). Research yields mixed results concerning the relationship between attitudes and behavior as well as the impact of environmental education on attitude formation (Bang, Ellinger, Hadjimacou, & Traichal,

2000; Gillet, Thomas, Skok, & Mc Laughlin, 1991; Leeming, Dwyer, Porter, & Cobern, 1993; Shepard & Speelman, 1985; Drissner, Haase, & Hille, 2010; Johnson & Manoli, 2011).

Environmental attitudes are conceptualized as being composed of beliefs and emotions towards an object. These attitudes again manifest themselves in an individual`s preference to ascribe importance to environment-related activities or problems (Schultz, Shriver, Tabanico, & Khazian, 2004). Defining the environment as an object seems difficult and complicates the study of environmental attitudes. Dobson (2007) provides a realistic example for environmental attitudes. A person declining the use of plastic bags shows a preferable environmental behavior. This behavioral mode, however, could simply stem from egocentric economic reasons. Not before the person decides to consciously deny plastic bags out of ecological reasons; can positive environmental attitudes be attributed to this behavior. Thus, environmental education should aim at fostering a sustainable shift of attitudes towards active environmental stewardship.

In recent years several scales have been developed to measure attitudes efficiently. In the frame of this study the 2-MEV-scale (Two Major Environmental Values) originated by Bogner and Wiseman (2006) which has been modified for the use of 9 to 12 year-old children by Johnson and Manoli (2011) was applied to measure the presence as well as possible alterations of environmental attitudes. The two independent dimensions preservation and utilization constitute the scale measuring attitudes (see Figure 2). Preservation is affected by a bio-centric preference for the protection and conservation of natural resources. Utilization accounts for the anthropocentric preference to take advantage of natural resources. The psychometric features of the 2-MEV-scale have been proved by several independent research groups (Boeve-de Pauw & van Petegem, 2011; Drissner, Haase, & Hille, 2010; Johnson & Manoli, 2011; Milfont & Duckit, 2004; Munoz, Bogner, Clement, & Carvalho, 2009) so that studies using the same measuring instrument bare comparable results.

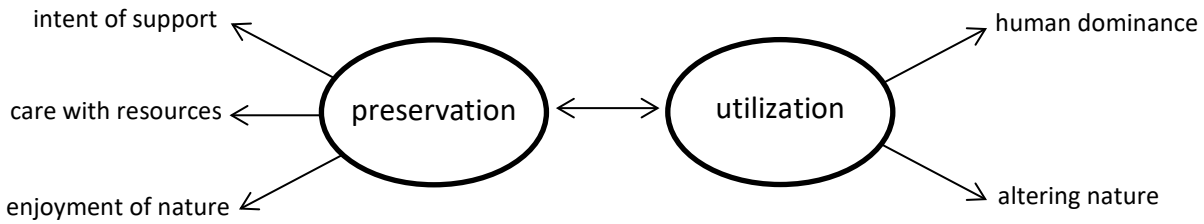

Figure 2: Dimensions of the 2-MEV model by Bogner and Wiesemann (2006). Figure created according to Bogner (2018)

Research suggests that children have a more positive environmental attitude than adults. Empirical studies showed that American secondary school students (aged 9 to 12) (Johnson & Manoli, 2011) have a clearly higher environmental attitude compared to German college students (average 22 years of age) (Wiseman, Wilson, & Bogner, 2012). However, these studies do not take cultural or sociodemographic variables into account. Further, where some studies found a more positive attitude in female participants (Bogner & Wisemann, 2006; Wiseman & Bogner, 2003) others did not find gender-specific differences concerning environmental attitudes (Boeve-de Pauw & van Petegem, 2011; Oerke & Bogner, 2010). However, empirical results concerning correlations between attitudes, knowledge and behavior remain inconsistent (Kollmuss & Agyeman, 2002) and environmental attitudes alone seem to be a minor predictor for pro-environmental behavior which is why this study considers a nearly entirety of possible influencing factors.

1.4 Environmental Knowledge

Many studies suggest that environmental knowledge has the potential to cultivate positive environmental attitudes and behavior (Frick, Kaiser, & Wilson, 2004; Liefländer, Bogner, Kibbe, & Kaiser, 2015; Sellmann & Bogner, 2011). Given that commonly knowledge counts as necessary precondition for a person's behavior traditionally, most educational interventions focus on knowledge transfer (Kaiser, Roczen, & Bogner, 2008).

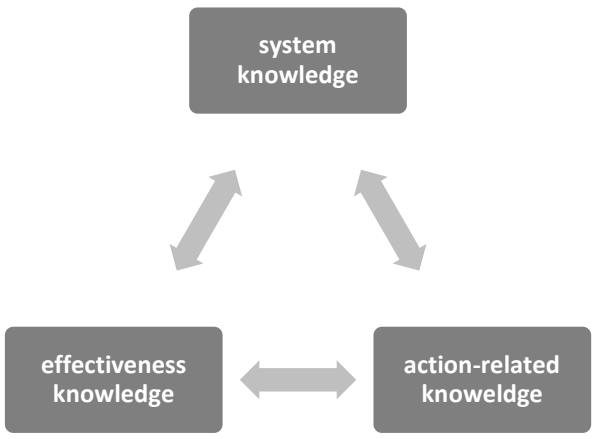

Figure 3: "Knowledge Structure Model". Source changed after Frick, Kaiser, & Wilson (2004)

Research suggests that knowledge although being insufficient in reliably predicting behavior, is a necessary mean to overcome psychological barriers such as unawareness, fear or misrepresentation (Kaiser, Roczen, & Bogner, 2008; Pratkanis & Turner, 1994; Ronis & Kaiser, 1989).

Environmental knowledge in the classical sense covers the factual knowledge about structures and functions as well as processes of ecosystems (Hines, Hungerford, & Tomera, 1986/87; Schahn & Holzer, 1990). Current studies indicate that a profound factual knowledge - also called *system knowledge* - about environmental systems and issues does not necessarily

lead to environmentally responsible behavior (Frick, Kaiser, & Wilson, 2004; Liefländer, Bogner, Kibbe, & Kaiser, 2015). Instead, an additional awareness of possible options of actions is crucial for individuals in order to be able to perform pro-environmental behavior. Schultz (2002) calls that type of knowledge which accounts for awareness about several courses of actions and how these are implemented adequately *action-related knowledge*. This type of knowledge has a more behavior-proximal nature and is therefore thought to be a better predictor of environmental behavior (Martens, Rost, & Warning-Schröder, 2001). Different environmental behavior patterns have different conservation capacities. In order to know which behavioral option has more benefit a third type of knowledge is required: *effectiveness knowledge*. Effectiveness knowledge describes the awareness of the conservational potential of several courses of action (Stern P. , 2000). Buying a new fuel-efficient car, so Stern and Gardner (1981) would be a more efficient conservation behavior in order to safe CO_2-emissions compared to driving an old car less often. Only if individuals have knowledge in all three domains they will be able to make deliberate and effective behavioral decisions.

According to the "Knowledge Structure Model" (see Figure 2) by Frick and his research group (2004) environmental knowledge entails all three dimension which are dependent upon each other.

Knowledge increase can be assessed via questionnaires gathering the number of correct answers prior and post intervention. Many studies proved that environmental education has positive influence on knowledge acquisition (Bogner, 1998; Fančovičová & Prokop, 2011; Randler, Ilg, & Kern, 2005; Shepard & Speelman, 1985; Sellmann & Bogner, 2004) however only one comparable study considered different knowledge dimensions in the educational intervention (Liefländer, Bogner, Kibbe, & Kaiser, 2015) so far. Still, the mentioned study presents a rather unrepresentative sample consisting of few participants deriving from one region and one age cluster only.

For measuring the educational success of an intervention in terms of the transfer of all three knowledge dimensions a program-specific measuring instrument containing scales for each dimension is needed. Hence, in cooperation with other educational staff from University and the partner company Ecofieldtrips the author developed a unique knowledge scale. Internal scale consistency as well as reliability and validity have been proven before application. Thus, growing knowledge levels along with knowledge integration indicate educational success.

1.5 Environmental Behavior

The world experiences various environmental crises such as global warming, air and water pollution or loss of biodiversity. Human behavior can be seen as a major reason for these problems (DuNann Winter & Koger, 2004; Vlek & Steg, 2007). Given that all human actions have an impact on the environment (e.g. traffic use, waste production, energy consumption etc.) environmental behavior in a narrow sense refers to behavioral modes that significantly try to reduce the negative human impact on the environment (Kollmuss & Agyeman, 2002; Stern P. , 2000). Various research groups explored the factors predicting environmental behavior (Hines, Hungerford, & Tomera, 1986/87; Kollmuss & Agyeman, 2002; Mobley, Vagias, & DeWard, 2010; Riess, 2003; Vlek & Steg, 2007). Nevertheless no theoretical framework could entirely explain the factors that lead to environmental behavior and its interrelations with other factors. Early models for explaining environmental behavior suggested a simple linear process that saw knowledge as a precondition for attitude changes which would lead to shifts in environmental behavior. Hence, teaching individuals in environmental knowledge was central for evoking pro-environmental behavior (Kollmuss & Agyeman, 2002). Till today, commonly attitudes and knowledge are suggested to potentially but not with certainty lead to pro-environmental behavior (Frick, Kaiser, & Wilson, 2004; Hinds & Sparks, 2008; Kaiser, Roczen, & Bogner, 2008; Schultz, 2001). Till the present date, research repeatedly experiences a gap between attitudes, knowledge and action (Gräsel, 2000; Rajecki, 1982; Riess, 2003). Current research suggests the existence of further explanatory demographic, internal or external factors when it comes to environmental behavior (Gifford & Nilsson, 2014; Kollmuss & Agyeman, 2002). The two most prominent but still insufficient approaches for predicting environmental behavior are Stern`s (2000) value-belief-norm and Ajzen`s (1991) theory of planned behavior. While the VBN emphases on values and norms as predictors of environmental behavior the TPB is based on self-interest and rational choices. In order to entirely reveal the relation between pro-environmental behavior and other influencing factors further research is necessary.

As people tend to over-report pro-environmental behavior it is hard to actually measure it. Therefore, it seems easier to also include the expressed intention to perform environmental friendly behavior of individuals for a more holistic assessment of behavioral patterns. Methodology for measurement of changes between baselines, intended and performed environmental behavior was adapted from Bögeholz (1999) to the aims of the present study. The scale is made of a multiple choice selection of explicit courses of action in the field of environmental conservation. To validate whether the participants actually realized

a change in behavioral elements after instruction the same items as in intended behavior were used and graded as performed behavior after the educational intervention.

2 Methodology

This chapter describes the applied methodology of the present research project. The evaluative design as well as the sampling entailing the measuring instrument and the samplings as well as the conducted environmental education program in its different realizations will be outlined.

2.1 Evaluative Design

As can be seen in Figure 3 empirical acquisition of baseline data was obtained at school two weeks prior to the educational intervention (T1) via questionnaire (paper and pencil). A second questionnaire was completed subsequently after the intervention (T2 - post-test) to measure immediate changes. Sustained changes were evaluated through a third questionnaire which was completed school six weeks after the program (T3). Participants from the control group completed the same questionnaire within the same time frame.

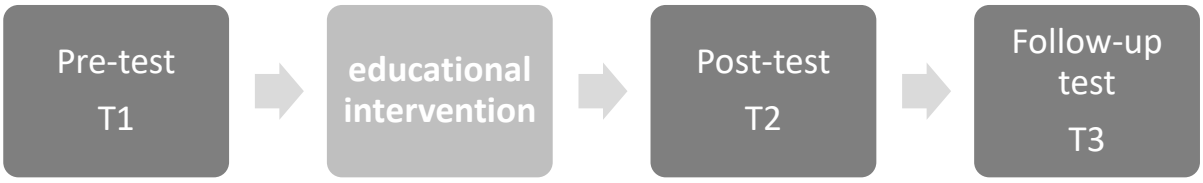

Figure 4: Study design. Own presentation.

The single items of the questionnaires were presented in a different order at each test time to avoid learning or memory effects. Every participating class (experimental and control groups) participated in the evaluation. Participants that failed to complete all three evaluations (e.g. due to absence at the measuring time) were omitted from analysis. Also questionnaires that were completed to less than 85% were not considered in the statistical analysis. This lead to a reduction of the net sampling size and varying sizes within different subsamples.

2.2 Study Participants

Participants were recruited via mail advertisement. 30 schools in Germany and 35 schools in South East Asia (BD: 5, SG: 15, MY: 15) were invited to participate the educational research study. All sampling classes registered for the outdoor education program

conducted by Ecofieldtrips (Asian samplings) or Goethe University (German sampling). Control cohorts derived from the same respective schools. Due to different numbers of registration for the environmental program and the individual willingness to participate in the study there are alterations in sampling sizes. All program participants were informed that their evaluation happened on a purely voluntary basis. As most of the participants were children, informed participant and parental consent was gained prior to the intervention. All students and parents were informed about the details of the study contents, the research process and data storage.

The present study was conducted in a quasi-experimental design. Participating primary and secondary school students derived from Bangladesh, Malaysia, Singapore and Germany. Table 1 gives an overview of the single experimental and control cohorts within the single sub studies. Participants were divided into four different age groups within seven to 18 years of age (7-9yrs / 10-12yrs / 13-15yrs / 16-18yrs). The net size of complete data sets considered in the statistical analysis added up to 1454 students out of which 887 students participated in an educational program and 567 students belonged to the control group which had school lessons covering the same topics. In total, 45 secondary school classes participated in the outdoor environmental intervention. All school types in Germany (Haupt- and Realschule, Gymnasium) were represented within the sample.

Table 1: Overview of the experimental and control groups within the single sub studies

	experimental				**control**			
country	**BD**	**MY**	**GER**	**SG**	**BD**	**MY**	**GER**	**SG**
Publication A				376				225
Publication B	43	100	154	121*			160	67*
Publication C			112	102			92	90
total			887				567	

*also part of Publication A

Apart from that sub sample taking part in the sub study examining the three knowledge dimensions all students participating in the environmental program completed the same questionnaire containing the scales for measuring nature connectedness as well as environmental attitudes, knowledge and behavior. Because the single sub studies focused on different questions not all scales were used for every publication. Due to the fact that those students whose data was used for examining the reported nature connectedness are also part of the sample for publication B the number of participants for the single publications is larger than the overall net number of study participants.

The net sample of **publication A** consists of 601 Singaporean students that were separated into different sub samples. 194 students participated in a five-day residential environmental program and 182 students joined a one-day outdoor educational program. 124 students represented the five-day control cohort and further 101 students were in the one-day control cohort. Altogether, the occurrence of different age groups was relatively equal with 24.8% of the students being in the age between 7 and 9 years, 26.3% between 10 and 12 years, 27.3% between 13 and 15 years and 21.6% between 16 and 18 years.

Data from **publication B** is combined from four bilateral samplings involving students educated in Germany (N=154), Singapore (N=121), Malaysia (N=100) and Bangladesh (N=43). Additionally, there were two control groups from Germany (N = 160) and Singapore (N = 67) that only attended scheduled school lessons making a net size of 645 data sets.

The sampling for **publication C** consists of two bilateral experimental cohorts involving secondary school students educated in Germany (N_1 = 112) and Singapore (N_2 = 102) which took part in an outdoor educational intervention. Two respective control groups living in Germany (N3 = 92) and Singapore (N4 = 90) ensured the exclusion of any learning effects due to the repeated completion of the questionnaire.

2.3 Measuring Instrument

Each questionnaire had an introductory section informing about research aims, the evaluative process and the instruction about the voluntarily basis of the assessment. Besides a set containing five demographic items each questionnaire had two items evaluating the comprehensibility of the items. Meeting the study aims, the questionnaire included 4 different measuring instruments with 36 items in total which were used in excerpts at the three measuring times. Depending on the measuring time the questionnaire consisted of 52 additional items which were not subject of this work. Each cohort was assessed using the same instrument. Due to the multi-national study design the instrument was translated into the language the students were educated in - German or English. Figure 4 shows the single scales that were used at the three measuring times.

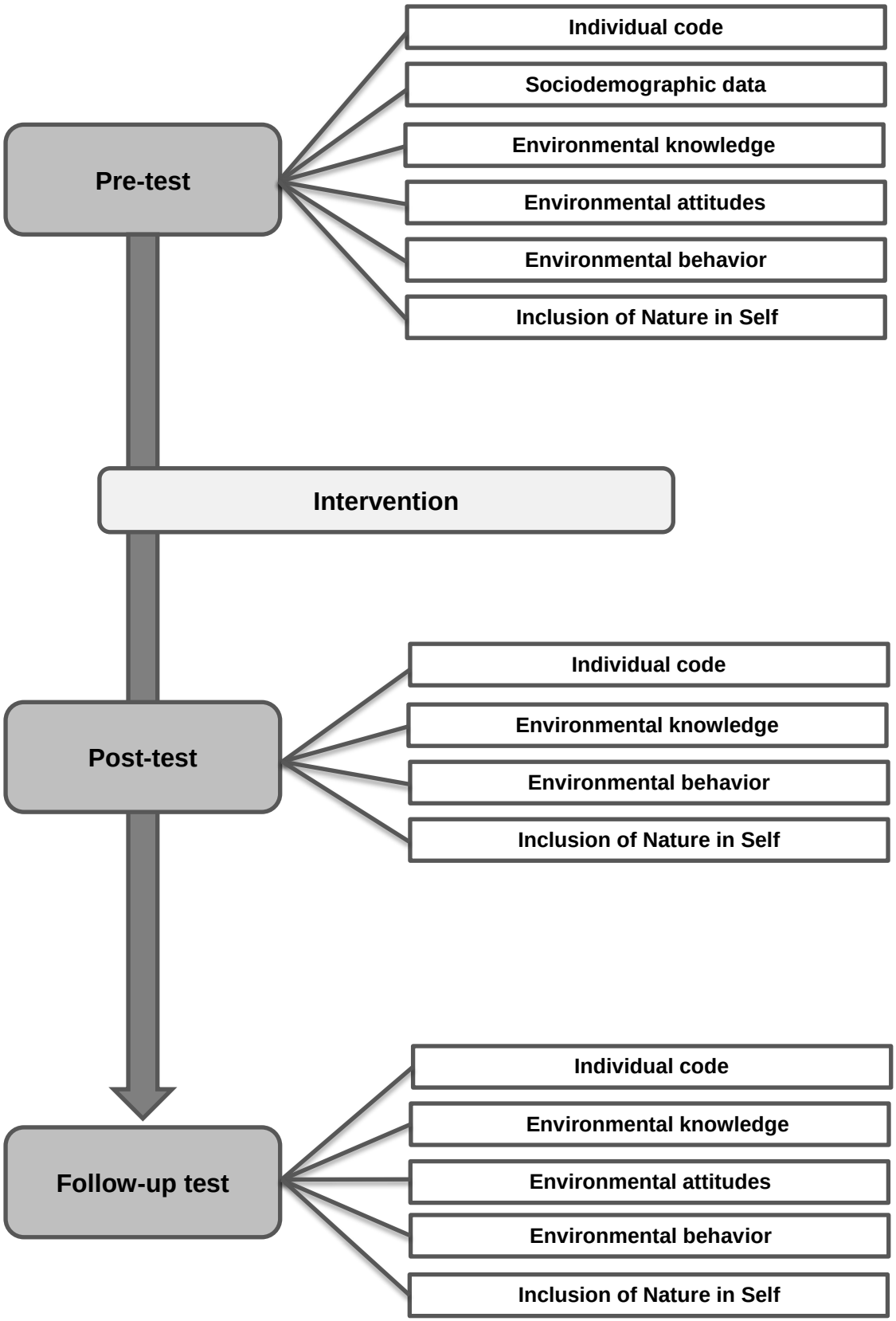

Figure 5: Applied scales. Own presentation.

Publication A explores differences in individuals' feeling of being part of nature and is based on the measurement of individuals' described connection to nature according to Schultz`s *Inclusion of Nature in Self* scale (2002). The INS displays a cognitive imagination of one self being part of nature. According to Schultz (2002) 'inclusion' incorporates affective aspects (caring for nature), cognitive connectedness and behavioral obligation. Accuracy for measuring individual connectedness with nature has been proven (Schultz, Shriver, Tabanico, & Khazian, 2004). The scale consists of one single graphic item. This item contains seven different circle-pairs labelled "nature" and "self" which differ in their degree of overlapping. Participants had to choose one of the seven graphics determining their individual feeling of interconnection with nature. The scale ranged from 1 (completely separated from nature) to 7 (completely connected with nature). For evaluating possible program effects the baseline values were compared with the other measuring times.

Publication B considers baseline differences and the effect of a singular outdoor educational program on environmental attitudes, knowledge and behavior between secondary school students on a multi-national level and is hence based on four different scales. Environmental attitudes were quantified using the 2-MEV (Two Major Environmental Values) model (Bogner & Wisemann, 2006). The scale is based on two independent spheres of environmental attitudes, preservation and utilization. Preservation is affected by a bio-centric preference for the protection and conservation of natural resources and would be preferentially selected by participants with a positive environmental attitude. The instrument originally consists of 20 items which were reduced to 16 for model simplification. The elimination of the four most difficult items was the attempt to enhance the comprehensibility especially for younger secondary school students. In order to corroborate the bilateral structure of the model a confirmatory factor analysis including bivariate correlations was conducted. The items were arranged in a five-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree) (see appendix). Attitude scores on the Likert scale were divided into positive (1-2), neutral (3) and negative for (4-5) for analysis and served as initial values for evaluation of baseline attitudes as well as further investigation of program effects. The 2-MEV was used in several international studies which contributes to the comparability of the study results on an international level. Numerous independent research groups proved the psychometric quality of the 2-MEV-scale (Boeve-de Pauw & van Petegem, 2011; Drissner, Haase, & Hille, 2010; Milfont & Duckit, 2004; Munoz, Bogner, Clement, & Carvalho, 2009).

Additionally, baseline differences in environmental knowledge of secondary school students and the educational success of the intervention were measured. Whereas **publication B** focuses on the acquisition of factual knowledge only, **publication C** investigates the three different knowledge dimensions factual, action-related and effectiveness knowledge. Since the evaluation of knowledge increase relies on items that were taught within the program the applied knowledge scale needs to be adapted to the program intents. Since there is no such thing as a uniform and comparable question sets published for measuring individual knowledge of environmental knowledge, an exclusive set of 16 environmental knowledge questions was autonomously developed. For obtaining a choice of possible answers for the items the questions were handed to non-participating secondary school students who had to come up with possible answers to the referring questions. Appropriacy of the suggested answers was then validated by environmental teachers from Goethe University, Germany and environmental education specialists from Ecofieldtrips Environmental Education, Singapore. Prior to the final selection of items, the pre-questionnaire was pilot tested to assure that the developed scale was valid. Since the selected questions aimed at syllabus relevant content teachers of the participating classes were plead not to cover any of the topics that would be conducted in the program and assessed through the questionnaire. The final scale consists of eleven single and five multiple choice questions. The battery for factual environmental knowledge was divided into the two categories: ‘global environmental knowledge’ and ‘program-specific regional environmental knowledge’. The first category focused on global environmental topics (e.g. climate change) and was identical in every questionnaire. The second category focused on syllabus content, specific to the educational program. German study questions differed from those in the Asian study in local specificity (e.g. deciduous vs. mangrove forests). The items partly assessed specialized factual knowledge that the students were unlikely to be aware of before any educational unit. Erroneous representation of knowledge through random guessing of multiple choice items was considered consistent for all questionnaires. Knowledge levels were traditionally defined by counting the number of correct answers. The comparison between the scores taken at T2 and T3 with T1 indicate the immediate respectively sustained educational program success.

Methodology for measurement of changes between baselines, intended and performed environmental behavior was adapted from Bögeholz (1999) to the aims of the present study. The scale consists of a multiple choice selection of specific courses of action in the field of environmental conservation, waste management, energy consumption and transport. For baseline behavior, nine items measured the currently fulfilled environmental actions and

further six items measured the intention to choose more environment friendly options of future action. To validate whether the participants actually realized a change in behavioral elements after instruction the same items as in intended behavior were used and graded as performed behavior in T3.

2.4 Statistical Analysis

The selection of statistical tests was dependent on the psychometric characteristics of the respective data sets and was chosen individually for every scale. All differences in nature connectedness, environmental attitude, knowledge, and behavior between experimental and comparison groups were examined in order to detect any differences in the efficacy of the developed outdoor program relative to school-based programs. All employed statistical modelling techniques were employed to understand which variables best account for the variability in attitudes, knowledge and behavior before and after the program.

Data of **publication A** did not show the conditions of normal distribution. Therefore, non-parametric tests had to be applied. All tests were conducted using SPSS, v.22. To examine baseline differences in nature connectedness Kruskal–Wallis one-way analysis of variance and Mann Whitney U test were applied. Effect sizes were calculated according to Cohen (1988) with d = .2 as a small, d = .5 as medium and d = .8 as large effect.

For identifying time-based alterations between subgroups across the different measurements Friedman test was applied. Differences between control and experimental group were measured using Kruskal–Wallis rank-sum test to allow non-normality in scored data.

Statistical analyses in **publication B** were run using R statistical package, v.3.1. Baseline attitude scores (T1) were categorized to reflect positive (1–2), neutral (3) or negative (4–5) attitudes and then fitted to an ordered logistic regression model. The knowledge scores were transformed to percentages and baseline scores (T1) were fitted to a linear regression model. Given that behaviors are constrained by zero the number of behaviors performed by students at T1 was considered quasi-Poisson data. Thus, this data was fitted to a Poission regression model. Changes in attitude, knowledge, and behavior were modelled using a binary fashion model to provide comparable metrics for program efficacy between ordinal and numerical model outputs using probabilities of positive changes in attitude, knowledge and behavior. All explanatory variables were fitted as factors.

Statistical analyses for **publication C** were again made using SPSS v.22. Due to the non-normality of the data and a detected heteroscedasticity of variance non-parametric tests were applied in order to allow ordinal data without being affected by outliners. Again, all knowledge scores were converted to percentages. Knowledge and behavior scores were compared using Kruskal-Wallis one-way analysis of variance followed by Mann-Whitney testing. Progressive changes between subgroups across the different measurements were explored using Friedman test followed by post hoc Wilcoxon signed rank testing. Constant error variance and presence of heteroscedasticity were confirmed using Levene's test. Correlation coefficients were calculated according to Spearman (Nisbet, Zelenski, & Murphy, 2009).

2.5 Outdoor Environmental Education Program

All empirical studies of this work are based on a singular extracurricular outdoor environmental education program called "Think global, act local – we protect our environment!". Program implementation took place between August 2013 and February 2015. Operators and schedules remained equal at all times to keep the general program structure consistent. Topics such as food webs, nutrient cycles, ecosystem services or nature conservation are all too often addressed on a theoretical and abstract basis in ordinary school lessons. In order to develop a sincere connection to nature tangible first-hand experiences are needed instead of barren school books. Through this outdoor environmental education program students got the chance to directly encounter natural surroundings and to consciously explore ecological coherences and principles.

Given the multi-national study design the educational intervention took place in different places. German study participants attended the program at two external learning sites near an in Frankfurt. They made field excursions to the Arboretum Main-Taunus in Eschborn or the MainÄppelHaus in Frankfurt. Participants of **publication B** and **C** visited the Arboretum Main-Taunus, a 76ha huge forest park showing more than 600 tree and bush species endemic in the northern hemisphere. Additionally to the numerous tree species from different world regions, visitors find an orchard meadow and a wetland biotope in this area. These diverse ecosystems again draw many animal species and make this place a worthy spot for biological field experiences.

Participants of **publication A** went to the MainÄppelHaus, a learning center on an orchard meadow in Frankfurt which is home to more than 5000 plant and animal species.

From forest to lake, this orchard meadow is providing a diverse range of ecosystems and fruit tree species. The various plant species attract various insects, birds, amphibians and small mammals.

In Asia study participants did also visit two out-of-school learning places comparable to those in Germany. For **publication A** Asian study participants went to an out-of-school learning center in Ipoh, Malaysia. Ipoh is a city in the Kinta valley and situated on the bank of the Kinta River. Ipoh is surrounded by limestone hills and lush rainforests. Study participants of **publication B** and **C** made a field trip to Tioman Island, Malaysia. The island is densely forested, crossed by plenty of rivers and sparsely inhabited making it a perfect spot for nature encounter. Large parts of the island are protected as wildlife reserve and are home of several protected mammal species such as the Slow Loris. All of the visited learning sites are appropriate for studying scientific concepts in-situ and for training field sampling techniques.

The German program was conducted by environmental teachers from the department for bioscience education at the Goethe University in Frankfurt. The department offers many extracurricular programs to school students and is experienced in environmental field work. The Asian program was executed by field biologists from Ecofieldtrips Environmental Education in Singapore. This established fieldtrip provider organizes school fieldtrips that focus on the exploration of the natural environment at the students' doorstep. The extensive program partly focusses on global environmental issues and partly refers to the German and Singaporean/ Malaysian curricular for the school subject biology. The main aim of the intervention was the original encounter of environmental conservation topics and syllabus appropriate material *in-situ*. In association with the environmental teachers from Ecofieldtrips the author designed the intervention and implemented the educational intervention in both study venues, Germany and Singapore/Malaysia.

The educational interventions differed in length depending on the respective study focus (see single publications). For **publication B** and **C** the program was adjusted to a one-day intervention covering the essential study components. One study focus was the intervention of necessary lengths for educational interventions in order to evoke shifts in nature connectedness and environmental knowledge. Therefore, the sample of **publication A** was split and one half participated in a five-day program, which entailed the exact same topics as the one-day program (of the other half), but more extensively. In order to match both programs as much as possible, despite the varying ecosystems, the taught content, the applied methods and tasks as well as the primary goals were kept as similar as possible.

There were several venues with one singular intervention which warrants a proper comparability.

The overall educational program was divided into various modules which differentiated in terms of their cognitive and affective emphases as well as the content-related focus and the applied methods. These differentiations are important with regard to the varying research questions. Field trip tasks were divided into cognitive (e.g. identification of plants or animals) and emotional exercises (e.g. recognizing smells or walking on a barefoot path) that seek to foster positive orientations, conservation awareness and increased environmental knowledge in various dimensions. The severity of the single tasks was adjusted to the skills of different age groups. Ecological interactions, connectivity and ecosystem threats were integral to program ethos. Each intervention model (may it be one day or five days) consisted of the same modules. Most parts were held outdoors. Due to the use of electric devices (e.g. microscopes) at some points it was necessary to work indoors. All participating students worked in groups with varying compositions between the single units. Each group was led by one biologist from either Goethe University or Ecofieldtrips at all times.

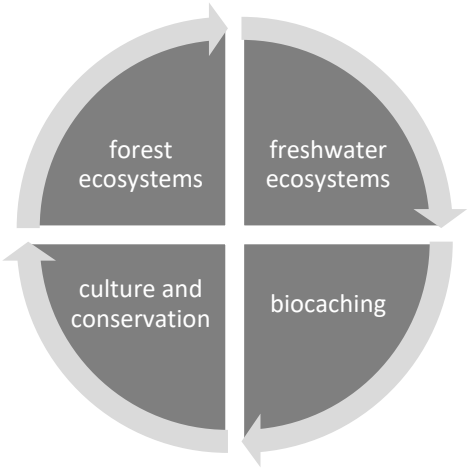

Figure 6: The four modules of the educational program. Own presentation.

The four modules accounting for the educational program were: “freshwater ecosystems”, “forest ecosystems”, “biocaching” as well as “culture and conservation” (see Figure 5). All of these modules were part of a field testing program. Field work requires proper preparation. Therefore, the general structure of the single modules remained the same. At the beginning of each module the students were introduced into the general topic enabling them a glimpse about what was going to happen. A short background section put the module into context. Before the students actually started their work they were acquainted with the testing procedures before they went into the field. Only after being aware of safe practices and potential dangers they could begin to work in their respective groups. The four program modules get described subsequently.

“Freshwater ecosystems” is a very action-oriented module based on scientific methods. It introduces students to the diversity of freshwater habitats such as rivers, streams or wetlands. It is designed to familiarize students with the knowledge and skills required for research into and conservation of freshwater ecosystems, for which there is a particular demand regarding the actual threats on freshwater systems. The module refers to the evolution of these systems, chemical and physical factors and how these affect the biological communities within and beyond. The close relationship between humans and freshwater ecosystems as well as the effects of human activity is another focus of the module. For the field work the students were divided into smaller work groups which allowed different sampling sites along the stream. Upon the arrival at the work site, students had to do a general physical observation including flora and fauna in the water and on land. They were required to assess the human impact estimating the sites of human disturbance and having a look at flow and water color, stream meanders, deposits or bank erosion. Further, the students had to do several measurements. In order to investigate physical and chemical water quality they measured the water temperature, pH, dissolved oxygen, nitrates, salinity, turbidity, velocity and created a stream profile by measuring the stream bank width with a perimeter. For interpreting the habitat biodiversity students had to carry out nets and get a kick sampling. The samples of the stream had to be taken back to the working site where the students used a freshwater invertebrate identification key to classify the organisms they had found. All results found were noted into their script and discussed in terms of an overall ecosystem health evaluation.

“Forest ecosystems” was a module familiarizing students with the globally distributed forest types. They learned about the different forest layers, the nutrient cycle, photosynthesis, food webs and threats to forests. The module focuses on the factual acquisition of knowledge as well as on the discussion of current concepts of interactions between forest and air pollutants and the effects of global climate change. Applying scientific working methods the students practiced several survey techniques such as measuring the height of trees, light intensity and soil quality monitoring. They also had to do a seedling and sampling count followed by the calculation of Simpson’s biodiversity index. Like all modules the forest module (as well) is designed to enable a direct experiencing of the approached ecosystem at first hand. Before starting the hiking tour through the forest the biologists prepared a short introductory presentation giving the students an overview about what they were going to see and do. They received short background information about the ecosystem

and the applied survey techniques before they started their guided tour in the smaller working groups. While hiking the forest the biologists explained several contents such as forest structures or plant adaptations to the students who could grasp these contents through seeing and touching. Arriving at the survey site in the forest the students did their scientific measurements. The biologists assisted the students. Besides the scientific work emotional tasks were another focus of the field trip in order to achieve a reconnection of the students to nature. Hugging trees, walking barefoot or listening to the forest sounds were the rather affective tasks.

"Biocaching" combines the currently popular extracurricular activity geocaching with the acquisition of knowledge about species. Besides the direct encounter of biodiversity in natural surroundings the module promotes the medial competence of students through the usage of GPS-devices. Selected tree species served as waypoints during the explorative hiking tour. The respective coordinates of the different trees, anthills or bird nests were saved in the GPS-device beforehand by the biologists. This way the students got to know plenty of different tree species. Every tree etc. that served as a waypoint was assigned with information sheets about the species. This information on the sheets was needed to complete the script and to get to the following waypoint. The students had to go on a modern treasure hunt, and thereby, got to know and determine new species. Besides the tree species that marked the waypoints the students came across a huge number of different insect species. Each student should carefully pick up an insect and with the help of identification keys attempt to determine the species exactly. The students were equipped with dip nets, magnifying glasses, containers and ID sheets. The wide sample should demonstrate the huge diversity of insects to the students. They learned about insects' basic morphological characteristics and about their roles as pollutants, sources of nutrition and soil conditioners.

The usage of the GPS-devices the students explored the forest playfully, which should foster an emotional bounding with the environment. The exploration hopefully awoke the potentially lost connection between individuals and nature.

The module **"Culture and conservation"** was developed to provide the students with a conservation qualification that encompasses theoretical and practical skills. It looks at processes that shape natural environments and evaluates natural heritage in relationship with individuals. The overall goal was the promotion of active environmental stewardship among the students. The module provides students with basic knowledge about environmental

sciences. In order to make a connection between basic ecological knowledge, human influences on the environment and ways to conserve nature the module “culture and conservation” imparts knowledge about contemporary challenges as global warming, renewable energies, crop plants and reveals individual ways to take environmental stewardship. A food web serves as theoretical example for what happens if one link is missing in a chain. It can lead to a total collapse of the system. Based on this knowledge the students made a human impact assessment and came to the conclusion that humans have huge influence on ecosystems and the living organisms. They also realized that if the current pressure on ecosystems prevails whole ecosystems can breakdown. Given the threats to various ecosystems the crisis potential became more visual. Discussed environmental issues were tropical rainforests (e.g. deforestation, acid rain), seas (e.g. illegal fishing, shark fin finning) or littering (e.g. Great Pacific Garbage Patch). Referring to their individual life styles the students designed a rescue plan for various natural ecosystems by weighting personal effort and conservational benefit and explaining how their actions would contribute to nature conservation. The overall solution for everyone was - according to Gandhi’s words - to be the change one wants to see in the world.

Table 2 depicts an exemplary schedule of a one day intervention. Table 3 shows the weekly schedule for the residential five-day intervention.

Table 2: Exemplary schedule of a one day intervention

time	**module**
08:45 – 09:00	introduction
09:00 – 10:30	forest ecosystems
10:45 – 11:15	freshwater ecosystems
11:15 – 11:45	break
11:45 – 13:15	biocaching
13:30 – 15:00	culture and conservation
15:10 – 15:30	post-test and feedback

As can be seen the modules covering the general topics remained the same. Yet, groups participating the five-day intervention processed these topics much deeper. So, these students had a much more intense nature experience because they could spend more time

outside and take more time to really explore the single ecosystems. The students participating the one day-group implemented the same methods but had less time to explore and analyze.

Table 3: Weekly schedule for the residential five-day intervention

time	Monday	Tuesday	Wednesday	Thursday	Friday
08:00			Breakfast		
09:00 - 12:00	journey and arrival	forest ecosystems	culture and conservation	conservation projects	final feedback & post-test
12:00			Lunchbreak		
13:00 - 17:00	freshwater ecosystems	forest hike	neighborhood walk and meeting with local villagers	biocaching	departure
17:00			Free time		
18:00			Dinner		
19:30 - 20:30	movie night	nature fashion show	night walk	bonfire night	

3 Results and Discussion

The present study examines the effectiveness of a singular outdoor environmental education intervention referring to a multitude of possible influencing factors. Following an introductory portrayal of the results of the three sub studies a closer individual discussion will be given. Then, the results will be elaborated in the overall context and discussed. Thereby, their relevance with regard to the formal and informal education sector as well as the environmental education research will be emphasized. Finally, references for the integration of the results into the daily school practice will be made.

3.1 Results of the Sub Studies

Given that the single sub studies pursued different study questions as well as aims it seems reasonable to present the results in the context of the respective publication.

3.1.1 Sub Study A

Sub study A examined the necessary length of outdoor education programs in order to affect the development of the reported feeling of being connected to nature. Age was taken as a further variable possibly determining the outcome.

The examination of baseline INS values yielded no significant differences between students from the experimental group and those from the control group. The overall level of nature connectedness was moderate. Age-based differences before the conduction of the educational program were apparent. 10 to 12 year old students demonstrated the highest reported feeling of being connected to nature. The investigation identified three determining factors for the development of connectedness to nature. Program duration, students' age as well as the initial INS values influenced the alteration of the reported felling of nature connectedness. Program duration accounted for highly significant immediate increases in nature connectedness within both intervention groups. The effect sizes, though, were relatively small. However, none of the control groups showed any significant changes towards a more intense nature connectedness after the theoretical treatment. Further, in contrast to their respective control groups that joined class lessons both experimental groups showed significant long-term effects in the form of lasting high levels of INS scores. Still, the effect size within the 5-day cohort was considerably stronger. Notably, the 5-day cohort even showed a sustained effect and intensified their feeling of being connected to nature within the time directly after the intervention till the last measuring at T3.

Age accounted as further predicting factor. Again, students from the control group didn't show any substantial changes in their connection with nature. Yet, there were age-based differences that varied depending on the program`s duration. Regarding the 5-day experimental group the most important shifts were detected within the age group from 7 to 9 year old students. Contrarily, in the one-day intervention group the oldest age group from 16 to 18 years of age showed positive shifts that outperformed these of the 7 to 9 year olds significantly. Regarding the long-term effects no significant age-based differences could be detected within the 5-day group. In the 1-day group again, the 16 to 18 year olds showed notably stronger sustained increases in nature connectedness.

The initial INS scores turned out to be a further influential factor determining the progress of nature connectedness. Students from the experimental and control cohorts with low or mediocre initial INS scores immediately increased their feeling of being part of nature after program participation. Students from the pooled control group who showed low INS scores significantly intensified their INS scores. Moderately connected students remained on their level. Notably, highly connected students from the control group even showed reduced INS scores after the theoretical intervention.

Students with low or mediocre INS scores from the five-day experimental group increased their initial values significantly over all measuring times. Students from the one-

day cohort showed the same pattern for the development from T1 to T2 but showed no more positive progression after T2 ending up at the similar values compared to the initial values at T3. Notably, in the pooled control group those students with low or medium initial scores showed no sustained changes but those students that started with a high feeling of connectedness showed a sustained decrease of nature connectedness.

3.1.2 Sub Study B

Sub study B examined possible influencing factors predicting changes in environmental attitudes, knowledge and behavior and found demographic variation in environmental education effects. The results for baseline environmental attitudes confirm gender as an influential factor. In the study, girls showed significantly more positive attitudes compared to boys. Regarding shifts in students' attitudes no differences could be detected between experimental and control cohorts. The probability of long term alterations was best predicted by country of residence given that Malaysian study participants showed the strongest positive shifts whereas Bangladeshi participants demonstrated the lowest shifts.

Baseline knowledge was best explained by a multitude of predicting factors. As the results show, participants' knowledge levels raise with growing age. Furthermore, country of residence influences standards of knowledge. Students from Singapore, for instance, demonstrated the highest knowledge levels. Finally, rural-urban differences account for differences in students' knowledge levels; namely that these students living in urban backgrounds demonstrated lower knowledge levels than those growing up in rural areas.

Efficacy of outdoor experiences was proven by the outperformance of students taking part in the outdoor program with regard to the control cohorts. Besides the influence of the educational program itself, the country of residence turned out to be a significant influencing factor when it comes to the development of knowledge. The probability of knowledge increase was much lower within students residing in Malaysia or Bangladesh compared to those living in Singapore or Germany.

The results concerning environmental behavior reveal that again, country of residence and rural-urban differences account for variances in baseline values. However, significant country-based differences regarding stipulated behavioral actions were only measured between Singaporean und Bangladeshi students. The comparison of the other groups was relatively homogenous. Moreover, those students living in rural surroundings reported significantly more environmental actions than their companions living in urban surroundings.

This pattern remains valid regarding the likelihood of positive long time changes given that Singaporean residents performed more environmental actions at T3 compared to German and Malaysian participants. Students growing up in urban backgrounds showed a greater probability to perform their previously intended actions than students from rural districts. These tendencies might stem from the higher number of resolutions and self-set goals stated by students growing up in urban backgrounds.

3.1.3 Sub Study C

Sub study C investigates baseline differences as well as the influence of a singular one-day outdoor environmental education program on the development of the three knowledge types system, action-related and effectiveness knowledge.

The prevalence of the respective knowledge types was highly various even though the single subsamples from Singapore and Germany showed a homogenous distribution of knowledge types. System knowledge had the highest appearance within the participants. The lowest scores were achieved in effectiveness knowledge. The participation in the one-day outdoor environmental education program led to a significant immediate increase of knowledge in all three dimensions. In contrast, students from the control group did not show meaningful alterations. The greatest shifts were shown in effectiveness knowledge. Regarding the knowledge level increase in system and action-related knowledge the German sample outperformed their Singaporean companions.

The number of reported environmental actions increased immediately in both experimental groups after program participation but only the German sample showed sustained changes across all measuring times. The correlation between the single knowledge types reveals a close dependency of action-related knowledge from system knowledge. Further effectiveness knowledge correlates with action-related knowledge. Yet, there were only weak correlations between the single knowledge dimensions and environmental behavior.

3.2 Discussion

Interactions between humans and the environment are complex. Hence, when trying to inspire people to develop enthusiasm for the protection of the environment and active engagement for a healthier nature it seems both impossible as well as inappropriate to think within a single fixed theoretical framework.

Instead, the efficacy of environmental education programs is highly dependent on the prevalence of manifold influential factors. This multitude of internal and external factors seems to be interwoven in a compound web. Some of these possible influencing factors have been examined in order to try to close the existing scientific gap in literature concerning the environmental education research field. The results of the single sub studies belonging to this scientific research study speak volumes in terms of the efficiency of this singular outdoor environmental education program in its different duration forms as well as environmental educational programs in general. Also, the relevance of the single factors influencing the outcome of educational programs is highlighted. Further, the results of this research can be applied to the daily practice at schools around the globe.

3.2.1 Sub Study A

As the results of **sub study A** show the participation in the presented environmental education intervention leads to a significant increase in the individual feeling of being connected to nature. This proves that outdoor education is efficient when it comes to fostering the personal relationship between humans and nature – one of the most vivid requirements of our time.

Even though both program durations caused an immediate strengthening of the individual feeling of being connected to nature especially those changes within the 5-day group were sustained over a long period of time (see Figure 7). This finding proves previous assumptions from literature (Kaiser, Roczen, & Bogner, 2008; Müller, Kals, & Pansa, 2009; Nisbet, Zelenski, & Murphy, 2009). With regard to the current neuroscientific research (Boyle, et al., 2007; Spitzer, 2007) we suggest that the time spent in nature through the educational program aroused the students' situational interest through positive experiences made there. This way they could improve their affective response in positive ways. And the increased connection to nature was the result.

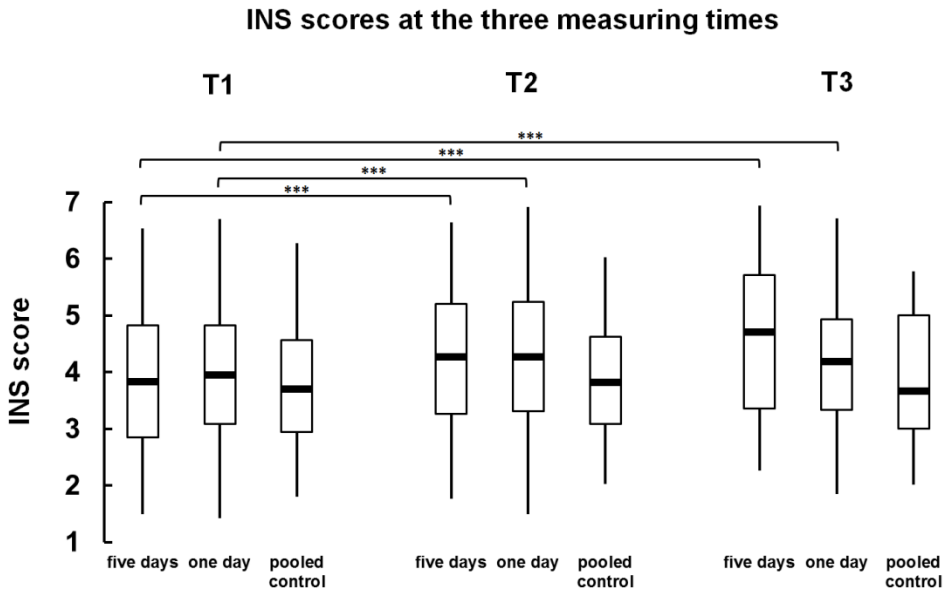

Figure 7: Grouped medians of nature connectedness shown by the subgroups across the three measuring times. The control cohorts were pooled. Significant shifts are marked with ***p < .001, **p < .01, *p < .05. Non-significant shifts of the control groups are not marked. The first quartile represents the bottom and the third quartile is the top of the boxplot. The ends of the whiskers represent all data from five percent as minimum to 95% as maximum. Source: (Braun & Dierkes, 2016)

These findings allow the conclusion that an intense nature experience over five days has a stronger effect on possible positive shifts towards a closer human-nature-relationship compared to a one-day fieldtrip. Still, even one-day educational program impact this relationship positively and are, thus, worth being integrated into school routine.

3.2.2 Sub Study B

Sub study B proved the advantages of outdoor environmental education in terms of its power to positively stimulate the alteration of environmental attitudes, knowledge and behavior. However, the results also prove that this kind of education doesn`t count as a variable on its own. In fact, every sort of education is liable to demographic and geographic variation. Environmental education especially protrudes here.

Just as demonstrated in **sub study A** the experimental groups within this specific research setting also outperformed their control cohorts in terms of a more positive attitude, an increased knowledge and an improved environmental behavior after program participation. The influence of geographic and demographic variables yet is mandatory.

Investigating the most powerful influential factors, country of residence and rural-urban differences turned out to have the highest forecast value when it comes to existing baseline values as well as probable variations of environmental attitudes, knowledge and behavior. Of course, the pure meaning of the different localizations of the specific countries

alone cannot account for the measured conditions. The findings rather approve the suggestion that the complex variety of different influential factors such as a country`s political, educational and societal system accounts for the children's possibilities to a large extent. This assumption got strengthened by the fact that "nationality" as a possible influential factor in isolation did not show any significant effects. Singapore is well known for putting emphasis on a strict and comprehensive education with academic achievements as the ultimate goal (Barr & Skrbiš, 2008; Tan, 2008; Lim, 2013). Figure 8 illustrates the probability of long-term knowledge increase. It becomes clear that country of residence significantly explains the differences in probabilities.

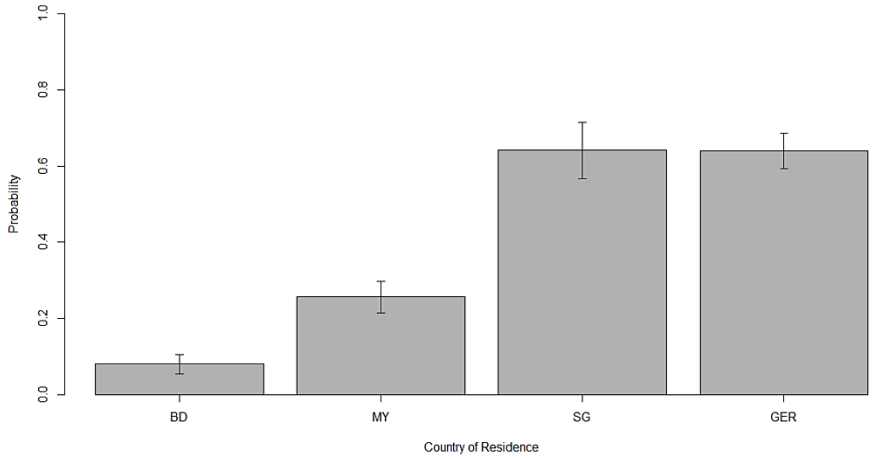

Figure 8: Probability of long-term knowledge increase. Only country of residence significantly explains differences in the probability of student knowledge increase from before the intervention (T1) to six weeks after (T3). Error bars represent 95% confidence intervals. Source: (Braun, Cottrell, & Dierkes, 2017)

As well in Germany and Malaysia every child has access to education (Maaz, et al., 2016; Ministry of Education Malaysia, 2013) but the pressure to perform well is incomparable. Those countries' outperformance of Bangladeshi students seems to be interwoven with the problems regarding the compulsory education Bangladesh is currently facing. Even though Bangladeshi children have compulsory education for five years the country doesn`t have a sufficient educational infrastructure (UNICEF, 2016).

The results of this study support the often claimed gap between knowledge and behavior (Kollmuss & Agyeman, 2002) given that they as well do not yield direct correspondence between an increased knowledge base and environmental friendly behavior. The web of inner and outer factors is too multifarious to let knowledge or attitude alone account for behavioral actions. Instead, the results seem to combine environmental education aspects with the respective countries' governmental pretentions. Again, the active

collaboration of the Singaporean government in environmental politics (Bertelsmann Stiftung, 2015; Yale Center for Environmental Law & Policy (YCELP) & Center for International Earth Science Information, 2015) and the public awareness seem to have resulted in a stronger willingness of Singaporean students to actively take stewardship for the environment compared to the other study participants.

Apart from the rather political-institutional influence the embossment of our immediate living environment influences the human-nature-relationship and explains differences in the examined variables. Growing up in rural surroundings leads to more positive attitudes, higher knowledge and a more environmentally friendly lifestyle. These results go along with the findings of previous studies (Gifford & Sussman, 2012; Hinds & Sparks, 2008; Huddart-Kennedy, Beckley, McFarlane, & Nadeau, 2009). We believe that those people directly experiencing nature (both in a positive and receptive way as well as in a negative, threatening way) develop stronger environmental concern in particular (Rajecki, 1982; Ullah, Hasan, & Uddin, 2013). They are rather willing to learn about ecosystems possibly in order to be competent enough to act in an environmentally friendly manner.

As the results show, gender especially affects environmental attitudes (see Figure 9). We found females to have far more positive attitudes compared to males which could be a result of the maintained role models and todays still rather traditional socialization of girls (Eisenberg, 2002; Gilligan, 1982). However, regarding the effect of the educational program gender did not affect its efficiency. Instead, both sexes showed a similar positive development of their attitudes after program participation.

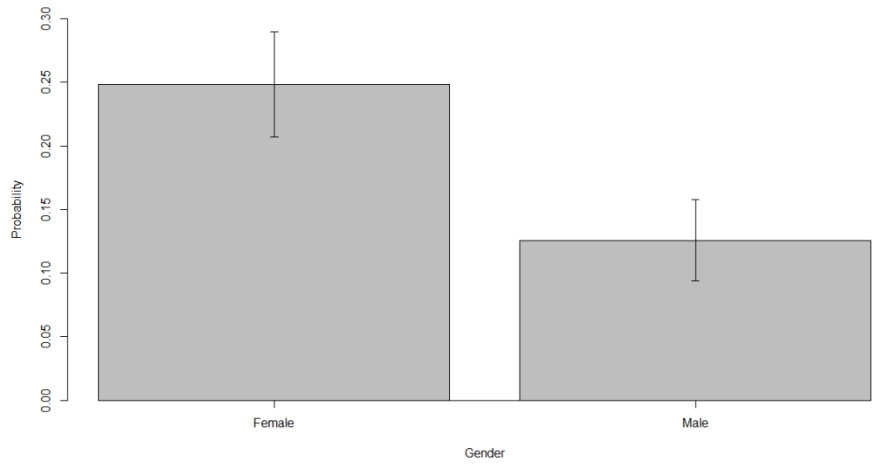

Figure 9: Gender differences in baseline attitudes. Barplots display the probability of positive attitudes (Likert scores of 1 or 2) among male and female students at T1. Error bars represent 95% confidence intervals. Source: (Braun, Cottrell, & Dierkes, 2017)

3.2.3 Sub Study C

Sub study b could already prove that outdoor education is efficient in fostering environmental knowledge. However, knowledge was treated as a one-dimensional, consistent construct primarily focusing on system knowledge. Environmental knowledge, though, consists of three different dimensions that constitute knowledge as a whole. **Sub study C** could prove the correlation between the three single knowledge dimensions system, action-related and effectiveness knowledge. It, further, gives insights into the interdependence of these knowledge types regarding the alteration of environmental behavior.

The results expose system knowledge as the most fundamental type. It operates as a prerequisite for action-related and effectiveness knowledge. Effectiveness knowledge again is heavily based upon action-related knowledge. This outcome is conforming to results concerning baseline data of knowledge type prevalence (Kaiser & Fuhrer, 2003). This gradual structure of environmental knowledge explains the single correlations between environmental behavior and the different knowledge types. Short-term changes correlate with system- and action-related knowledge whereas long-term changes correspond to action-related and effectiveness knowledge.

Program participation lead to positive shifts in all three knowledge types. It also lead to increased numbers of environmentally friendly behaviors (see Figure 10). The implementation of such outdoor interventions into the regular school routine seems obligatory if we want children and young adults to develop an environmentally friendly lifestyle. Nonetheless, all knowledge dimensions must be included in order to create a fertile basis.

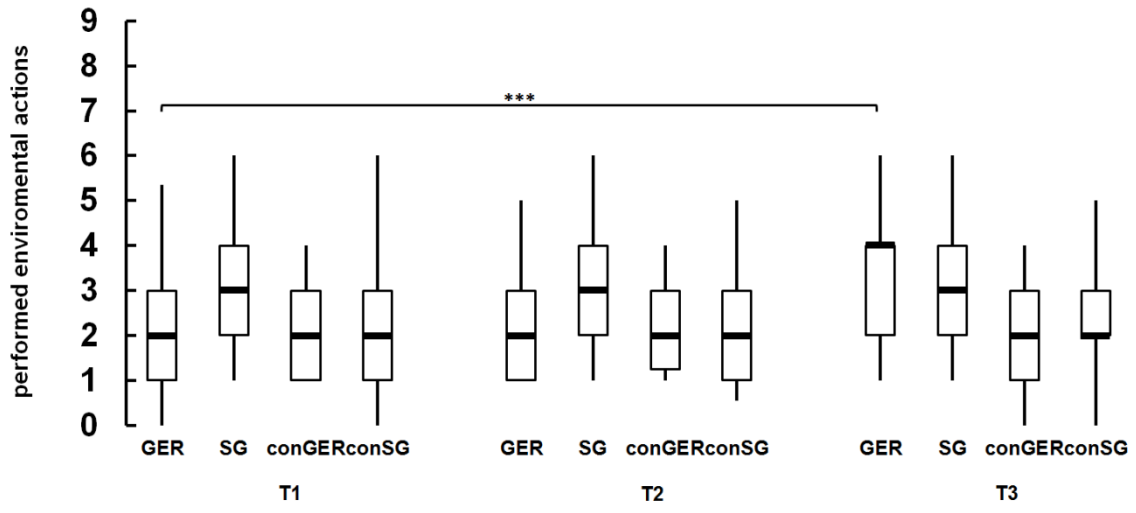

Figure 10: Performed environmental actions at all test times. Significant differences are marked with ***p < .001; **p < .01; *p < .05. Non-significant differences are not marked. The first quartile represents the bottom and the third quartile is the top of the boxplot. The ends of the whiskers represent all data from 5% as minimum to 95% as maximum.

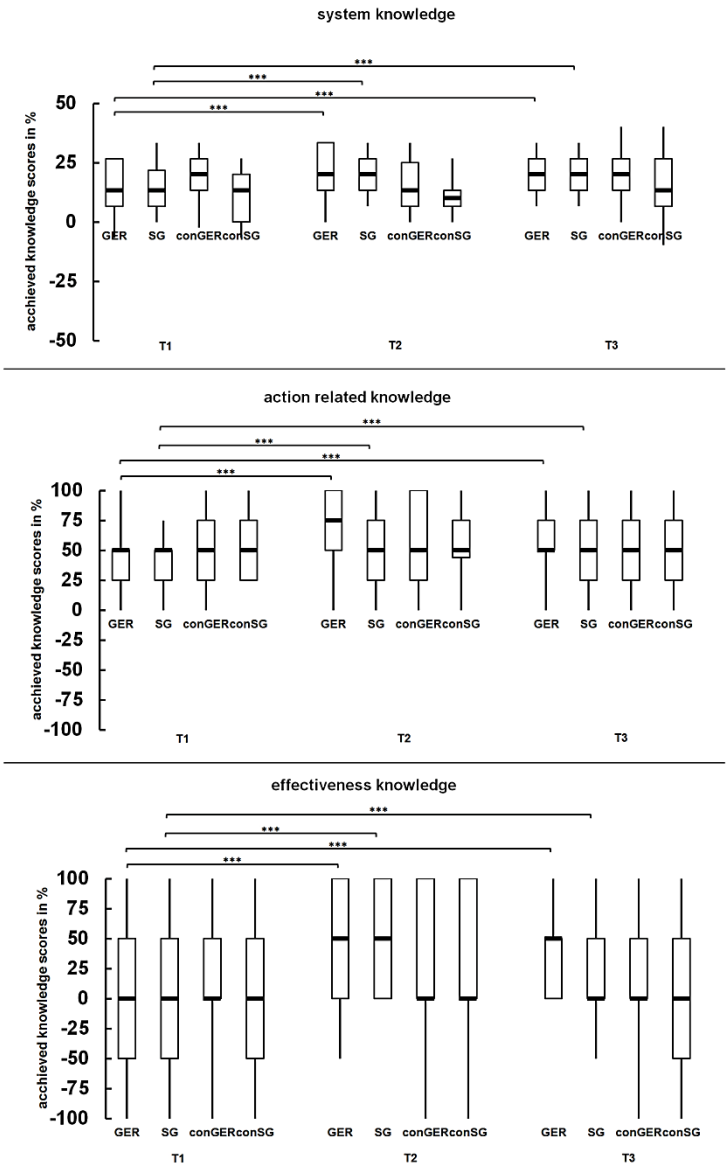

Figure 11: Shifts in the three knowledge dimensions. Significant differences are marked with ***p < .001; **p < .01; *p < .05. Non-significant differences are not marked. The first quartile represents the bottom and the third quartile is the top of the boxplot. The ends of the whiskers represent all data from 5% as minimum to 95% as maximum. Source: (Braun & Dierkes, 2017)

Taking into account the numerous influencing factors discussed in **sub study B** it must be clear that even a successful integration of all knowledge types within a regular study frame alone won`t necessarily cause educational success. Hence, each knowledge type counts as a puzzle piece in this vast net of influencing factors. The results of this study contribute to a more comprehensive understanding of the single correlations between the respective knowledge types that possibly lead to an increased base of environmentally responsible manners in people's daily routines.

Additionally to the sequential construction of knowledge itself, various researchers (Hofstede, 2001; Nankervis, Compton, & Baird, 2002; Patrickson & O`Brien, 2001) as well as the results of the sub studies previously mentioned within this research frame postulate that the immediate living environment people grow up and live in is predominantly shaping their understanding and their appreciation of nature. Also, the results of this sub study confirm that country of socialization is major in predicting existing knowledge levels among children and young adults. However, the country we grow up in does not necessarily and inevitably predict and limit shifts in knowledge due to program participation. A vivid example is the high prevalence of baseline system knowledge among the Singaporean sample (also found in **sub study B**) in contrast to the high level of action-related knowledge found among the German control cohort. These values could represent the Singaporean emphasis on meritocratic

principles (Barr & Skrbiš, 2008; Tan, 2008) and academic achievement contrarily to the German focus on individual self-sufficiency and practicability. Thus, it seems that differences concerning the different knowledge dimensions can be at least partly explained by different culture-based emphases in the respective educational policy.

3.3 Conclusions for Teaching and Research

The present research is a new contribution to the environmental education research. It presents findings concerning the connection between children and adolescents and nature and how this connection can possibly be influenced through outdoor environmental education in a cross-national research setting. It further offers new and valuable insights into a multitude of influencing factors affecting students' environmental attitudes, knowledge and behavior. Besides the geographic variation enabled through the multinational evaluation design, this research could prove the general efficacy of outdoor environmental education interventions in terms of a positive alteration of the above mentioned variables and, thereby, contributes to the lacking literature base in environmental education research. A particular focus was set upon the structure of environmental knowledge and how it correlated with environmental behavior.

These results in the overall context are interesting for both the educational as well as the research field. The results point out the necessity of outdoor environmental education interventions for children and adolescents and highlights the most effectual age, intervention duration as well as a multitude of so far unexamined influencing factors shaping children's attitudes, knowledge and behavioral manners. The overarching goal is the promotion of students' environmental attitude, knowledge and behavior as well as their feeling of being connected to nature.

Duration and intensity of direct nature experience have strong effects on peoples' feeling of being connected to nature. The results of this research confirm that even one day spent in nature has the capacity to positively impact the relationship between humans and nature. Time spent in nature can even operate as a predictor of the later nature connectedness (Kals, Schumacher, & Montada, 1999). Indeed, both program durations, one day and five days, had a positive influence on the reported feeling of being connected to nature. But the effect within the five-day intervention group was much stronger. Being aware of these facts is especially relevant with regard to the scholastic educational sector where timetables do not always (and especially not regularly) allow longer or even residential educational programs. It yields hope for all teachers and educators who wish to inspire children to develop a

connection with nature since it evinces that even though one fieldtrip can make a difference it seems that the more time and the more positive experiences children have in nature the more likely they will develop a positive connection to nature.

The research concerning internal and external factors affecting the human attitude towards the environment as well as the knowledge thereof is an ongoing one. It constantly needs to affirm an enormous net of potential influencing aspects which might foster environmentally friendly behavior (Bamberg & Moser, 2007; Clayton, 2003; Eagles & Demare, 1999; Ernst & Theimer, 2011; Kollmuss & Agyeman, 2002). Many of these aspects have been examined repeatedly. This research also focused on so far underexplored possible influencing factors and now offers interesting insights especially addressing educational policy.

Facing the fact that country of residence was the strongest influencing factor we suggest that educational success in general is highly dependent on the overall political conditions a country keeps. Of course, all teaching staff can only act within a set frame that allows certain expenses, curricular, lesson times etc. Still, even within this frame educators should attempt to make the best of it. We, therefore, suggest that any educational treatment should contextualize their objectives according to the respective landscapes and environmental occurrences this particular immediate surrounding reveals. This way the bond between humans and the environment becomes strengthened in a way more individual and personal way. The condition of our immediate living environment seems to shape the human-nature relationship and functions as the most efficient way to create a bond with nature. The most promising tool of nature connection, though, is direct nature experience.

On top of nature immersion as a factor various researchers have found that gender is predetermining environmental attitudes (Chan, 1996; Lee, 2009; Tikka, Kuitunen, & Tynyns, 2000; Torgler, García - Valiñas, & Macintyre, 2008). Interestingly, baseline values may be reliable to gender but positive alterations after environmental lessons were homogenous for both sexes. Hence, environmental education can reach females and males similarly. However, teachers should try to include topics into their teaching units that could particularly interest male students.

After all the positive influence of such environmental education interventions there still remains a gap between knowing and acting that has been diagnosed through this research as well as through several other researchers (Kollmuss & Agyeman, 2002). In order to minimize or even close this gap it seems more important than ever to promote all dimensions

of knowledge because only the entirety of the so far known knowledge dimensions can possibly lead to an awareness which fosters taking actions for a healthier environment.

The identified knowledge types among students showed an uneven distribution of the single types. The highest knowledge level was measured in system, the smallest in effectiveness knowledge. Starting with the weakest baseline values effectiveness knowledge increased the strongest. This result represents that current environmental education interventions do not focus on that specific kind of knowledge enough. Yet, effectiveness knowledge is a highly important part of any environmental education given that it provides people with the knowledge of how to act environmentally friendly in a sufficient way. Therefore, teachers, outdoor educators and other pedagogical staff in the environmental education sector should particularly try to integrate this knowledge type into their interventions in order to equip their students with the necessary tools to act adequately.

Being aware of the relations between the single knowledge types and between knowledge and behavior is of enormous importance for any teaching staff. Educational programs need to build knowledge gradually taking into account the respective dependencies of the single knowledge types. It may seem logical that students need to have an understanding of factual information concerning ecosystems and environmental issues first before they can start developing a knowledge base encompassing ways how to protect the environment and which of those, moreover, are effective and personally realizable. However, this claim is challenging for any teaching personnel, themselves. They need to reflect upon every knowledge type itself and embed it into a framework that is didactically and methodically profitable.

Regardless of the many influencing factors, this research detected a lack of knowledge about environmental issues among the participating student body which strengthens results of previous research (Diekmann & Franzen, 1996; Frick, Kaiser, & Wilson, 2004). When trying to inspire students to act in an environmentally friendly way it seems necessary to promote an adequate environmental education on a global level – may it be through the integration of lessons covering environmental issues into the scholastic curricular or through the promotion of extracurricular environmental education programs. The efficacy of such interventions has been proven through all sub studies within this research frame once more.

All these results indicate the urgency to integrate the three knowledge dimensions into educational programs logically and successively in order to equip students with the necessary knowledge about the environment and how it can be saved effectively. Future research should

focus on further studies covering the same age range as in this research to compare and where appropriate confirm the results in order to create a meaningful literature base.

Long-term studies would be reasonable in order to understand the development of nature connectedness as well as environmental attitudes, knowledge and behavior from childhood to adolescence and even further. It would make sense to accompany specific groups of participants over years to examine alterations and possible influencing factors.

The disparity of the applied scales is an ongoing problem in terms of a difficult comparability of the single studies. Of course, scales must be adjusted to the respective teaching content. Yet, researchers should try to develop more scales that could be appropriate for different research settings. Concerning environmental attitudes and nature connectedness this goal seems to be nearly accomplished. For knowledge and behavior though such approaches are further needed.

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III. Publications

1 Publication A: Connecting students to nature – how intensity of nature experience and student age influence the success of outdoor education programs

Author`s contributions

Authors:

Tina Braun (TB, PhD candidate),

Paul Dierkes (PD)

(1) Development and planning

PhD candidate (TB): 90%
PD: 10%

(2) Execution of surveys and experiments

PhD candidate (TB): made contact with the officials at Ecofieldtrips Pte in Singapore, obtained the permission to work as a field biologist and conduct the research, developed the educational program, recruited school classes, organized the fieldtrips, familiarized the staff with the program, implemented the educational program, collected data (INS) (100%)

(3) Compilation of datasets and preparation of figures

PhD candidate (TB): organized and prepared all data collected before, during and after the fieldtrips for the analyses. Apart from one, TB prepared all figures and tables presented in the manuscript and supplementary info (90%)
PD: made one figure and gave advise on the display of the results (10%)

(4) Data analyses and interpretation of results

PhD candidate (TB): conducted all statistical analyses and interpreted results (90%)
PD: supervised analyses and contributed to the interpretation of results (10%)

(5) Preparation of manuscript

PhD candidate (TB): 90%
PD: 10%

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Connecting students to nature – how intensity of nature experience and student age influence the success of outdoor education programs

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ABSTRACT
Nature connectedness counts as a crucial predictor of pro-environmental behavior. For counteracting today's environmental issues a successful re-connection of individuals to nature is necessary. Besides the promotion of knowledge transfer the aim of the educational program presented in this study is to connect students to their environment. This research explores the impact of an outdoor environmental education program on primary and secondary school students' nature connectedness with regard to the extent of their nature experience and participant age. The intervention was implemented in two durations: one-day and five-days. Participants were divided into four subsamples from seven up to 18 years of age. Findings suggest that both intervention types evoke immediate shifts towards a stronger nature connectedness among students ($p < .001$). Notably, the five-day outdoor education interventions were significantly more effective in sustainably promoting nature connectedness compared to one-day field trips ($p < .001$). Seven to nine year old students performed the strongest shifts towards nature. The value of short-term and residential outdoor environmental education interventions is discussed.

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Environmental education; inclusion of nature in self; nature connectedness; outdoor education; evaluation

Introduction

In the past few years, eco-psychological research yielded a number of concepts explaining the relationship between humans and nature. According to the biophilia hypothesis (Kellert and Wilson 1993) humans have an innate affinity for every living thing resulting from evolutionary heritage of the human species. Wilson (1984) calls nature connectedness a universal concept. Despite some conceptual differences, various authors agree upon nature connectedness as a relatively stable characteristic trait of humans which varies in its intensity of manifestation among individuals. However, currently the world is experiencing environmental issues (e.g. loss of biodiversity, deforestation, climate change) potentially caused by anthropologic actions (Global Footprint Network 2016; McNeill 2000; WWF 2014). These problems might have arisen from a disconnection between humans and their natural environment (Jordan 2009; Tacey 2000). Individuals who feel connected with nature and appreciate its values are the ones which are most likely to behave in an environmentally responsible manner (Clayton 2003; Dunlap et al. 2000; Nisbet, Zelenski, and Murphy 2009). Hence, in order to counteract environmental problems the bonding between humans and the natural world needs to be re-established.

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This study evaluates the impact of two different outdoor educational intervention modes in order to supplement the current knowledge regarding the influence of duration of intervention on nature connectedness. Further, age and socialization background are evaluated as influencing factors. Additionally, this research examines whether students with a low baseline inclusion of nature in self (INS) display greater shifts after program participation compared to students with high baseline INS values.

The notion of nature connectedness

Given that the concepts for nature and connectedness on their own are controversial there is no clear, universally accepted definition for the notion of nature connectedness. According to the various interpretations, nature connectedness as a scientific construct is likewise applied as inclusion of nature in self, emotional affinity towards nature, nature relatedness or connectivity with nature. While many authors underline the emotional base when defining the concept of nature connectedness (Mayer and Frantz 2004; Müller, Kals, and Pansa 2009; Nisbet, Zelenski, and Murphy 2009; Raudsepp 2005) another approach focuses on the role of the natural environment in a person`s identity (Clayton 2003). This study relies on the definition of nature connectedness as the degree to which individuals rationally perceive nature as part of their own identity (Nisbet, Zelenski, and Murphy 2011; Schultz 2002). Schultz (2002) determines three components which constitute the construct of nature connectedness. The cognitive component manifests itself as the individual feeling of being integrated with nature. The affective component is expressed through the sensitivity for nature protection. The behavioral component describes the personal engagement in nature conservation. The focus of this study lies on the cognitive component. Despite the varying emphases for different contents of nature connectedness numerous authors agree upon experiences as the basis of this concept (Kals, Schumacher, and Montada 1999; Mayer and Frantz 2004; Nisbet, Zelenski, and Murphy 2009; Raudsepp 2005; Schultz 2002).

Analogously to interpersonal relationships which grow stronger through time spent with the according person, the relationship with nature is intensified through time spent in natural surroundings (Kaiser, Roczen, and Bogner 2008; Schultz 2002). Various studies show a correlation between time spent in natural surroundings and positive experiences made there with nature connectedness (Cervinka et al. 2009; Hinds and Sparks 2008; Mayer and Frantz 2004; Nisbet, Zelenski, and Murphy 2009; Raudsepp 2005; Schultz and Tabanico 2007). In contrast to the universal view of nature connectedness, various researchers follow a place-based approach suggesting that nature connectedness has no benefit when using it imprecisely (Beery and Wolf-Watz 2014; Brown and Raymond 2007; Ewert, Place, and Sibthorp 2005; Stedman 2002). Instead, they emphasize a rethinking in favor of context-specific experiences at particular places that possibly evoke changes in the feeling of being connected to nature. Given the current alienation of children from nature (Jordan 2009; Tacey 2000) environmental education at particular sites outdoor seems to be a very promising tool to re-connect individuals to their natural surroundings (Potter 2010). Since enjoyable and attaching experiences in nature can foster nature connectedness they offer an educational opportunity of stimulating motivation for nature conservation (Ernst and Theimer 2011; Kaiser, Roczen, and Bogner 2008; Liefländer et al. 2013).

Literature proposes that childhood is the crucial life period regarding the development of a bonding with nature (Berk 2006; Kals, Schumacher, and Montada 1999; Kellert 2002). This highlights a need for (early) nature experiences of which outdoor education may be a profitable source to foster the connection with the natural environment. However, there are only few extensive studies investigating the crucial developmental stages in individuals' lives during which nature connectedness can be promoted most efficiently. Some authors (Ernst and Theimer 2011; Kellert and Westervelt 1983; Wells and Lekies 2006) suggest focusing on younger children for the reason of the affective dimension of nature connectedness. Further, literature suggests that environmental attitudes develop early and are harder to modify as children grow older (Clayton 2003; Gifford and Sussman 2012). Still, literature is lacking sufficient research examining possible changes in feeling connected to nature over time.

If childhood is an important phase for the development of the connection to nature then rural/urban differences in the place of residence could further play a vital role. Natural landscapes are more accessible

in rural areas than in heavily urbanized residences. Research brought up contradicting findings concerning the influence of childhood socialization so far. Proving that people who grew up in rural areas show a higher nature connectedness, Hinds and Sparks (2008) suppose the missing access to natural surroundings in urbanized cities as a possible reason for a lower degree of connectedness to nature. Moreover, Raudsepp (2005) confirms the effect of childhood socialization on the emotional bonding to nature. Denying these effects, Müller, Kals, and Pansa (2009) could not detect differences comparing the degree of connectedness to nature of people who were brought up in the country and those who grew up in the city. The only differences that could be found were those in nature contact. Yet the degree of nature connectedness remained unaffected. The extent to which the amount of time spent in nature contributes to a positive nature connectedness and how nature is defined needs to be further examined empirically.

A further important characteristic of nature connectedness is its correlation with the individual life style (Mayer and Frantz 2004). This significance becomes even clearer regarding the deep interweaving between nature connectedness and environmentally responsible behavior making nature connectedness a fundamental motivation for the conservation of nature (Frantz et al. 2005; Kaiser, Roczen, and Bogner 2008). Various studies confirm the positive influence of outdoor environmental education on environmental knowledge, attitudes and behavior (Bogner 1998; Dettmann-Easler and Pease 1999; Ernst and Theimer 2011; Leeming, Dwyer, and Porter 1993). Some studies examined the effect of out-of-school learning experiences on individuals' connectedness with nature (Ernst and Theimer 2011; Kossack and Bogner 2012; Liefländer et al. 2013). The necessary length of these nature experiences, however, has not yet been adequately determined through empirical studies that directly compare educational programs differing in length. Also, it remains unclear within which time frame program durations can be sufficient. So far, literature yields mixed results. No positive effects on sixth graders' connectedness to nature could be evoked through a one-day intervention (Kossack and Bogner 2012) whereas longer interventions up to four days within a month achieved positive effects (Ernst and Theimer 2011). Yet Kossack and Bogner's (2012) study sample lacks representation and Ernst and Theimer (2011) applied another measuring scale as the one used in this study.

Subsequently, this study contributes to the partly incomplete data base in nature connectedness research. Widening the previously surveyed age range towards adulthood, this study extends the current literature base concerning individuals' self-reported connectedness with nature.

Methods

This research employs a quasi-experimental design and examines the effects of two outdoor environmental education interventions differing in their duration on the degree of students' self-evaluated connection to nature. There were two different samples participating either in the one-day or the five-day education program. For both program durations the authors had the ambition to make the program as productive as possible in the time available. In order to eliminate learning effects two additional control groups only attended scheduled school lessons detailing conservation ecology for either one day or five days.

Recruitment of participants happened via mail advertisement. Ten primary and 15 secondary schools in Singapore were invited to participate in the educational research study. The sampling classes were collected from local and international schools following the Singaporean, British or American educational system. There are differences in sampling sizes due to the different numbers of registration for the touted environmental study and the willingness of the individual students to participate in the study. The number of participants was constrained by available appointments, staff and resources. Allocation of places occurred in the order of registrations considering all inclusion and exclusion criteria (age, school type, place of residence). Thus, 25 additional requests for program participation from 14 primary and 11 secondary school classes could not be fulfilled. All program participants were told that their evaluation was purely voluntary. As most of the participants were children, informed participant and parental consent was gained prior to the intervention. All students and parents were informed about the details of the study contents, the research process and data storage.

Table 1. Age distribution within study subsamples.

	Five-day sampling	One-day sampling	Five-day control	One-day control
7–9 yrs	*N* = 41	*N* = 51	*N* = 32	*N* = 25
10–12 yrs	*N* = 61	*N* = 41	*N* = 33	*N* = 23
13–15 yrs	*N* = 48	*N* = 46	*N* = 40	*N* = 30
16–18 yrs	*N* = 44	*N* = 44	*N* = 19	*N* = 23
Complete	*N* = 194	*N* = 182	*N* = 124	*N* = 101

Sampling

The comparative study exploring individuals relation to nature is based on a survey which included *N* = 601 students from seven primary and 15 secondary school classes in Singapore. Through the feedback of the schools the authors got a stratified random sampling consisting of a population that was sorted into different grades. To guarantee equal treatment groups the authors randomly selected classes to participate in the study prior to the intervention. Afterwards these classes were randomly assigned to serve as experimental or as control groups. Study participants were divided in age specific subgroups ranging from 7 to 9 year olds up to 16 to 18 year olds (see Table 1).

One hundred and ninety-four students participated in a five-day residential environmental program. One hundred and eighty-two students joined a one-day outdoor educational program. Two hundred and twenty-five students did not take part in any outdoor educational intervention but took lessons at school covering the same content out of which 124 students had a five-day teaching unit and 101 students were taught in ecology for one day.

Measurement

Given that the authors rely on Schulz's cognition-based concept of nature connectedness his Inclusion of Nature in Self (INS) scale (2001) was used. This scale measures the individuals' grade of connectedness with nature as a cognitive imagination of one self being part of nature to a certain degree. The INS is a single-item scale containing seven different circle-pairs labeled 'nature' and 'me' which differ in their degree of overlapping (see Appendix 1). Participants were asked to choose one of the seven graphics determining their individual feeling of interconnection with nature. The scale ranged from 1 (completely separated from nature) to 7 (completely connected with nature; more details can be found in Schultz 2002).

The INS scale was applied two weeks prior to the intervention (T1- pre-test). Immediate changes were measured through a second questionnaire (T2 – post-test) completed subsequently after the field trip. Long-term shifts were monitored through a third survey (T3 – retention test) six weeks after the trip. Participants from the control group completed the same questionnaire within the same time frame.

Scale validity has been tested and the scale has been shown to be a valid measurement (Schultz 2001). Results for retest reliability after 1 week ($r = .84$) yielded good results (Schultz 2002).

The conditions of normal distribution could not be confirmed within data. So, non-parametric Kruskal–Wallis one-way analysis of variance and Mann Whitney U test was applied (IBM SPSS, Inc., 2013) to examine baseline differences. Effect sizes were calculated according to Cohen (1988) with $d = .2$ as a small, $d = .5$ as medium and $d = .8$ as large effect.

For detecting temporal shifts between subgroups across the different measurements Friedman test was applied. Differences between control and experimental group were assessed using Kruskal–Wallis rank-sum test to allow non-normality in scored data.

Procedure

Both one-day and five-day environmental program were conducted by environmental teachers from Ecofieldtrips Environmental Education in Singapore. This established fieldtrip provider organizes school

fieldtrips that focus on the exploration of the natural environment at the students' doorstep. While trekking the rainforest with the field biologists, searching, collecting, examining and determining plant and animal species students learned about ecosystem ecology and natural heritages. Students participating in the residential program stayed with the staff at a resort for five days undertaking various trips into the rainforest whereas students of the one-day sample made a singular full-day field trip to the rainforest. The author of this paper was instructing both outdoor intervention types as a field biologist as well as all teaching units for the control groups at school to guarantee the comparability of contents, methods and teaching goals.

The maxim of all educational programs – indoors and outdoors – was 'nature and species conservation in your environment – think global, act local'. Participants elaborated global and local environmental phenomena which were visible at the learning site outdoors. The overall goal was the reconnection of students with nature through the interactive encounter with the biodiversity of immediate ecosystems and memorable hands-on experiences in that environment. In order to foster shifts in nature connectedness among study participants that would yield effects after the end of the program different components of nature connectedness were addressed. Additional to the study's aim to promote the participants' cognitive knowledge, the activities were designed to appeal to the affective domain as well. All participating students worked in groups with varying compositions between the single units. Both intervention types involved teaching units concerning the nutrient cycle in temporal forests and rainforests, adaptations of plants and animals to the life in the forest and harmful pollution. All participants worked on the different forest layers, food webs in the forest and ways of sustainable use of ecosystem services. All students used the same scientific devices. After participating in either of the two interventions students should have a more profound understanding of environmental ecology and species knowledge as well as global conservation processes. They further learned about societal impact on the environment and how they themselves influence nature.

The teaching units at school were implemented indoors exclusively to guarantee the contrast to the outdoor intervention. There were different working stations covering the same topics as elaborated in the outdoor interventions which the students could work through in groups. Each student had a script containing similar exercises and working material. Instead of originals students from the control group worked with pictures, short films and texts. The amount of hands-on material and experiential learning was comparable to the outdoor sample. The one-day control group had less working stations to elaborate than the five-day group. Also the five-day group could work more in-depth.

Results

The comparison of baseline INS scores through Kruskal–Wallis one-way analysis of variance yielded no significant differences between the five-day and the one-day sample. The range of grouped medians of the single subgroups indicates a rather moderate level of nature connectedness. Within the samplings however, there were significant age based differences. Mann–Whitney test showed that 10–12 year old students demonstrated a higher nature connectedness compared to 13–15 year olds ($p < .05$). Table 2 shows the grouped medians of all subgroups across all test times.

Cronbach's α for the test-retest reliability of the INS scale within this study did not yield values as satisfying as in earlier studies (Liefländer et al. 2013; Schultz 2002; Schultz et al. 2004) but still indicated a strong correlation (α 1-week retest = .602; α 6-week retest = .570).

Experimental groups vs. control groups

Figure 1 shows the subgroups' grouped medians of reported nature connectedness across the three measuring times. The comparison of INS scores between pre- (T1) and post-test (T2) through Friedman test revealed highly significant increases in connectedness to nature within both experimental subgroups ($p < .001$). The effect sizes though were relatively small (d Cohen 5-days = .261; d Cohen 1-day = .212).

Table 2. Grouped medians of the subsamples across three measuring times.

	*T*1	*T*2	*T*3
1 day experimental			
7–9 yrs	3.97	4.17	4.08
10–12 yrs	4.37	4.43	4.38
13–15 yrs	3.59	4.22	4.0
16–18 yrs	3.78	4.27	4.24
Complete	3.94	4.26	4.80
1 day control			
7–9 yrs	4.0	4.13	4.0
10–12 yrs	4.29	3.89	4.0
13–15 yrs	3.50	3.64	3.70
16–18 yrs	3.71	3.71	3.67
Complete	3.85	3.82	3.82
5 days experimental			
7–9 yrs	3.43	4.25	4.43
10–12 yrs	3.86	4.24	4.72
13–15 yrs	3.75	3.96	4.77
16–18 yrs	4.21	4.64	4.81
Complete	3.82	4.26	4.69
5 days control			
7–9 yrs	3.59	3.78	3.62
10–12 yrs	3.50	4.0	3.59
13–15 yrs	3.67	3.80	3.50
16–18 yrs	3.57	3.54	3.64
Complete	3.59	3.80	3.58

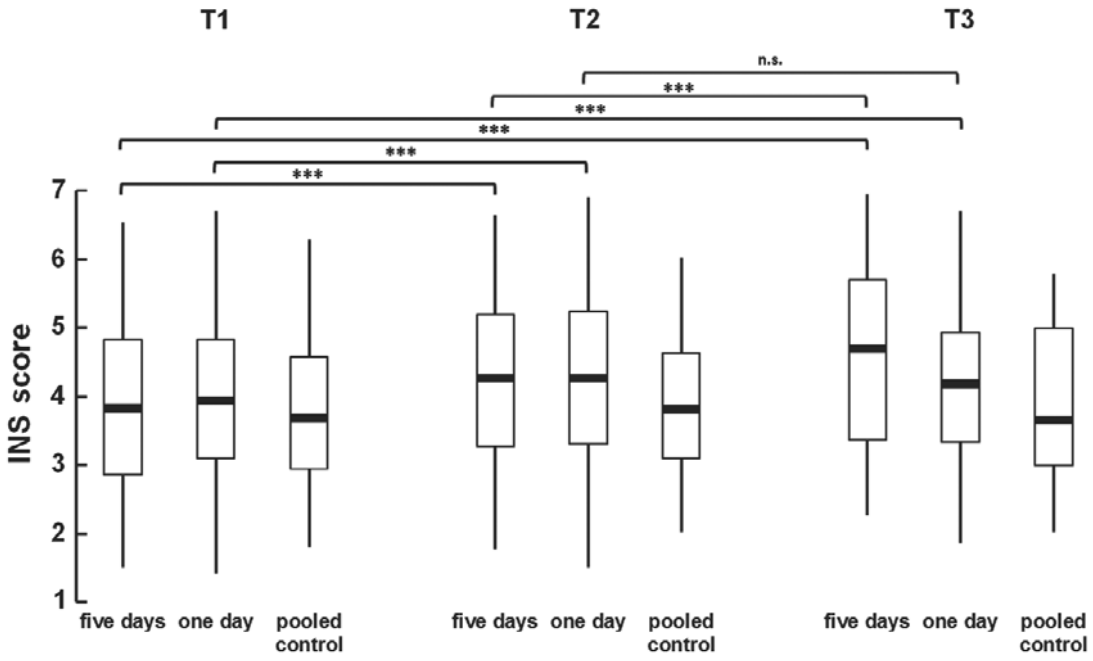

Figure 1. Grouped medians of nature connectedness shown by the subgroups across the three measuring times.

Notes: The control cohorts were pooled. Significant shifts are marked with ***$p < .001$, **$p < .01$, *$p < .05$. Non-significant shifts of the control groups are not marked. The first quartile represents the bottom and the third quartile is the top of the boxplot. The ends of the whiskers represent all data from five percent as minimum to 95% as maximum.

Contrarily, none of the control cohorts did show significant changes in their degree of nature connectedness pre and post intervention. Notably, participants of the five-day intervention significantly increased their INS scores between T2 and T3 ($p < .001$) where one-day intervention participants remained on their immediately achieved level without significant changes. Both experimental groups yielded highly significant long-term increases in connectedness to nature ($p < .001$). The long-term increase in nature connectedness of the five-day intervention subsample was significantly stronger

compared to the one-day subsample ($p < .001$; d Cohen 5-days = .59; d Cohen 1-day = .166). Both control groups did not demonstrate significant changes.

Participant age as influencing factor

Where both experimental samplings revealed significant immediate age-dependent differences in educational achievement ($p < .05$) from T1 to T2 no significant differences could be detected between single age groups within the two control cohorts. In the five-day sample seven to nine year old participants performed the most positive shift in nature connectedness which was significantly larger than that of 10–12 and 13–15 year olds ($p < .05$). Regarding the one-day subsample the 16–18 year old students showed a significantly larger increase of INS scores than seven to nine year olds ($p < .05$). Regarding shifts from T1 to T3 single age groups within the five-day cohort did not differentiate significantly. Sixteen to eighteen year old participants of the one-day intervention increased their inclusion of nature in self more than the 7–9 year olds ($p < .05$). There are no significant alterations between age groups in the one-day control group. Within the five-day control cohort 13–15 year olds showed a distinctly weakened connection to nature after 6 weeks and thereby differentiate from the age group of 10–12 years olds significantly ($p < .05$).

Baseline INS values as determining factor

For examining intensification, stability or reduction in students' reported nature connectedness immediately and sustainably after program participation each subsample was split into seven groups representing participants' initial INS scores. Based on these baseline scores, Figure 2 illustrates short- and long-term effects within both experimental and the pooled control group.

Concerning immediate shifts from T1 to T2 five-day and one-day intervention groups show similar patterns. Participants with low baseline INS scores (2–3) as well as students reporting a medium (4) INS score significantly increased their scores after the intervention ($p < .05$). Weakly connected students even scaled up their median. Students reporting high initial INS scores (5–7) remained on this high level. Within the control group rather disconnected students with low baseline scores immediately increased their INS values after the teaching unit ($p < .001$). Medium connected students with moderate INS scores did not show significant shifts. Highly connected control students significantly reduced their INS scores ($p < .01$) after the theoretical school lessons. Table 3 illustrates the significance levels of the shifts across the measuring times.

Regarding sustained changes from T1 to T3 in reported INS five-day and one-day experimental groups differ crucially. Except for those individuals showing very high initial INS values (6 and 7) all other students within the five-day intervention group increase their INS values significantly ($p < .001$) so that the median sustainably increases one level. Students from this subgroup notably were the only ones increasing their INS scores not only from T1 to T2 but also from T2 to T3 significantly ($p < .05$) whereas students from the one-day intervention group do not show significant shifts after T2. Besides the overall significant sustained increase ($p < .05$) the majority of students within the one-day group showed the same mediocre scores (4) at T1 as at T3. Students of the control cohort with high initial INS scores decrease from T1 to T2 and from T2 to T3 ($p < .05$). Control studentswithmedium INS values showed no sustained changes. Students with low initial INS scores remained on their level (3) or increased (2). The average five-day intervention cohort displayed the highest sustained median. The control cohorts showed the lowest median. The significances of the single developments are shown in Table 3.

Discussion

After participating in the outdoor environmental intervention both experimental groups revealed a significantly stronger connection to nature than prior to the intervention. Both respective control cohorts did not show any significant change concerning their individual nature connectedness. This finding

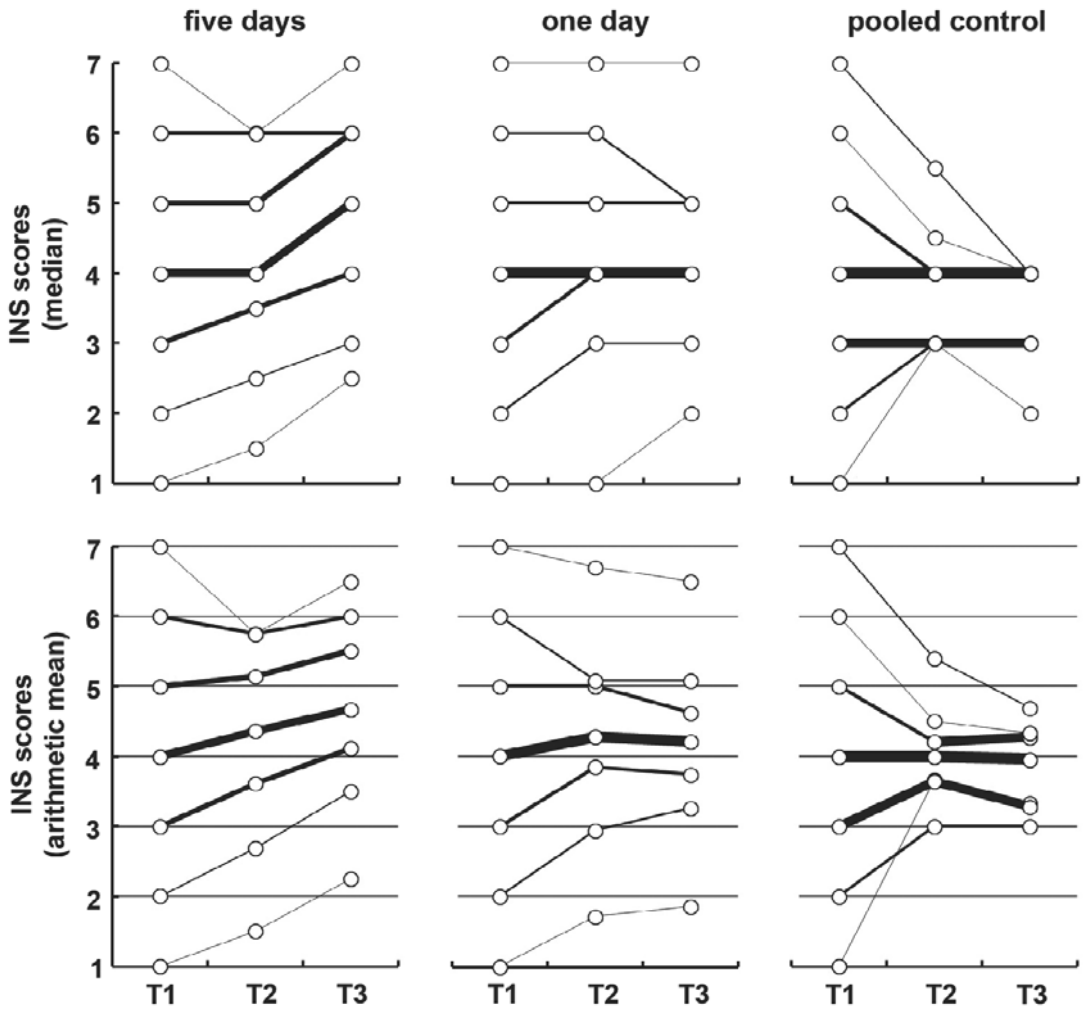

Figure 2. Immediate and long-term shifts in reported inclusion of nature in self within experimental and control groups. The stroke width of the graphs is proportional to the number of students being represented. Thick graphs reveal the majority of the sampling whereas thin graphs denote statistical outliers. For a more definite visualization of the developments between the three measuring times both, medians and the mean values are illustrated.

Table 3. Significance levels of shifts in nature connectedness within subsamples.

	*T*1 → *T*2			*T*2 → *T*3			*T*1 → *T*3		
Initial INS score	Five days	One day	Pooled control	Five days	One day	Pooled control	Five day	One day	Pooled control
7	*	n.s.	**	n.s.	n.s.	n.s.	n.s.	n.s.	**
6	n.s.	*	**	n.s.	n.s.	n.s.	n.s.	**	*
5	n.s.	n.s.	***	**	n.s.	n.s.	***	*	**
4	***	**	n.s.	*	n.s.	n.s.	***	*	n.s.
3	***	***	***	***	n.s.	*	***	***	**
2	***	*	***	***	n.s.	n.s.	***	**	***
1	n.s.	n.s.	n.s.	***	n.s.	n.s.	***	*	n.s.

Significance levels are labelled with ***$p < .001$; **$p < .01$; *$p < .05$. Non-significant results are marked with n.s.

proves the efficacy of outdoor environmental education programs when it comes to strengthening students' connectedness with nature. There were no statistically relevant immediate differences in the increase of nature connectedness in both experimental groups which indicates that both programs were able to provoke immediate changes in students' feeling of being connected with nature.

Both experimental subgroups perform significant long-term-shifts in reported INS whereas none of the control samples did perform changes. Notably, the increase of the five-day sample is significantly

greater compared to the increase of the one-day sample. Most importantly, students participating in the five-day intervention further demonstrated significant positive shifts in INS within the 6 weeks after intervention and thereby revealed higher median scores compared to the values immediately after the program. As the INS scores at T3 indicate participation in the five-day educational program did not only increase students' nature connectedness over time but also further strengthened it. In line with previous literature stating that the most significant predictors of nature connectedness are the frequency of time spent in nature and positive experiences made there (Clayton 2003; Kaiser, Roczen, and Bogner 2008; Mayer and Frantz 2004; Müller, Kals, and Pansa 2009; Nisbet, Zelenski, and Murphy 2009; Raudsepp 2005; Schultz and Tabanico 2007) we suggest that extended outdoor environmental education programs have a higher efficacy in provoking long-term shifts in the individual feeling of being part of nature compared to one-day interventions. Our findings confirm that experiencing nature for several days has a much stronger positive impact on connectedness with nature compared to a shorter intervention.

We explain the fact that participants from the five-day sample further increased their degree of nature connectedness after the intervention by an increased interest deriving from positive experiences made outdoors. From a neuroscientific point of view positive emotional excitation can cause a more intense cognitive elaboration of contents (Hidi 2006; Spitzer 2007). Research indicates that affective responses of students towards a learning experience cause higher levels of motivation which result in further examination as well as enhanced learning (Boyle et al. 2007; Kern and Carpenter 1986; Rennie 1994). In this context Kern and Carpenter (1986) mention the *carry-over-effect* which leads to a takeover of the positive feelings associated with the field experiences to one's individual attitudes. We suggest that the educational program aroused the students' situational interest and improved their affective response in positive ways. Through the long-term concentration on nature the situational interest could have developed to individual interest which might lead to a deeper focusing elaboration after intervention. These suggestions need to be examined empirically.

When focusing on the development of INS values departing from various initial scores it becomes clear that certain groups of students benefit more than others and that the length of the study program is crucial for predicting shifts in nature connectedness. In this study, students from the five-day sample with low or mediocre initial INS values demonstrated highly significant immediate and sustained shifts. They even increased their nature bonding between T2 and T3. Within the one-day sample however, students with a low starting level also achieved significant immediate and long-term shifts but these cohorts did not increase their feeling of nature connectedness after program participation. The control cohorts even demonstrated negative shifts after the theoretical intervention. In line with current educational research (Baker, Jensen, and Kolb 2002; Hope 2009) we suggest that first hand experiences enhance the understanding and help develop skills. In this case, the five-day intervention challenged students' preconceptions more than the one-day intervention.

The results of this study indicate in particular that age can be a clear predictor of educational success. Especially in combination with program duration age is a meaningful influencing factor. It was the five-day sample that showed the most positive shifts in nature connectedness and within this sample the youngest age group demonstrated the strongest effects. 16–18 year olds scored highest within the one-day sample but still the educational success of the seven to nine year olds was incomparable. These findings support the literature stating that environmental attitudes and nature connectedness are formed in early years and remain a stable character trait that is hard to change as children grow older (Clayton 2003; Ernst and Theimer 2011; Gifford and Sussman 2012; Wells and Lekies 2006). Referring to findings from developmental research (Kuhn and Pease 2006) we think that the connection to nature of 7–9 year old students can be triggered by fascination and emotional concern which is not demonstrated to that extent by older students. Hence, we call for an early influence of these attributes rather than a late one. Based on our findings we support the call for outdoor environmental education (Kellert and Westervelt 1983; LaHart 1978; Liefländer et al. 2013; Wells and Lekies 2006). Even though we think that environmental education is valuable within all age groups we highlight the importance of intense nature experiences for young children for fostering their connectedness with nature which again hopefully results in environmentally responsible behavior.

Study limitations

The contents of both educational interventions were coordinated and focused on global environmental issues. The author of this study implemented both program types using the exact same methods, tasks and devices. Despite these attempts to make both interventions as comparable as possible an unfettered comparability is not achievable due to the different amounts of content being taught. Additionally, acting as author and instructor at the same time can bias the study in ways that are not known.

The applied measuring instrument was advantageous in terms of practicability but considering the fact that it was made of only one item the probability of students answering according to social desirability was higher compared to a longer instrument. Further, the improved values in nature connectedness after the outdoor intervention could possibly be associated with a novelty effect. Still, the different developments of the two experimental groups in the long term suggest that the participants understood the instrument and applied it reasonably.

Conclusion and educational implications

In light of the growing alienation from nature among children educational programs re-connecting students to the environment seem more important than ever. The intervention presented in this study showed that direct experience of the surrounding environment can restructure students' connection to nature.

The findings of this research therefore may be of interest to school and university educators and should be considered when developing the environmental education curriculum not only in Singapore but around the globe. This study suggests that students with a rather moderate nature connectedness demonstrate sustained shifts towards a stronger feeling of being connected with nature. In line with previous research, two factors could thereby be identified as important when it comes to intensifying students' bonding to nature: the frequency of time spent in natural surroundings and the age of participants (Kals, Schumacher, and Montada 1999; Schultz and Tabanico 2007; Wells and Lekies 2006).

The results of this study confirm the positive impact of learning experiences in authentic natural surroundings and highlight its benefit compared to ordinary school lessons covering the same topics. Whilst both program durations – one day and five days – had immediate positive impact on the connectedness to nature, the five-day intervention achieved significantly stronger long-term effects. Subsequently, we support the implementation of residential outdoor environmental education programs on a regular basis into the school curriculum for an effective promotion of nature connectedness.

The five-day intervention showed the greatest potential to raise nature connectedness among the younger students. Seven to nine year olds showed the most positive shifts after the direct nature experience. Older age groups responded stronger to the one-day intervention. In line with previous literature (Kellert and Westervelt 1983; LaHart 1978; Liefländer et al. 2013; Wells and Lekies 2006), we recommend regular environmental outdoor interventions – especially for primary and lower secondary school classes.

Even though the effect of the five-day course was significantly stronger, we acknowledge the value of one-day interventions when it comes to the re-connection of students to nature as well. Considering that one-day field trips are much easier to integrate into the ordinary school routine we call for a holistic approach of environmental education. Consequently, the combination of both program types (one-day and long-term field trips) in order to achieve an optimal outcome in terms of a strengthened nature connection seems reasonable. Moreover, given that students attending ordinary school lessons covering the same ecological topics did not increase their degree of nature connectedness any type of outdoor environmental education intervention seems recommendable.

Disclosure statement

No potential conflict of interest was reported by the authors.

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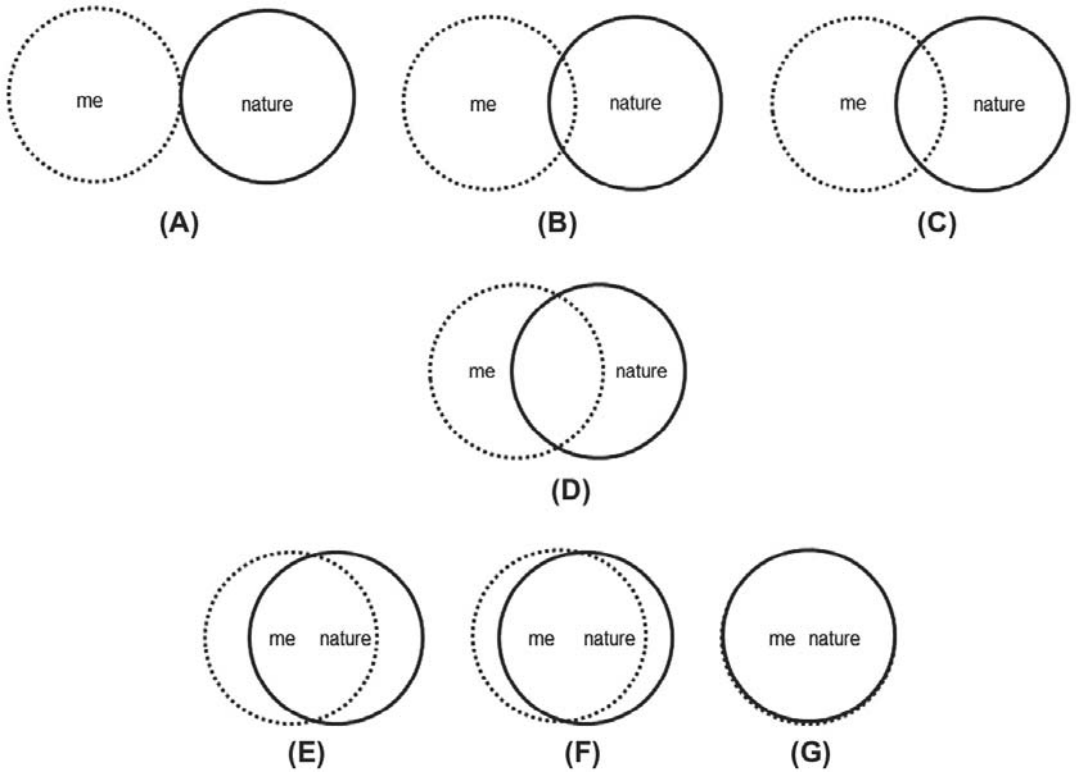
Appendix 1.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2 Publication B: Fostering changes in attitude, knowledge and behavior: demographic variation in environmental education effects

Author`s contributions

Authors:

Tina Braun (TB, PhD candidate),

Richard Cottrell (RC),

Paul Dierkes (PD)

(1) Development and planning

PhD candidate (TB): 90%
RC: /
PD: 10%

(2) Execution of surveys and experiments

PhD candidate (TB): obtained the permission to work as a field biologist and conduct the research, developed the educational program, recruited school classes, organized the fieldtrips, familiarized the staff with the program, implemented the educational program, collected data (environmental attitudes, knowledge and behavior) (80%)
RC: contributed to the implementation of the educational program (20%)

(3) Compilation of datasets and preparation of figures

PhD candidate (TB): organized and prepared all data collected before, during and after the fieldtrips for the analyses. TB prepared all figures and tables presented in the manuscript and supplementary info (80%)
RC: contributed to the preparation of figures and gave advise on the display of the results (15%)
PD: gave advise on the display of the results (5%)

(4) Data analyses and interpretation of results

PhD candidate (TB): conducted all statistical analyses and interpreted results (70%)
RC: contributed to the conduction of statistical analyses and the interpretation of results (20%)
PD: supervised analyses and contributed to the interpretation of results (10%)

(5) Preparation of manuscript

PhD candidate (TB): 85%
RC: 5%
PD: 10%

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Fostering changes in attitude, knowledge and behavior: demographic variation in environmental education effects

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ABSTRACT

This study employs a uniquely multi-factorial, large-scale design to investigate baseline differences and the effects of a singular outdoor educational program on environmental attitudes, knowledge and behavior among primary and secondary school students educated in four different countries. Statistical modelling approaches employed country of residence, age, nationality, sampling year, gender and urban/ rural habitation as predictor variables. Baseline scores were explained by a number of predictors but country of residence and rural-urban differences appeared as the most consistent explanatory variable for positive changes in attitude, knowledge and behavior. Given the nexus of political, social, natural and cultural data contained within the residence variable, we discuss the complex web of drivers that may influence environmental literacy and environmentally responsible behavior. Spatial variation in the value of outdoor education programs is also discussed.

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Outdoor education; environmental knowledge; pro-environmental behavior; environmental attitude; geographic specificity

1. Introduction

Research indicates that outdoor environmental education can equip students with environmental literacy, skills and the inspiration to develop behavioral patterns that protect the environment (Dillon et al. 2006; Hope 2009). Over the past 40 years the promotion of this environmentally-friendly behavior has increased through social media and the growing spectrum of formal and informal environmental education programs (Ballew, Omoto, and Winter 2015). Outdoor environmental education represents a distinctive and important active 'mode of learning' (Fuller et al. 2006) that promotes cognitive and affective gains (Boyle et al. 2007; Fuller et al. 2006). Nevertheless, the variety of empirical studies quantifying the value of outdoor environmental education programs for affecting participants environmental knowledge, behavior and attitude, have yielded mixed results. (Bamberg and Moser 2007; Ernst and Theimer 2011; Gifford and Sussman 2012; Hines, Hungerford, and Tomera, 1986/87; Kollmuss and Agyeman 2002; Leeming et al. 1993; Zelezny 1999). Numerous attempts have endeavored to establish theoretical frameworks for understanding the development of environmental behavior and all associated, interacting factors (Burgess, Harrison, and Filius 1998; Fietkau and Kessel 1981; Fishbein and Ajzen 1975; Hines, Hungerford, and Tomera 1986/87). However, no singular framework appears to appropriately describe and predict links between environmental attitudes, knowledge and behavior. Instead of insisting on the need of a theoretical framework this study approaches quantification and comparison of the efficacy of a singular outdoor education program across four different countries.

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Very few of the well-known, multinational studies (e.g. PEW Global Attitudes Project, Eurobarometer, International Social Science program) (Leiserowitz, Kates, and Parris 2005) consider a range of demographics across different nations. This is most pronounced in the current body of research relating to outdoor education and knowledge acquisition which has largely focused on traditional explanatory variables such as age, gender and urban/ rural habitation.

In response, this multifactorial, large-scale study pursues two targets. First, it examines the effects of a singular outdoor environmental education program on students' environmental attitudes, knowledge and behavior. It aims to explain variation in program efficacy through well studied variables mentioned above, but expands the scope by adding the variables country of residence, nationality and sampling year. Second, this research identifies baseline differences in environmental attitudes, knowledge and behavior in students from different countries of residence, nationalities, age, gender and rural/urban habitations. These criteria were then used as predictor variables for modelling subsequent departures from baseline values as result of outdoor environmental education programs. Thus, we seek to extend the knowledge regarding the empirical effects of environmental education across a range of demographics, ultimately contributing to wider discussions in environmental sustainability research.

2. Theoretical background

2.1. Environmental knowledge

A large body of research suggests that environmental knowledge has the potential to support positive environmental attitudes and behavior (Bogner 1998; Frick, Kaiser, and Wilson 2004; Heimlich and Ardoin 2008; Liefländer et al. 2015; Schultz 2013; Sellmann and Bogner 2012; Wiek, Withycombe, and Redman 2011) and commonly, knowledge is considered as a basic precondition for a person`s behavior (Frick, Kaiser, and Wilson 2004; Gifford and Sussman 2012). Nevertheless, knowledge cannot be interpreted as guaranteed determinant for environmental behavior given that many studies did not identify a link between knowledge and behavior (Kollmuss and Agyeman 2002). Hines, Hungerford, & Tomera found 'that those individuals with greater knowledge of environmental issues […] were more likely to have reported engaging in responsible environmental behaviors than were those who did not possess this knowledge' (1986/87, 2). Many other studies corroborate this (Frick, Kaiser, and Wilson 2004; Pratkanis and Turner 1994; Ronis and Kaiser 1989; Schahn and Holzer 1990). Environmental education is considered as a significant influential factor for fostering environmental knowledge (Abd El-Salam, El-Naggar, and Hussein 2009; Cumming and Wyse 2013; Zsóka et al. 2013). Especially outdoor environmental education programs are widely considered as a promising tool in developing children's knowledge and awareness about environmental issues (Bögeholz 2006; Drissner, Haase, and Hille 2010; Kruse and Card 2004; Liefländer et al. 2015; Sellmann and Bogner 2012) and showing potential as an important tool for fostering more environmentally friendly behavior. Liefländer, Bogner, Kibbe and Kaiser (2015) found a significant increase in environmental knowledge among students after participation in a 4-day outdoor program and Sellmann and Bogner (2012) detected a significant knowledge increase after a one-day outdoor program. Both research teams explain their results by referring to the benefits of extracurricular learning. Given that early knowledge shapes later adult-thinking, fostering environmental literacy among children has the potential to prepare tomorrows decision-makers for the future challenges they will likely face (Damerell, Howe, and Milner-Gulland 2013). Due to the cognitive dimension of environmental learning, many studies have focused on environmental knowledge of the youth (Mifsud 2012). However, patterns appear inconsistent. Some studies describe substantial knowledge of environmental topics among students (Ahmad, Noor, and Ismail 2015; Alp et al. 2006; Barrett, Kuroda, and Miyamoto 2002; Ivy, Lee, and Chuan 1998; Kaplowitz and Levine 2005; Said, Yahaya, and Ahmadun 2007) whereas others have described low baseline knowledge (Barrett, Kuroda, and Miyamoto 2002; Kuhlemeier, Van Den Huub, and Nijs 1999; Makki, Abd-El-Khalick, and Boujaoude 2003). For decades scientists identified gender differences concerning knowledge. Yet there have always been mixed results regarding who

possesses the higher knowledge level. Where early studies found males to possess higher knowledge of environmental issues (Blum 1987; Schahn and Holzer 1990) more current research finds women to have a distinct environmental knowledge (Chu et al. 2007; McCright 2010). No cross-national study could be found that has lately investigated differences in students' knowledge due to country of residence and rural/ urban differences as well as nationality.

2.2. Environmental attitude

The manner in which we perceive our environment is strongly dependent on the way we value it. The construct of environmental attitudes is based on the psychological tendency expressed by the individual evaluation of the natural environment resulting in an inclination towards preservation (conservation and protection of the environment) or utilization (feeling of dominance over the environment) (Milfont and Duckitt 2010). Schultz, Shriver, Tabanico and Khazian (2004, 31) call it a 'collection of beliefs, affect, and behavioral intentions a person holds regarding environmentally related activities or issues'. Personal appreciation of the natural environment is deemed to be shaped by both the individual's relationship to nature as well as by cultural conditioning (Gifford and Sussman 2012). Based on varying theories there exist many scales to measure environmental attitudes. Following the definition for environmental attitudes of Milfont and Duckitt (2010) this research applied the two-dimensional 2-MEV scale by Johnson and Manoli (2011) (see Section 3) which was confirmed to be capable in detecting changes in children`s environmental attitudes.

Research only partially yields conclusive results regarding the variables implemented in this study. Evidence suggests that environmental attitudes are formed in early childhood, nearly set by the age of twelve (Clayton 2003; Ernst and Theimer 2011; Gifford and Sussman 2012; Wells and Lekies 2006). Study results referred to in the course of this article focus on pupils' or adults' environmental attitudes. A large body of scholarship finds that environmental attitudes are significantly more positive in women compared to men (Dietz, Dan, and Shwom, 2007; Ergas and York 2012; Theodori and Luloff 2002; Xiao and McCright 2012). Research results concerning rural/ urban habitation displayed different results. While some researchers found that people who lived in rural areas showed more concern for the environment (Hinds and Sparks 2008; Milfont 2007) other researchers did not find significant differences (Müller, Kals, and Pansa, 2009; Xueying 2014). Only few studies focused on country of residence as influential factor for environmental attitudes (Sarigöllü 2008; Schultz 2002). Where Schultz (2002) compared studies from different countries and found significant differences Sarigöllü (2008) directly compared people's environmental attitudes in Turkey and Canada and detected differences due to cultural and socio-demographical characteristics. But none of those studies purely investigated the country of residence. In their cross-national meta-analysis Franzen and Meyer (2009) could identify significant differences in environmental attitudes among various countries and attribute these to their respective prosperity. The literary body of studies investigating nationality as affecting factor for environmental attitudes is even more underdeveloped and no cross-national study on students' attitudes could be found. Several studies indicate that outdoor environmental education can positively affect the development of environmental attitudes (Ernst and Theimer 2011; Harding 2016; Liddicoat and Krasny 2013).

Environmental education should, therefore, aim at building and strengthening awareness for environmental problems and through feasible realization examples foster the individual motivation to change behavioral habits. Since empirical results concerning correlations between attitudes and behavior remain inconsistent (Kollmuss and Agyeman 2002) environmental attitudes alone seem to play an inconsequential role as predictor for pro-environmental behavior.

2.3. Environmental behavior

Environmental behavior refers to modes of behavior which aim at minimizing negative human impacts on the natural and built environment (Kollmuss and Agyeman 2002). Where some early models assumed the linear triad of increased environmental knowledge leading to a change in attitude expressed

through pro-environmental behavior (Burgess, Harrison, and Filius 1998) others have found a discrepancy between knowing and acting (Bamberg and Moser 2007; Gräsel 2000; Kollmuss and Agyeman 2002; Mobley, Vagias, and DeWard 2010; Riess 2003). Rajecki (1982) earlier suggested that indirect experiences cannot equate with direct concern and that personal attitudes, familiar habits, social norms and cultural traditions have a determining influence on behavior. Further suggestions involved a variety of not conclusively researched internal and external factors which compose a person`s individual environmental behavior (Fietkau and Kessel 1981). Heimlich and Ardoin (2008) suggest that the hierarchy of environmental behavior is based on the consciousness of an individual concerning the performed actions.

Research on environmental education programs has shown that early childhood experiences in nature provide children with cognitive and emotional benefits and influence the development of lifelong environmental attitudes and behavior (Chawla 2006a, 2006b; Wells 2000; Wells and Lekies 2006). The growing number of children spending less and less time in nature causes concern about whether these individuals will be capable of acting in an environmentally responsible manner in the future (Hofferth and Curtin 2006; Pyle 2002). Scholarship on the structure and the developmental stages of environmental behavior in children is insufficient. Current developmental analyses show that children develop an understanding for ecological principles and the potential anthropogenic impact on the environment by the age of 11 years (Evans et al. 2007). They surely don`t dispose background knowledge by then but they have an awareness of several environmental problems.

One aim of the implemented educational program was to enable students to evaluate their individual performance and to change their actions consciously. Changing behavior in this sense is more than changing specific actions. It means replacing old routines. This process requires much more willingness to change something because it is more than adding a new element. Instead it requires an entire rethinking of the everyday life.

3. Methods

3.1. Educational program

The program for participants from Bangladesh, Malaysia and Singapore was implemented by teachers from Ecofieldtrips Pte Ltd, Singapore. This outdoor education company provides school fieldtrips that focus on the exploration of the surrounding natural environment. The German program was conducted by pedagogical employees from the department for bioscience education at Goethe University Frankfurt. The program contents as well as the teaching methods of all interventions have been coordinated by the implementing teachers from both conducting institutions to ensure a comparative educational framework. Each program included the same cognitive and affective tasks and discussed the same conservation issues. Only the specific examples that make the outcome of these issues vivid were compiled in the context of the respective surrounding. All survey classes participated in a one day outdoor educational program about conservation ecology in the forest, all following a close format. None of the participants had attended the program before or received any information in advance. The program objective was to expand the education beyond classroom walls and to deepen students' understanding of ecology and global conservation issues. Participants experienced the forest ecosystem and studied ecological principles *in situ*. Program content was adapted to the biology syllabuses of Germany and Singapore as accurately as possible and provided unique hands on experiences fostering students' understanding of environmental ecology and global conservation issues. Each teacher led a group of seven to ten students on a fieldtrip to a forest area. Their role was to introduce students to their surroundings, enabling them to make their own experiences in a more unstructured, holistic and student-centered way. The program started with a short briefing introduction on the schedule, the forest ecosystem and expected behavior. Each group worked through the same items on the agenda although not necessarily in the same order. The program included a hiking tour through the forest, spotting of different plants and animals and using a range of sampling techniques to investigate animal behavior, population dynamics, ecosystem interactions and dependencies. The breaks were held

together and involved a picnic lunch. Besides knowledge acquisition, this program aimed to inspire a passion among participants for protecting the explored ecosystems. Tasks were divided into cognitive (e.g. identification of plants or animals through identification keys) and emotional exercises (e.g. recognizing the individual benefit of nature through a collection of natural products) that seek to nurture conservation awareness and an increased knowledge base. Educational content included the nutrient cycles of temperate and tropical rainforests, adaptation of flora and fauna and human-induced pollution and impacts. The difficulty level of the single tasks was adjusted for the skills of different age groups. The teaching unit for the comparison group was implemented at school exclusively to ensure the contrast to the outdoor intervention. To possibly exclude other influential factors or further environmental programs the respective teachers and parents agreed not to cover the topics of the intervention in class or to participate in additional environmental programs or fieldtrips. for the six weeks following the intervention.

3.2. Evaluative design

Baseline data on environmental attitudes, knowledge and behavior of primary and secondary school students was collected via questionnaire at school prior to an educational program (T1) and compared to data collected immediately after (T2) in order to receive information about short-term shifts in the variables. A third questionnaire six weeks after the end of the program (T3) provided insights to long-term changes. The items were presented in a different order at each test time. 929 students participated in the program. 606 students were in the experimental group, 323 constituted the comparison cohort. Every class participating in the program conceded the evaluation process. In a first step, participants that failed to complete all three evaluations were omitted from analysis. Those questionnaires that had less than 85% of the items completed or that obviously showed certain response biases such as acquiescence bias, primacy or recency effects were not incorporated. The respond rate amounted to 69.43% yielding a net sampling size of $N = 645$ complete data sets.

3.3. Sampling

The study was performed on a comparative basis in a quasi-experimental design from August 2013 to October 2014. Data is combined from four samplings involving students educated in Bangladesh ($N = 43$), Malaysia ($N = 100$), Singapore ($N = 121$) and Germany ($N = 154$). The sampling also entails two comparison groups from Germany ($N = 160$) and Singapore ($N = 67$) that only attended scheduled school lessons detailing conservation ecology and completed the same questionnaires as the experimental groups within the same time frame. The sample derived from 29 heterogeneous primary and secondary school classes (50.9% male). Participants were divided into age groups from 7 to 9 years of age (25.4%), 10–12 years (25%), 13–15 years (28.4%) and 16–18 years (21.2%) (see Table 1). Participating countries were determined due to the application areas of both implementing institutions. Ecofieldtrips operates

Table 1. Overview of the single samplings of the study.

		Samplings					
		Experimental				Control	
		BD	MY	SG	GER	SG	GER
N		43	100	121	154	67	160
Age (yrs)	7–9 yrs	8	14	26	42	16	33
	10–12 yrs	13	29	27	72	22	44
	13–15 yrs	11	28	47	21	10	50
	16–18 yrs	11	29	21	19	19	33
Gender	Female	18	50	72	72	31	82
	Male	25	50	49	82	36	78

with schools in Singapore, Malaysia and Bangladesh whereas Goethe University is limited to Hessian schools in Germany. For organizational reasons it was impossible to obtain a comparison group for the Malaysian and Bangladeshi sample.

For participant recruitment, 70 schools (GER: 30; BD: 5, MY: 15, SG: 15) were contacted by mail, advertising the educational program and informing of the integrated evaluation. All sampling classes registered for the outdoor education program conducted by Ecofieldtrips (all samplings from Asia) or Goethe University (German sampling). Comparison cohorts derived from the same respective schools. Parents of minor students were informed and submitted their declaration of consent. All Asian classes belonged to international schools following the British or North American school system. The German sampling was collected from local and international schools following the German educational system. In order to have preferably comparable samples German participants were recruited from three school types (Haupt- & Realschule, Gymnasium). The number of participants was constrained by available appointments, staff and resources. Allocation of places occurred in the order of registrations considering all inclusion and exclusion criteria (age, school type, place of residence).

3.4. Measuring instrument

Following the *ask the same question* approach (Harkness 2003), in a cross-national collaboration the authors created and selected items for the source questionnaire. For equal assessment of all subsamples the same questionnaire was translated into German and back translated into the English language before both versions were compared.

Quantification of environmental attitudes at T1 and T3 was achieved using the 2-MEV (Two Major Environmental Values) Model of Bogner and Wiesemann (2006) that later has been revised by Johnson and Manoli (2011) for the use of 9 to 12 year-old children. The scale is based on the two independent domains preservation and utilization. Preservation is affected by a bio-centric preference for the protection of natural resources and would be preferentially selected by participants with a positive attitude towards the natural environment. Instrument validity, reliability and factor structure have been proved in previous studies (Bogner and Wiseman 2006; Johnson and Manoli 2011). Due to problems of comprehension among the test sample following Johnson and Manoli (2011) the original 20 items on the instrument were reduced to 16 for model simplification and were arranged in a five-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). Psychometric quality of the 2-MEV-scale has been confirmed by various independent studies (Boeve-de Pauw and Van Petegem 2011; Drissner, Haase, and Hille 2010; Milfont and Duckitt 2004; Munoz et al. 2009) and should be maintained given the fact that both model domains were net of two items.

Given that environmental knowledge is exclusive to each educational program there is no standardized comparable measuring instrument. Hence, the authors developed a unique set of 12 questions (see Appendix). Content appropriacy was validated by academics (Goethe University, Germany) and environmental education specialists (Ecofieldtrips Environmental Education, Singapore). In a pre-study with one school class covering students aged 10 to 11 in each participating country, psychometric properties, validity and internal reliability of the knowledge set was verified. Item difficulty was checked and is in the medium range ($Øp_i = 0.4$). Frequency distribution of test values is located within normal distribution. Items show an appropriate selectivity of $r_{it} = 0.6$. Final assessment was made by a set of twelve multiple choice questions. The question battery was divided into 'global' and 'program-specific regional' environmental knowledge. Seven questions focused on global environmental topics (e.g. photosynthesis or climate change) and were identical in both parts of the study. German program-specific study questions differed from those in the Asian study in local specificity (e.g. temperate vs. tropical rainforests). The reduction of the *a priori* probability of random guessing was achieved by a varying number of correct answers and distractors. Out of five response options one to three answers were correct and there was always the option to tick 'I don't know the answer'.

Methodology for measurement of changes between baseline (T1), intended (T2) and performed (T3) environmental behavior was adapted from Bögeholz to the aims of the present study. The construct

consists of a multiple choice selection of specific individual routine environmental conservation behavior options of concrete areas of action (waste management, energy consumption, transport and conservation) that are reasonably practicable for children and adolescents (e.g. 'I tried to save water'). Validity and reliability of the scale have been established (Bögeholz 1999). The instrument included nine items to measure current behaviors and six items to measure intended behaviors. In the follow-up survey (T3), these six intended items were tested again to see whether the intentions were implemented.

3.5. Statistical analyses

All data analysis including model fitting and assumption testing was conducted using R statistical package v. 3.1. We examined differences in attitude, knowledge, and behavioral scores between experimental and comparison groups to detect any differences in the efficacy of outdoor programs relative to school-based programs. We then employed statistical modelling techniques to understand which variables of student country of residence, age, gender, nationality, urban/ rural habitation and the year that sampling was conducted best account for the variability in attitudes, knowledge and behavior before (T1) and after the program (T3). Differences in attitude and behaviour changes between experimental and comparison groups were analysed using Kruskal-Wallis rank-sum test to allow for non-normality in scored data. Knowledge scores were converted into percentages and one-way Analysis of Variance (ANOVA) was used to detect differences in changes between experimental and comparison groups.

Baseline attitude scores (T1) were categorised to reflect positive (1–2), neutral (3) or negative (4–5) attitudes and then fitted to an ordered logistic regression model to account for ordinal response data. All knowledge scores were converted to percentages and baseline scores (T1) were fitted to a linear regression model. The number of behaviours performed by students at T1 was considered quasi-Poisson data given that behaviours are constrained by zero and the data displayed obvious right skew. Thus, this data was fitted to a Poission regression model.

The efficacy of the outdoor education program (measured as positive change in attitude, knowledge or behaviour) was then modelled in a binary fashion for each aspect. Absolute changes in attitude, knowledge, and behaviour were modelled this way in order to provide comparable metrics for program efficacy between ordinal and numerical model outputs using probabilities of positive changes in attitude, knowledge and behaviour. Long-term positive results of the educational program were deemed to be achieved if at T3:

- Likert scores for attitude had decreased from T1 (i.e. attitudes had become more positive),
- knowledge scores had increased since T1 or,
- performed behaviours equalled or surpassed those intended at T2

Scores of 1 were assigned for 'success' and 0 when these criteria were not met. Binary data were fitted to a logistic regression model.

All model explanatory variables were fitted as factors to allow the response to vary in a non-linear manner with treatment contrasts. Models were first fitted with all explanatory variables (individual, year, gender, age, country of residence, nationality, urban/rural habitation). Collinearity within the model was treated through the removal of variables producing variance inflation factors above 10 and all-possible-subset model selection techniques were applied to remaining variables. Interaction terms were subsequently introduced between all variables in the reduced model before all possible subset techniques were applied again. Model best-fit was determined by minimizing corrected Akaike Information Criterion scores (AICc) (Burnham 2004; Davies, Neath, and Cavanaugh 2006).

Dispersion parameters were estimated to check that over-dispersion did not influence model inference for logistic and Poisson regression models. The following tests were also conducted to inspect if linear model assumptions were met: constant error variance and independence in the residuals were checked using the Breusch-Pagan and Durbin-Watson tests respectively. Normality of residuals was

also assessed using the Shapiro-Wilks test, and histograms of model residuals and Quantile-quantile plots (Figure S1).

3.5.1. Satisfying statistical model assumptions

Assumptions of the linear model fitted to baseline knowledge scores were all satisfied. No evidence was found against the critical assumptions of independence in model residuals ($DW = 1.82$, $p = .066$) or constant error variance ($\chi^2 = 0.437$, $p = .508$). While non-normality was detected in the residuals ($W = 0.991$, $p = .0128$), the slight skew illustrated in a histogram of standardized residuals and Quantile-quantile plots suggest this is of little concern to model interpretation (Figure S1). Linearity in the model is not of concern given explanatory variables were fitted as factors.

Dispersion parameters were estimated for all binomial and Poisson models (both families assume dispersion to equal to 1). All estimates were reasonable for attitude change (0.996), knowledge change (0.986), baseline behaviors (1.05) and behavioral change (1.01), suggesting that over-dispersion was not present in any model and data was fitted appropriately.

3.5.2. Model interpretation and analysis

As all models were fitted with explanatory variables as factors, intercept only models provided baselines of comparison with treatment contrasts from each variable. Linear model coefficients return estimates on the scale of the response and are obtained directly from model output. In contrast interpretation of Poisson regression model output on the scale of the response was achieved through the inverse of the log-link function:

$$yi = e^{\beta 0+\beta 1x1i+\beta 2x2i+\beta nxni} + \in i$$

where y = the number of behavioral actions taken by the *ith* individual of a given nationality, age, gender, country of residence, urban/ rural habitation or sampling year. β_x = coefficient for predictor variable x, x = value of predictor variable, $n = n^{th}$ number of variables, $\in i$ = error term.

Similarly, logistic and ordinal logistic regression models return estimates on the scale of the logit-link function. Thus calculating the probability of 'success' in program efficacy was achieved through the inverse of the link function

$$pi = \left(e^{\beta 0+\beta 1x1i+\beta 2x2i+\beta nxni}\right)/1 + \left(e^{\beta 0+\beta 1x1i+\beta 2x2i+\beta nxni}\right) + \in i$$

where p_i = probability of a positive baseline attitude or program 'success' for the i^{th} individual of a given nationality, age, gender, country of residence, urban/rural habitation or sampling year. β_x = coefficient for predictor variable x, x = value of predictor variable, $n = n^{th}$ number of variables, $\in i$ = error term.

Differences between probabilities derived from exponentiation model coefficients were then tested for significance using a hypothesis Z-test.

4. Results

Internal reliability analysis using Cronbach's α of the aggregated scale for attitude assessment showed moderate results for both pre- and follow-up test (αT1 = .693, αT3 = .682), constructs of both intended (αT1 = .770) and demonstrated environmental behavior (αT3 = .683), as well as for baseline behavior preprogram ($\alpha = .772$). Reliability was modest for all environmental knowledge T1 data (αglobal = .767; αregional, Germany = .682; αregional, Asia = .756), T2 environmental knowledge data (αglobal = .896; αregional, Germany = .736; αregional, Asia = .672) and this pattern is also displayed at follow-up [T3] (αglobal = .726; αregional, Germany = .686; αregional, Asia = .693). Confirmatory factor analysis supported the supposed dichotomous structure of the 2-MEV model showing two dimensions which fall on two axes. Preservation accounted for 18.745 % and utilization for 11.878 % of the total variance. Chi-squared (2.34) was above the recommended maximum of 2.0. Therefore, RMSEA (.05), CFI (.92) and SRMR (.10) suggested a satisfactory approximate model fit.

4.1. Environmental attitudes

4.1.1. Pre-program attitudes

Model selection revealed that only gender significantly predicted differences in baseline student attitudes. The probability of positive attitudes before the program was significantly greater in female students than male ($z = 3.25$ 3 s.f, $p < .01$) (Figure 1).

4.1.2. Predicting long-term, positive attitude shifts

No significant difference was detected between changes in attitudes between either German or Singaporean experimental groups relative to their controls.

In those students exposed to an outdoor education program, country of residence was the sole variable that significantly predicted the probability of positive, long-term shifts in attitude (Figure 2).

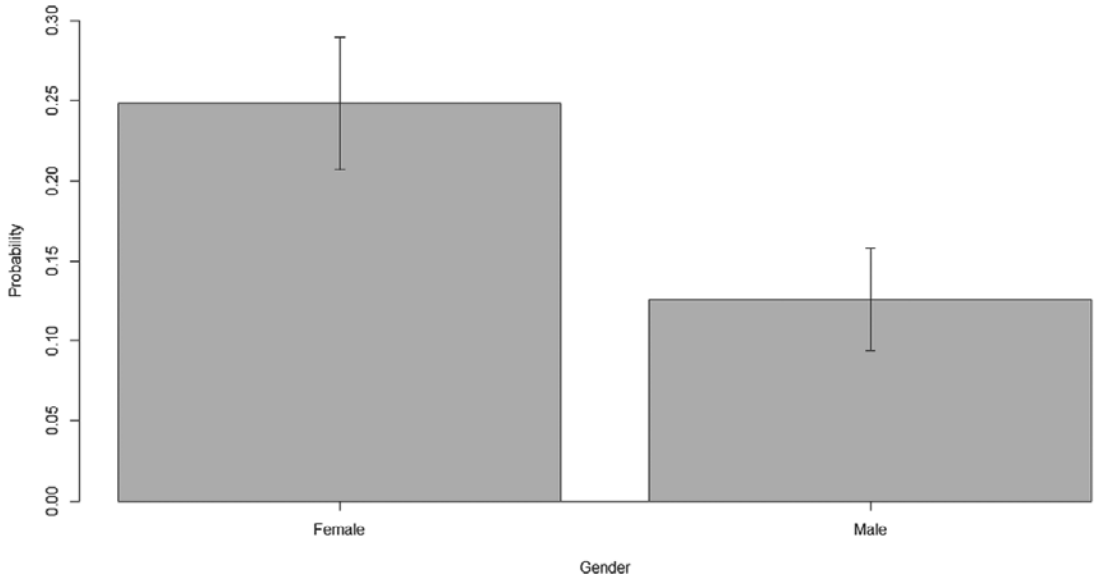

Figure 1. Gender differences in baseline attitudes. Barplots display the probability of positive attitudes (Likert scores of 1 or 2) among male and female students at T1. Error bars represent 95% confidence intervals.

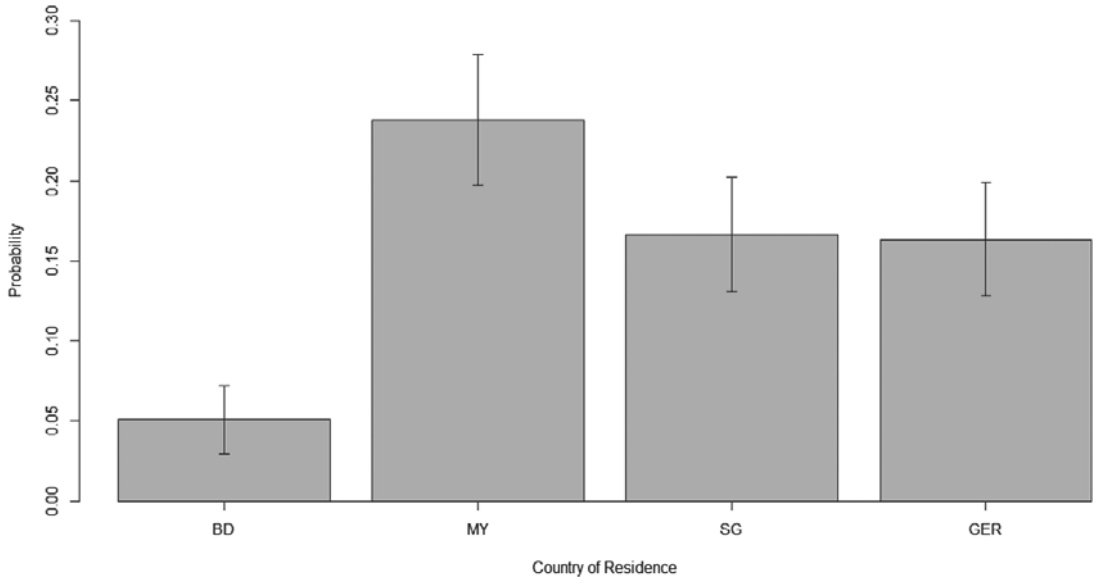

Figure 2. Probability of long-term, positive attitude shifts. Only country of residence significantly accounts for differences in the probability of student attitudes becoming more positive from before the intervention (T1) to six weeks after (T3). Error bars represent 95% confidence intervals.

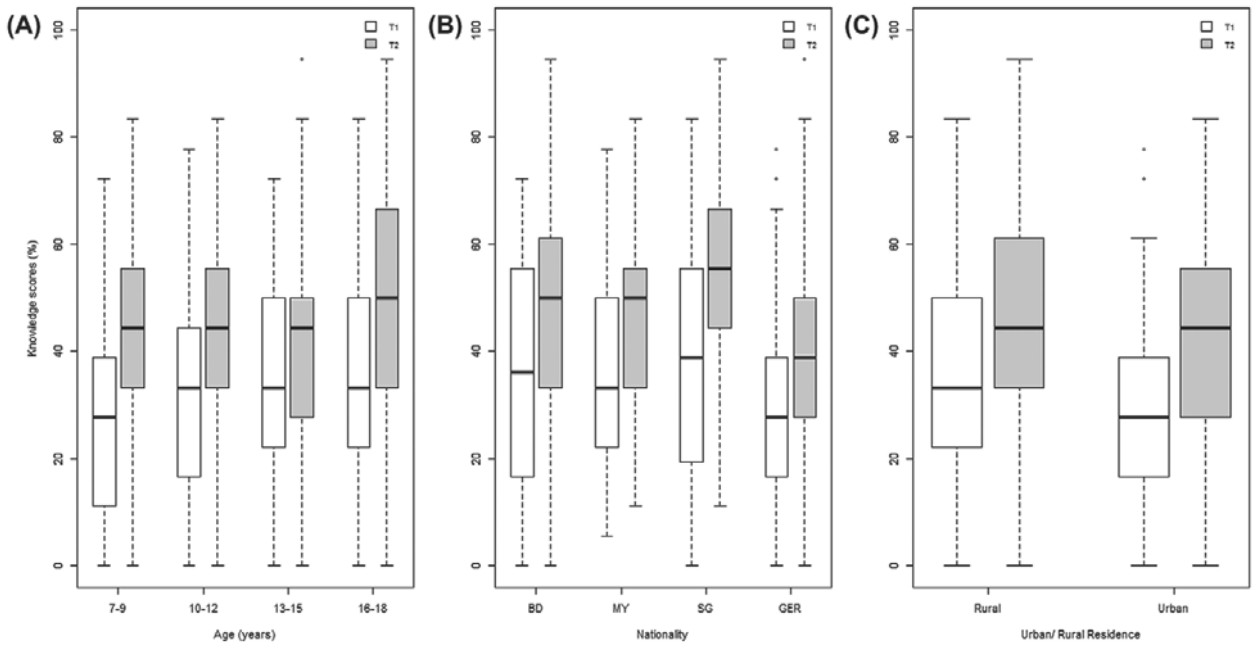

Figure 3. Baseline knowledge scores. Boxplots show distribution of knowledge score data (%) among students of different A age groups B nationalities C urban/ rural backgrounds at baseline at before (T1) and immediately after (T3) the intervention.

Students residing in Bangladesh showed a significantly lower probability of long-term positive attitude shifts than cohorts from Malaysia, Singapore or Germany ($p < .01$).

4.2. Environmental knowledge

4.2.1. Pre-program knowledge scores

Age, rural/ urban habitation and nationality were retained during model selection to explain variability in baseline student knowledge. Knowledge tended to increase with age as expected (Figure 3), with 10–12, 13–15 and 16–18 year olds achieving significantly greater scores than 7–9 year olds ($t = 2.31$, 3.45 & 3.23, $p < .01$). Singaporean students achieved the highest baseline knowledge scores overall with German students achieving lower scores than all other groups ($t = 2.77$, $p < .01$). Further, students residing in urban areas displayed significantly lower baseline knowledge than those living in more rural settings ($t = 2.54$, $p < .05$). Median knowledge scores also increased between T1 and T2 for all groups (Figure 3).

4.2.2. Predicting long-term increases in knowledge

German experimental groups displayed greater long-term changes in knowledge than classroom comparison groups ($F = 7.49$, $p < .001$). Experimental groups from Singapore also outperformed their classroom colleagues on average but differences were not significant.

Country of residence was the only significant predictor of long term knowledge change among students exposed to the outdoor education program (Figure 4). The greatest probability of sustained increases in knowledge lay with students residing in Singapore and Germany. Whereas, the probability of students increasing knowledge from baseline scores was much lower in Bangladeshi residents than all other groups ($p < .01$).

4.3. Environmental behavior

4.3.1. Baseline behaviors

Variability in baseline behavioral data was best explained by country of residence and urban/rural habitation. Significantly more of the behaviors stipulated at T1 were demonstrated by students residing

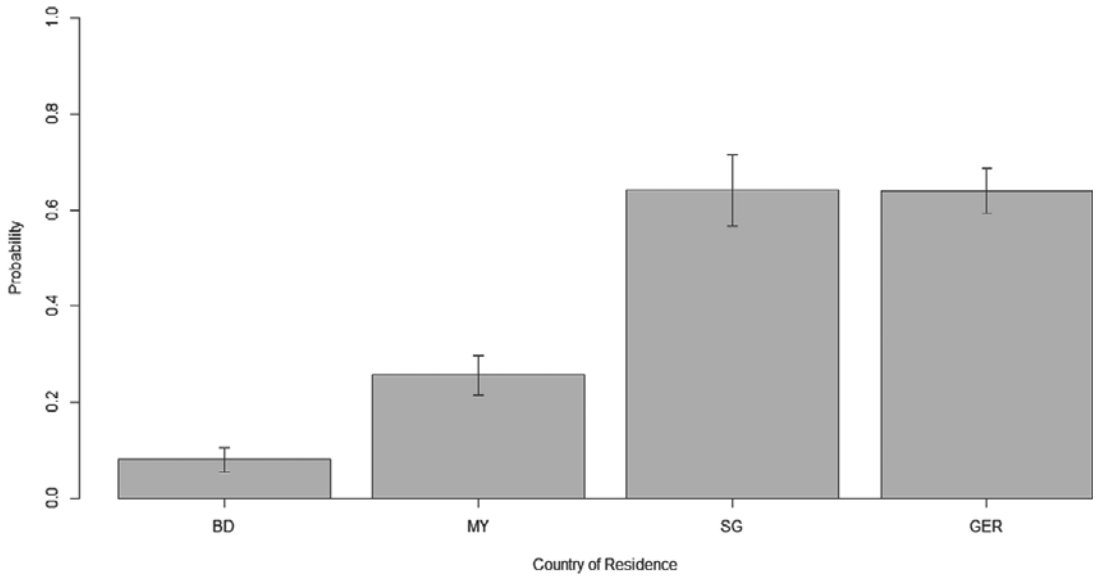

Figure 4. Probability of long-term, knowledge increase. Only country of residence significantly explains differences in the probability of student knowledge increase from before the intervention (T1) to six weeks after (T3). Error bars represent 95% confidence intervals.

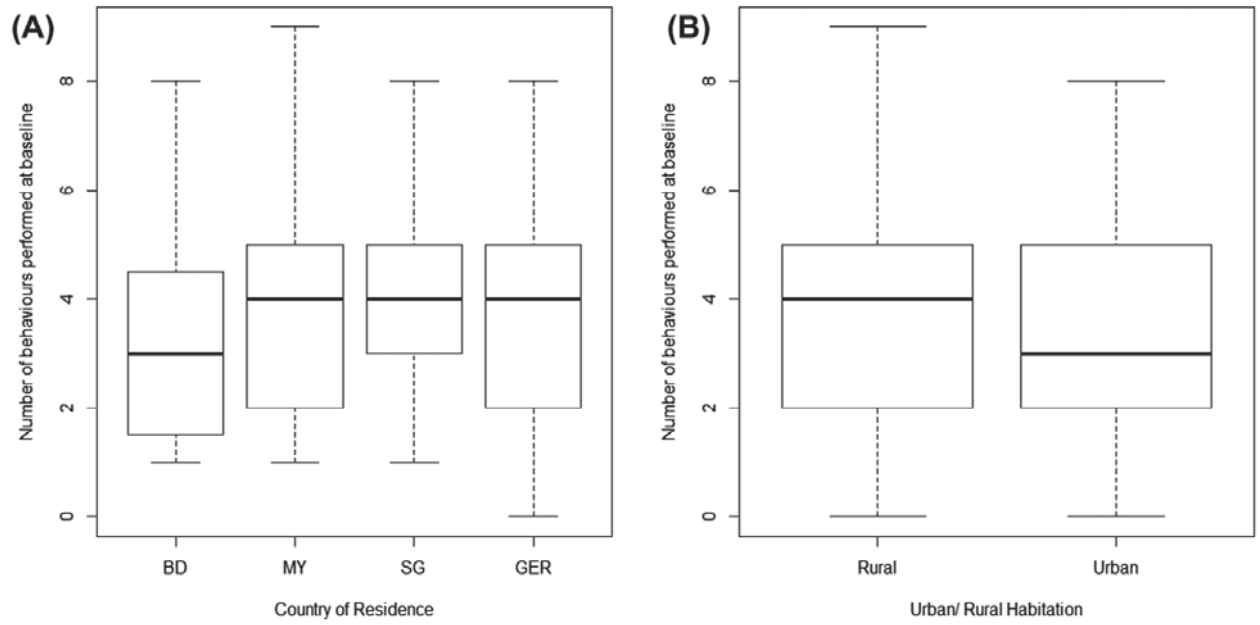

Figure 5. Baseline behaviour scores. Boxplots show distribution of baseline behavioral score data before the intervention (T1) among students of different A countries of residence and B urban/ rural backgrounds.

in Singapore relative to Bangladeshi residents ($t = 2.35$, $p < .05$), however no significant difference was apparent among baseline behaviors of any other group (Figure 5). Those residing in more rural residences also claimed to perform significantly more of the stipulated baseline behaviors than those from urban backgrounds ($t = 2.06$, $p < .05$)

4.3.2. Predicting likelihood of performing intended behaviors

At T3, German experimental groups were far more likely to have performed as many or more of their intended behaviors stipulated at T2 than their classroom comparisons ($\chi = 6.59$, $p < 0.05$). No significant difference in behavioral change was detected between Singaporean experimental and comparison groups, however.

In-keeping with baseline behavior, the probability of experimental groups performing intended behaviors was best explained by country of residence and rural/ urban habitation (Figure 6 and 7). Singaporean residents performed more behaviors on average at T3 than German and Malaysian residents, and Bangladeshi residents were the only group to increase median scores from those intended at T2 (Figure 6). Singaporean residents were more likely to perform behaviors intended at T2 than both Malaysian and German students ($z = 3.39$ & 2.21 respectively, $p < .05$) (Figure 7). Those residing in urban environments displayed a greater probability of performing intended behaviors than those from more

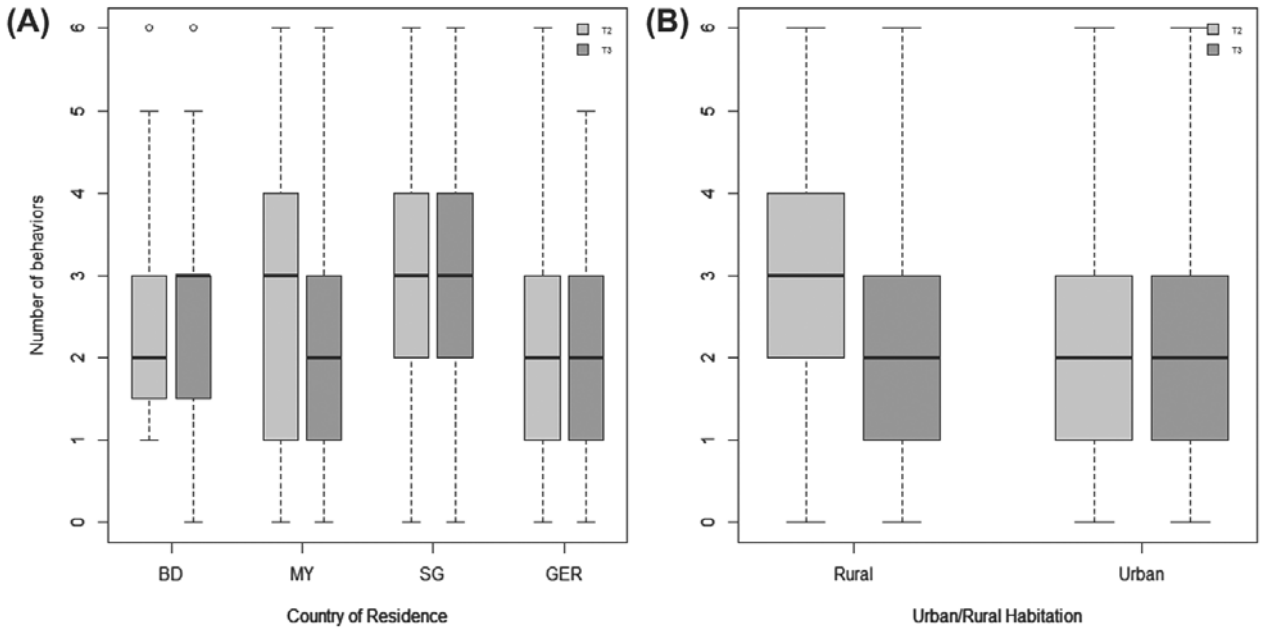

Figure 6. Intended and performed behaviour scores. Boxplots show distribution of intended behavioural data immediately after the intervention (T2) and performed behaviour six weeks after the invention (T3) among students of different A country of residence and B urban/rural background.

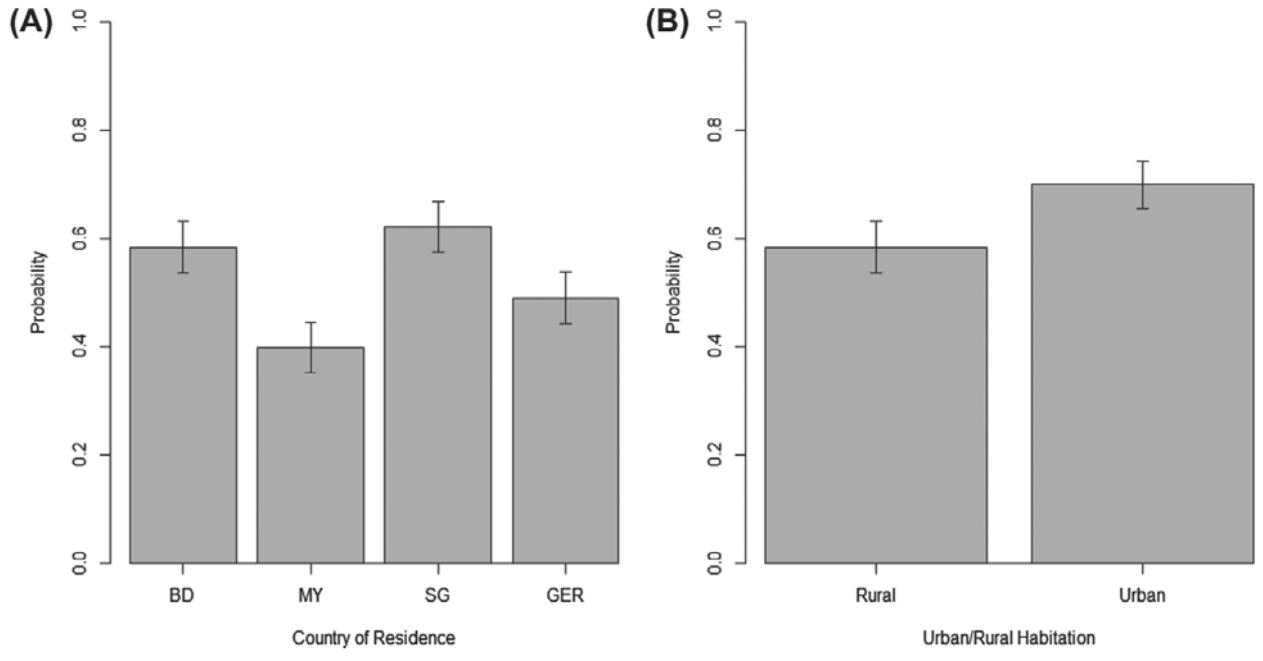

Figure 7. Probability of performing intended behavior. A Country of residence and B urban/rural background were retained during model selection to explain the probability of students performing as many or more of the behaviours intended immediately after the program (T2) by six weeks after (T3). Error bars represent 95% confidence intervals.

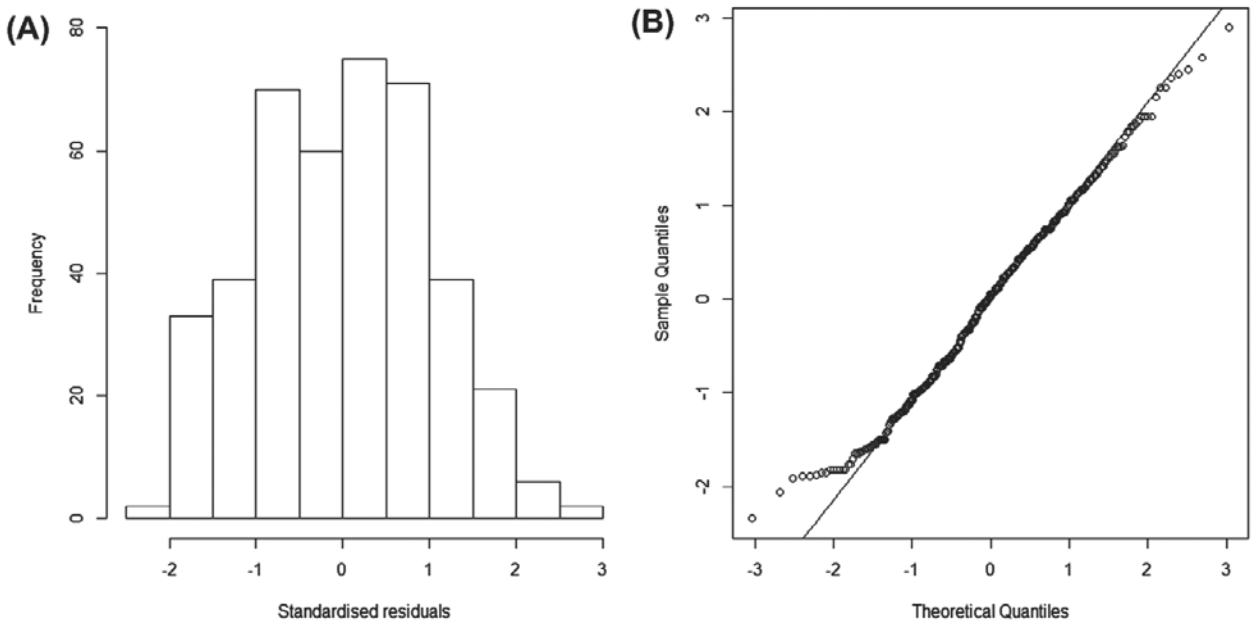

Figure 8. Exploratory data analysis of normality in linear model assumptions. A Histogram of standardised residuals for linear model of baseline knowledge scores. No obvious skew present in distribution to cause serious concern. B Quantile-quantile plot of sampled residuals plotted against theoretical quantiles. Only departure of sampled residuals away from theoretical quantiles is present in tails of distribution and of little concern to model assumptions.

rural backgrounds ($z = 2.44$, $p < .05$) (Figure 7). However, it is worth noting the number of behaviors intended to be performed by urban students was lower than in students from a rural background (Figure 6 and Figure 8).

5. Study limitations

In order to yield representative and generalizable results this study is broad in scope, conducted at a multinational level, including different socialization backgrounds and a wide age range. Ensuring the equality of all educational interventions was challenging. The study content of all interventions in all participating countries was synchronized and all programs focused on global ecological contexts, environmental issues and individual contributions to nature conservation. Equitable representation of all syllabuses from all participating countries was not possible but each syllabus contains similar elements which were focused on during the programs. Of course, since the different study sites depicted different geographical zones there are limitations in comparisons between ecosystems and effect of exposure to them. While general structure of the ecosystems examined were as similar as possible, the systems and organisms examined in each of the distinct world regions were naturally different. Also even though the implementing teachers based on the same manuscript each one disposes specific individual teaching methods that could lead to variation among the single samplings.

In terms of measurement, two important points should be acknowledged. First, even though we aimed to eliminate confounding factors as random guessing – complete exclusion cannot be guaranteed. Second, there are always limitations in 'self-report' approaches in behavioural measurement due to pressures of social desirability and positive self-presentation.

6. Discussion

Given the complex interactions between humans and the environment, it seems reasonable that when trying to inspire people to act in an environmentally responsible manner, we must consider solutions outside of a single framework to possibly close the gap between attitudes, knowledge and action.

Efficacy of in situ and ex-situ environmental education to foster changes in attitude, knowledge and behavior is liable to geographic and demographic variation.

Country of residence and rural/urban differences were identified as the most significant influential factors concerning baselines and shifts in environmental attitudes, knowledge and behavior. Using country of residence as a single explanatory factor may seem audacious as the variable contains within itself, a huge variety of different influences from politics, education, cultures, societies and natural systems. Yet, this spatial factor appears meaningful enough to determine the probability of shifts in an individual`s perception, devotion and knowledge about the environment even with many other factors considered. Where nationality could not explain any significant shifts in attitude, knowledge or behavior in this study, we suggest that country of residence is far more valuable as a predictor of change *because* of the complex information it holds. It highlights the tangled nature of the social, economic and natural drivers of individual attitude, knowledge and behavioral development.

Outperformance of Bangladeshi residents by the Singaporean, Malaysian and German samples in aspects of attitude and knowledge shifts, supports the assumption of this complex interaction of different circumstantial factors concerning the value of education and conservation among various countries. Singapore follows meritocratic principles, holding that power and prosperity should be vested in individuals almost exclusively based on ability and talent (Barr and Skrbiš 2008; Tan 2008). Therefore, in Singapore there is a strong emphasis on academic achievement as the sole, legitimate means of success. Indeed, in Singapore every child has access to education but there is high pressure to perform well (Drysdale 2010; Lim 2013). Education in Malaysia has also undergone fundamental changes aiming to improve quality of education and improve education rates (Ministry of Education Malaysia 2013). Germany also emphasizes the importance of education and every child has access to it (Maaz et al. 2016). In all three countries, environmental education is an obligatory part of the school curriculum. Bangladesh, in contrast, faces problems in compliance with compulsory education, resulting in 42.3% illiteracy rate in 2013 (UNICEF 2016). Based on the above remarks we explain the varying results across different countries by the determinants for general education that the respective countries offer. The gross domestic product of a country is considered the foundation for educational opportunities and later learning success of the citizens (UNESCO 2016). The wealthier a country is the more it can invest for education. Where in industrialized countries as Germany the principles of sustainable development can variously be promoted they are hardly implementable in developing countries as Bangladesh is one. Singapore may be deemed a tiger state. But other than Malaysia it yields high incomes and invests in education and sustainable development. The results of these inequalities are heavy regional differences in environmental literacy. We do not regard the differences in knowledge shifts across countries after one and the same educational program as coincidences but trace them to the respective stage of development in the respective country.

In this study, however, standards of knowledge or attitude do not appear to correspond to behavioral responses. For instance, Malaysian residents were most likely to display more positive attitudes by T3 but also displayed a low tendency to act as they intended. In contrast, students residing in Bangladesh were more likely to perform their intended behaviors than both Malaysian and German residents despite having significantly lower likelihood of gaining knowledge or improving positivity in the long-term. This corroborates previous work suggesting that attitudes are minor in predicting behavior (Kollmuss and Agyeman 2002) and highlights the complex nature of behavioral drivers. Within a place of residence, we suggest that environmental behavior is shaped by contextual factors, such as individual and public opportunities. Political atmosphere and expression (i.e. environmental campaigns, regulations, laws) may also forge public behavior and social norms (Kinzig et al. 2013). Our findings represent the interaction of environmental education effects and governmental pretensions of the participating countries. Singaporean residents ranked highly both in baseline behaviors performed at T1 and number of behaviors performed at T3 - outperforming Malaysian and German residents. Singapore actively collaborates in global environmental politics and pursues ambitious environmental goals through efficient governmental implementations. Performing above average in Environmental Performance Indices, these implementations may help shape public behavior more effectively than in other countries

who rely more non-governmental organizations for conservation efforts (Bertelsmann Stiftung 2015; Central Intelligence Agency 2015; Economist Intelligence Unit 2011; Kamieniecky 1993; Yale Center for Environmental Law & Policy (YCELP) & Center for International Earth Science Information, 2015).

Rural/urban differences in habitation also played a vital role in our study. It helped explain baseline values in attitude, knowledge and behavior. Participants growing up in rural backgrounds exhibited the most positive environmental attitudes, higher knowledge levels and demonstrated more environmentally-friendly behaviors, reiterating the importance of rural/urban residence found by others (Berenguer, Corraliza, and Martín 2005; Gifford and Sussman 2012; Hinds and Sparks 2008; Huddart-Kennedy et al. 2009). Exposure to nature may generate more positive attitudes and increase awareness of environmental issues close to home, evoking greater environmental concern. What's more, rural residents from Asian countries participating in this study may consistently experience natural disasters (e.g. flood, tsunamis and tidal bores) and human-induced environmental incidents such as land degradation and erosion or the pollution of air and water (Central Intelligence Agency 2015; WWF - Malaysia, 2001). Direct involvement is more likely to evoke environmental awareness and concern and thereby foster more positive attitudes than indirect information delivered to more resilient urban areas (Rajecki 1982; Ullah, Hasan, and Uddin 2013). Increased access to nature and first-hand experiences made there may also influence understanding of natural systems (Arp 1996; Bassett, Jenkins-Smith, and Silva 1996; Elliott et al. 1993) explaining results presented here. Further, the direct experience of natural phenomena could foster the investigative spirit and lead to a deeper examination of those experienced natural environment.

Gender specific differences were also significant in explaining baseline attitudes in line with other works (Chan 1996; Lee 2009; Tikka, Kuitunen, and Tynys 2000; Torgler, García - Valiñas, and Macintyre 2008). The association of females with greater concern for the environment is assumed to be a product of their socialization to the role of caregivers (Eisenberg 2002; Gilligan 1982). It is possible that traditional normative and moral role models of the past decades are maintained and still have relevance to younger age groups. Notably, while girls showed more positive baseline attitudes this effect did not influence the value of the intervention. Instead, boys were just as likely to show long-term positive attitude shifts as girls indicating that the efficacy of outdoor environmental education does not seem to hold a gender bias.

Students reveal different learning modalities and increased hypothetical and deductive intelligences at different stages in their growth (Farr 2010; Sternberg and Kaufmann 2011) and as expected, increased age contributed to greater baseline environmental knowledge scores. We base our finding of a higher environmental literacy upon Piaget`s theory of cognitive development (Torres and Ash 2007) – a concept that suggests children gradually acquire and use knowledge. Where students in the concrete operational stage (age 7 to 11) are not yet able to think hypothetically, adolescent students progressively develop their knowledge within the formal operation stage (Ginsburg and Opper 1979). Between the age of 11 and 20 years students increasingly learn to logically use abstract concepts and solve problems (Piaget 1972). The implemented knowledge scale contained questions concerning factual knowledge (e.g. photosynthesis) as well as abstract concepts (e.g. average earth temperature) and action-oriented problem solving (e.g. reduction of energy consumption). Given that age remained a significant factor despite question formulations differing to meet the cognitive capabilities of the respective age groups - our results support Piaget`s theory.

It is logical that students from similar year groups or classes have similar baseline knowledge due to their socialization background and cognitive development. Suggesting that knowledge acquisition is contingent on pre-knowledge and basic concepts, this pattern was also reflected in the experimental groups` knowledge gains. Notably, the German experimental groups regularly out-performed their respective comparison cohort – a pattern not consistently reflected by Singaporean residents. While in some ways this highlights the previously refuted potential value of outdoor environmental programs (Bang et al. 2000; Eagles and Demare 1999), efficacy may be prone to spatial variation. Therefore, future studies should consider the limitations of comparison and experimental comparisons across countries.

It is widely agreed that only a small fraction of pro-environmental behavior can be directly attributed to a greater environmental knowledge base (Kempton, Boster, and Hartley 1995; McFarlane and Boxall

2003; McFarlane and Hunt 2006; Olli, Grendstat, and Wolleback, 2001), since many other factors are thought to be integral to inspire people to individual conduct (Kollmuss and Agyeman 2002). While the Singaporean and German experimental groups displayed the greatest knowledge change and Singaporean residents also performed the greatest number of intended behaviors, this pattern was not proportionally reflected in any other group. If increased knowledge induces pro-environmental behavior, the specificity of knowledge types (Frick, Kaiser, and Wilson 2004) that may be the most influential for provoking behavioral changes should be further examined.

Country of residence appeared as the most consistent predictor of whether outdoor environmental education can yield positive changes in attitudes, knowledge and behavior in this study. However, observed shifts in attitude and knowledge from students from a specified country of residence did not equate to similar trends in their behavior. Instead we highlight that for a given outdoor environmental education approach, there will likely be spatial variation in its ability to both foster environmental literacy or illicit pro-environmental action. Indeed, the very value of outdoor education compared with classroom comparisons exhibited variability between countries. Detecting such strong signal from country of residence across attitude, knowledge and behavior, within such a broad multivariate study, suggests that environmental understanding and stewardship is forged based on both societal norms and immediate relevance for the individual. Thus, we suggest that outdoor education programs should aim to contextualize their objectives within the landscape of social and natural pressures participating students are exposed to in their home country in order to create a bond to the personal natural surrounding and to make the content of these programs meaningful to the participants. Further, this should also account for contrasts between environmental issues experienced in urban areas with those in rural settings. This may be the most efficient path to fostering attitudes, knowledge and behavior that works towards a sustainable future.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix. Environmental knowledge items

Global	(f)	Deforestation causes…	A change in the amount of rainfall
			Destruction of habitats
			A dryer and hotter climate
	(f)	Which of the following is the reason for the greenhouse effect?	A more fertile ground
			The proceeding destruction of the ozone layer
			The increased vegetation on earth
			The increased amount of carbon dioxide in the atmosphere
			The melting of the polar ice caps
	(p)	You can minimize the energy consumption by…	Wasting less warm water
			Using the air-condition on high level
			Turning off the lights when you leave a room
			Leaving electric devices on the standby mode
	(p)	What can you contribute to the conservation of plants and animals?	Feeding birds in the park with bread
			Consuming organic farming products
			Buying products of endangered species (e.g. ivory)
			Keeping a pet (e.g. a dog)
	(p)	By using which kind of bottle do you damage the environment the most?	One-way glass bottles
			Returnable glass bottle
			One-way plastic bottle
			Returnable plastic bottle
	(p)	By denying which food(s) can you save the most greenhouse gases?	Fruits and vegetables
			Meat
			Bread and rice
			Sweets
	(f)	What is the name of the process by which plants produce oxygen with the help of the sunlight?	Mitosis
			Photosynthesis
			Apoptosis
			Metamorphosis
	(p)	The temperature on earth averages +15 °C. Where would the temperature lie without the natural greenhouse effect?	+12 °C
			+5 °C
			−18 °C
			+20 °C

(*Continued*)

Appendix. (*Continued*)

Regional - Asian	(f)	Which of these products do not contain palm oil?	Paper
			Soap
			Chocolate
			Cosmetics
	(f)	The name of which great ape species means "person of the forest" in Malaysian?	Chimpanzee
			Gorilla
			Orangutan
			Gibbon
	(f)	What are mangroves important for?	Desalination of seawater
			Water filter
			Coast protection
			Building fish farms
	(f)	Which are layers of the rainforest?	Understory layer
			Basement layer
			Emergent layer
			Canopy layer
Regional – German	(f)	Which are coniferous trees?	Beech tree
			Douglas fir
			Cedar
			Spruce
	(f)	Which is the overwintering strategy of the European squirrel?	Winter sleep
			Hibernation
			Torpor
			None
	(f)	What is a boskop?	A type of pear
			A type of apple
			A bird
			A tree
	(f)	Which types of a maple tree do exist?	Field maple
			Round maple
			Norway maple
			French maple

(f) = factual knowledge, (p) = problem solving. Correct answers are highlighted. Each item had the response option 'I don't know'.

3 Publication C: Evaluating Three Dimensions of Environmental Knowledge and Their Impact on Behaviour

Author`s contributions

Authors:

Tina Braun (TB, PhD candidate),

Paul Dierkes (PD)

(1) Development and planning

PhD candidate (TB): 90%
PD: 10%

(2) Execution of surveys and experiments

PhD candidate (TB): obtained the permission to work as a field biologist and conduct the research, developed the educational program, recruited school classes, organized the fieldtrips, familiarized the staff with the program, implemented the educational program, collected data (environmental knowledge dimensions) (100%)

(3) Compilation of datasets and preparation of figures

PhD candidate (TB): organized and prepared all data collected before, during and after the fieldtrips for the analyses. TB prepared all figures and tables presented in the manuscript and supplementary info (100%)

(4) Data analyses and interpretation of results

PhD candidate (TB): conducted all statistical analyses and interpreted results (90%)
PD: supervised analyses and contributed to the interpretation of results (10%)

(5) Preparation of manuscript

PhD candidate (TB): 95%
PD: 5%

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Evaluating Three Dimensions of Environmental Knowledge and Their Impact on Behaviour

Tina Braun[1] · **Paul Dierkes**[1]

Abstract This research evaluates the development of three environmental knowledge dimensions of secondary school students after participation in a singular 1-day outdoor education programme. Applying a cross-national approach, system, action-related and effectiveness knowledge levels of students educated in Germany and Singapore were assessed before and after intervention participation. Correlations between single knowledge dimensions and behaviour changes due to the environmental education intervention were examined. The authors applied a pre-, post- and retention test design and developed a unique multiple-choice instrument. Results indicate significant baseline differences in the prevalence of the different knowledge dimensions between subgroups. Both intervention subsamples showed a low presence of all baseline knowledge dimensions. Action-related knowledge levels were higher than those of system and effectiveness knowledge. Subsample-specific differences in performed pro-environmental behaviour were also significant. Both experimental groups showed significant immediate and sustained knowledge increases in the three dimensions after programme participation. Neither of the two control cohorts showed any significant increase in any knowledge dimension. Effectiveness knowledge improved most. The amount of demonstrated environmental actions increased significantly in both intervention groups. Both control cohorts did not show shifts in environmental behaviour. Yet, only weak correlations between any knowledge dimension and behaviour could be found.

Keywords Environmental education · Out-of-school learning · System knowledge · Action-related knowledge · Effectiveness knowledge · Environmental behaviour

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Introduction

Over the past 40 years, the promotion of sustainable, pro-environmental behaviour has been the primary goal of environmental education. More recently, educational interventions have focused heavily on the enhancement of environmental knowledge as a crucial prerequisite for provoking more environmentally friendly behaviour (Kaiser et al. 2008). Findings from current literature in environmental sustainability research provide evidence that a profound knowledge base does not directly lead to a more responsible behaviour. Instead, information-based educational approaches have yielded limited efficacy for instigating behavioural changes among learners (Barr 2003; Finger 2010; Leiserowitz et al. 2005; McKenzie-Mohr 2000; Stern 2000; Trumbo and O'Keefe 2001).

For years, the relationship between knowledge and behaviour was the focus of environmental studies. Current research explains the failure in promoting pro-environmental behaviour by increasing knowledge with the lack of a full understanding for the relationship between these two factors (Finger 2010; McKenzie-Mohr 2000; Simmons and Volk 2002). Still, although knowledge seems to be insufficient in solely predicting pro-environmental behaviour, the importance of knowledge as prerequisite of pro-environmental behaviour is increasingly accepted (Frick et al. 2004; Grob 1995; Schultz 2013; Wiek et al. 2011). Finally, Kaiser and Fuhrer (2003) highlight the necessary condition of convergent development of different dimensions of knowledge in order to promote environmentally friendly behaviour. They presented an overall framework that links pre-conditions for behaviour to effective educational methods for sustainability.

To date, most studies solely focus on one (Bang et al. 2000; Gambro and Switzky 1999; Leeming et al. 1995; Moore et al. 1994; Simmons and Volk 2002) or two (Hines et al. 1986-1987; Schahn and Holzer 1990; Schultz 2002) dimensions of environmental knowledge. None of these studies examines a possible influence of an educational programme on the development of the single knowledge dimensions. Few studies investigate multiple knowledge dimensions in their research (Frick et al. 2004; Liefländer et al. 2015) or investigate the role of interaction between declarative, procedural and effective knowledge for causing behavioural shifts. An extensive literature search could not identify results for the quantification of the relationship between knowledge increase and shifts in behavioural patterns. In their large-scale study, Frick et al. (2004) found that action-related and effectiveness knowledge directly contribute to behavioural performances, whereas system knowledge remains unrelated to behaviour. Interestingly, Liefländer et al. (2015) provided evidence that a 4-day environmental education programme can foster each knowledge dimension. On that basis, it seems to be meaningful to examine whether shorter programmes that are better includable into regular teaching can have a comparable effect on fostering the single knowledge dimensions.

There are studies that confirm the efficacy of 1-day environmental programmes in promoting an increase in students' knowledge levels (Farmer et al. 2010; Kinder 2012; Nates et al. 2012; Sellmann and Bogner 2012), but no study focused on the differences between single knowledge dimensions. Since literature calls them to be significant in determining the later probability of environmentally friendly behaviour, it seems necessary to examine the influence of such programmes on fostering the different knowledge dimensions. Moreover, it is crucial to find out whether in our globalized world there exist differences due to spatial variation.

This study is the first to evaluate the development of the three environmental knowledge dimensions *system*, *action-related* and *efficiency* knowledge among secondary school students after participation in a singular outdoor educational intervention. Also, this study makes a

cross-national comparison between students educated in Germany and Singapore. The detected shifts in each knowledge dimension are correlated to eventual changes in the students' performed environmental behaviour. By employing this cross-national approach and showing a wider age range of participants than other comparable works, we extend the current fragmented stock of knowledge studies.

Environmental Knowledge Dimensions

Traditionally, school education regards the acquisition of factual knowledge as the main objective and criterion for success (Kaiser et al. 2008b; Simmons and Volk 2002). According to Frick et al. (2004) environmental knowledge incorporates at least three different subtypes: system, action-related and effectiveness knowledge. To enable a person to act in an environmentally friendly manner, they must primarily understand the basic structural and functional characteristics of an ecosystem (system knowledge). Furthermore, knowledge about solutions for environmental issues (action-related knowledge) and the benefit of sustainable actions (effectiveness knowledge) are deemed crucial for an individual to choose a set of behaviours.

System knowledge relates to the information about basic structures and functions of environmental ecosystems as well as the awareness of environmental problems (Kaiser and Fuhrer 2003). It focuses on techniques, mechanics and biophysical processes within these ecosystems. For example, the knowledge that the majority of the earth's organisms are dependent on water and that the demand from the burgeoning global human population is increasing water scarcity functions as an exacerbating environmental and social stressor.

While the linear information deficit model claims that system environmental knowledge automatically increases awareness and ultimately results in eco-friendly behaviour, it is widely agreed that system knowledge is insufficient to change behavioural patterns in isolation (Kollmuss and Agyeman 2002; Lévy-Leboyer et al. 1996; Schultz 2002; Stern 2000). However, Monroe (2003) concludes that despite this, system knowledge has a potential to form action-related and effectiveness knowledge.

Action-related knowledge is essential in order to be able to take advantage of possible strategies within a set of circumstances. Research indicates that compared to system knowledge, action-related knowledge is more effective in fostering behavioural changes (Kaiser and Fuhrer 2003; Smith-Sebasto and Fortner 1994). Martens et al. (2001) suggest this efficacy could derive from the more behaviour-proximal nature of action-related knowledge. Effectiveness knowledge addresses *know-how* information, providing a range of possible behavioural courses of action (Frick et al. 2004; Kaiser and Fuhrer 2003; Monroe 2003). Action-related knowledge answers questions of *how to* without being loaded with value attributions. For example, the acquisition of action-related knowledge transmits knowledge of possible solutions to reduce global water scarcity and thereby allows people to act appropriately according to certain circumstances. Where Kaiser and Fuhrer (2003) do not differentiate between the terms action-related and procedural knowledge, Frick et al. (2004) affirms that the two should not be confused. The explanation lies in the nature of effectiveness knowledge, which contrary to action-related knowledge has direct or indirect relevance for individual action and goes beyond merely addressing discrete skills and action schemas. Possessing particular action-related knowledge, individuals know that they can save water by showering instead of taking a bath. Still, this type of knowledge does not answer the question of how effective this economy measure is.

Research suggests that effectiveness knowledge is crucial for achieving a certain behavioural goal (Frick et al. 2004; Kaiser and Fuhrer 2003). It is bound to subjective values, attitudes and norms and addresses the relative conservational effectiveness related to specific actions. Effectiveness knowledge values certain behavioural patterns and thereby shapes how actions influence the environment (Frick et al. 2004; Kaiser and Fuhrer 2003; Monroe 2003). If an individual does not think of saving water as a cost-effective or sustainable means of nature conservation, this negative attitude may affect behavioural output.

It is suggested that rather than in isolated components, knowledge convergence is critical to achieving a conservational goal, where each knowledge type must jointly promote environmentally friendly behaviour (Kaiser and Fuhrer 2003).

Social knowledge is a fourth dimension of knowledge which is sometimes included in educational research; however, due to its subjective nature, it is not possible to assess and compare it to other one-dimensional knowledge types. Consequently, social knowledge has been precluded from this study.

Environmental Behaviour

The world is facing environmental issues as global warming or habitat pollution and human behaviour can be seen as a major reason for many of these problems (DuNann Winter and Koger 2004; Vlek and Steg 2007). Given that all human actions have in some way an impact on the environment (e.g. traffic use, waste production, energy consumption), environmental behaviour in a narrow sense refers to behavioural modes that significantly try to reduce the negative human impact on the environment or seek to promote the health of the environment (Kollmuss and Agyeman 2002; Stern 2000). These individual environmental behaviours can include the recycling of waste, the use of public transport instead of a private car or the reduction of animal food.

Various research groups explored factors predicting environmental behaviour (Hines et al. 1986–1987; Kollmuss and Agyeman 2002; Mobley et al. 2010; Riess 2003; Vlek and Steg 2007), but still, no theoretical framework could entirely explain all aspects that cause environmental behaviour and its interrelations with other factors. Hence, teaching individuals the skills which are essential to achieve changes towards a healthier environment seems central for evoking environmental behaviour (Heimlich & Ardoin 2008; Kollmuss and Agyeman 2002). Commonly, knowledge is suggested to potentially but not with certainty cause environmental behaviour (Frick et al. 2004; Hinds and Sparks 2008; Kaiser et al. 2008b; Schultz 2001). Till the present date, research repeatedly experiences a gap between knowledge and action (Gräsel 2000; Rajecki 1982; Riess 2003), and current research suggests the existence of further explanatory demographic, internal or external factors when it comes to environmental behaviour (Gifford and Nilsson 2014; Kollmuss and Agyeman 2002).

Methods

Study Design

Data was acquired between June 2014 and February 2015 in Singapore and Germany, applying a pre-, post- and retention test design (Pospeschill 2013). Participants' baseline scores in system, action-related and effectiveness knowledge as well as baseline values in

environmental behaviour were collected at school via paper and pencil questionnaires two weeks prior to the educational intervention (T1). Short-term changes in the single knowledge dimensions and behaviour values were then evaluated by data gathered at the programme venue immediately after intervention (T2). A third questionnaire was completed at school six weeks after intervention (T3) to quantify sustained changes. Test items were presented in a different order at each test time. The evaluation process was conceded by every study participant.

Sampling

The sampling consisted of two bilateral experimental cohorts involving secondary school students educated in Germany (N_1 = 112) and Singapore (N_2 = 102). The sampling also entailed two respective control groups living in Germany (N_3 = 92) or Singapore (N_4 = 90) that ensured the exclusion of any learning effects due to the repeated completion of the questionnaire. Table 1 depicts the composition of the single subsamples.

The control cohorts did not take part in the educational programme but attended scheduled school lessons covering the same topics as implemented in the educational programme. Both control groups completed the same survey questionnaires as the experimental group within the same time frame. To ensure a preferably direct comparability of the samples, most of the control cohort students derived from a parallel class of the experimental cohort. The experimental sample consisted of nine heterogeneous secondary school classes from lower to upper secondary school. Singaporean classes belonged to international schools following the British or North American school system. The German sampling was collected from local and international schools following the German educational system. In order to have preferably comparable samples, German participants were recruited from three school types (hauptschule, realschule, gymnasium). Special needs schools were excluded.

The control cohorts consisted of seven secondary school classes. Participants were recruited through invitation by mail. Fourteen schools in Germany and 11 schools in Singapore were contacted and received information about the educational programme concomitant with its evaluation. There are differences in the sampling sizes due to the different numbers of registration for the touted environmental study and the willingness of the individual students to participate in the study. All programme participants were aware that their evaluation was purely voluntary. As most of the participants were children and not of legal age, informed

Table 1 Sampling composition

		Samplings			
		Experimental		Control	
		Germany—N_1 (GER)	Singapore—N_2 (SG)	Germany—N_3 (conGER)	Singapore—N_4 (conSG)
N		112	102	92	90
Age (years)	10–12	46	42	27	27
	13–15	34	40	39	35
	16–18	32	20	26	28
Gender	Female	54	59	49	40
	Male	58	43	43	50

participant and parental consent was gained prior to the intervention. All students and parents were informed about the details of the study contents, the research process and the data storage. Singaporean sampling classes registered for the evaluated outdoor education programme directed through Ecofieldtrips. The programme conducted in Germany was realized by the Department for Bioscience Education at the Goethe University, Frankfurt.

Outdoor Environmental Education Programme

The educational programme presented in this study focuses on imparting the three knowledge types—system, action-related and effectiveness knowledge. Instead of solely trying to increase the knowledge levels of participating students, convergences of different knowledge types and their correlation to behavioural changes was the main focus of the presented educational intervention.

The educational programme was embedded in a 1-day field excursion to an informal learning centre. Guided by environmental teachers from the Department for Bioscience Education at the Goethe University in Frankfurt, participants from the German experimental group visited the MainÄppelHaus Lohrberg, a learning centre on an orchard meadow in Frankfurt. This orchard meadow provides heterogeneous biotopes, including forest and lentic freshwater systems. All Singaporean participants attended a field course to Tioman Island in Malaysia which has a similar degree of heterogeneity. The programme contents of both interventions consisted of the same cognitive and affective tasks which have been coordinated to ensure a comparative educational framework.

Participants attended three modules during the intervention: *forest ecosystems*, *freshwater ecosystems* and *culture and conservation*. The overarching aims were the extension of students' classroom knowledge and the promotion of a profound understanding for ecosystem function and importance, hopefully fostering responsibility and environmental engagement. Both learning sites were rich in diversity and were a convenient setting for exposing students to concepts and sampling methods used in environmental sciences.

The freshwater module focused on invertebrates, food webs and water quality monitoring. Students had to catch, describe and classify freshwater fauna, as well as quantify physical and chemical ecosystem characteristics. The aim of the forest ecosystem module was to expose students to forest ecology, including global distribution, associated food webs and ecosystem services. Quantitative studies also assessed tree height, light intensity and biodiversity indices.

The module *culture and conservation* focused on topics such as global warming, renewable energies, crop security and individual contributions to environmental stewardship.

Action-related and effectiveness knowledge were addressed in particular through participants designing individual conservation projects. Proposed projects needed to address ecosystem restoration by weighting personal effort and conservational benefit and explain the significance of the proposal.

In order to answer the needs of the different learning groups, the difficulty level was determined according to the respective age cluster and school type. The didactical methods were student-centred, multisensory and based on hands-on activities. All students worked in groups which changed their composition between each module. Learning in cooperative groups fosters social and practical competences and thus supports cognitive achievements (Lord 2001). Each module was supervised by an environmental teacher either from Goethe

University or from Ecofieldtrips. Each student had a booklet for securing the results and making notes.

Measuring Instrument

Following the *ask the same question* approach (Harkness 2003) in a cross-national collaboration, the authors created and selected items for the source questionnaire. For equal assessment of all subsamples, the same questionnaire was translated into German and back-translated into the English language before both versions were compared.

To date, there is no standardized comparable set of questions assessing the three environmental knowledge subtypes simultaneously, and in response, the authors autonomously developed a unique instrument consisting of six single- and multiple-choice questions each addressing system, action-related and effectiveness knowledge (see Table 4, appendix). Referring to the knowledge scales of Liefländer et al. (2015), a set of items appropriate for defining the programmes' effects was established. For obtaining a choice of possible answers, the questions were handed to non-participating secondary school students deriving from the same age group who had to come up with possible answers to the referring questions. Appropriateness of the suggested answers was then validated by environmental teachers from Goethe University, Germany, and by environmental education specialists from Ecofieldtrips Environmental Education, Singapore. Prior to the final selection of items, the pre-questionnaire was pilot-tested with one school class respectively in Singapore and Germany covering students aged 10 to 12 to assure that the developed scale was valid. Psychometric characteristics as well as the validity and the internal reliability of the knowledge set were corroborated. Item difficulty was tested and is to be found in the medium range (Øpi = 0.5). Cronbach's α for internal consistency was acceptable (αT1 = 0.785, αT2 = 0.772, αT3 = 0.792). Frequency distribution of test values is located within normal distribution. Items show an appropriate selectivity of r_{it} = 0.6. Since the selected questions aimed at syllabus-relevant content, teachers of the participating classes were asked not to cover any of the topics that would be conducted in the programme and assessed through the questionnaire.

The scale for measuring changes in environmental behaviour was modified from Bögeholz (1999) to the aims of the present study (see Table 5, appendix). Validity and reliability of the scale have been established (Bögeholz 1999). The scale involves a set of different specific actions in the field of environmental conservation, waste management, energy consumption and transport which can be multiply chosen. For measuring baseline behaviour at T1, participants could tick up to six items representing environment-friendly actions. For confirming programme-related changes, the same scale was used at T2. If the values did not vary from T1 to T2, it is safe to assume that changes between T2 and T3 would be contingent on the programme participation. Realized changes in behaviour were validated 6 weeks after instruction, enquiring the same items as in the pre- and post-test.

Statistical Analysis

Statistical analyses were conducted using SPSS v.22. Multiple considerations of the data justify the application of non-parametric analysis. First, Kolmogorov-Smirnov testing could not confirm assumptions about normally distributed data within this set ($p < .01$). Further,

Levene's test detected a heteroscedasticity of variance ($p < .05$). Extreme values in the data set were included in order not to present a palliated result. Finally, a linear dependency of the dependent variable could not be detected regarding the independent variable. So, analysis types were run that do not presume homoscedasticity of the residuals and that can handle ordinal data without being affected by outliners. Internal scale consistency was measured using Cronbach's alpha. Environmental knowledge test scores for the single knowledge types were calculated adding up the single item results. All knowledge scores were converted to percentages. Knowledge and behaviour scores among samples were compared using Kruskal-Wallis one-way analysis of variance followed by Mann-Whitney testing. Temporal shifts between subgroups across the different measurements were explored using Friedman test followed by post hoc Wilcoxon signed rank testing. Constant error variance and presence of heteroscedasticity were confirmed using Levene's test, and correlation coefficients were calculated according to Spearman (Nisbet et al. 2009). Concerning occurring problems with type I errors when doing multiple comparisons, Holm-Bonferroni tests were run in order to control family-wise error rate.

Results

Baseline Values

Kruskal-Wallis testing revealed highly significant baseline differences in the prevalence of different knowledge dimensions between subgroups ($p < .01$). Figure 1 shows the availability of the three different knowledge types among the probands. No significant variations in system knowledge could be detected between the Singaporean and the German experimental groups, but the Singaporean experimental cohort yielded significantly higher system knowledge scores than its respective control cohort ($p < .001$). Yet, German control students displayed a significantly higher system knowledge level

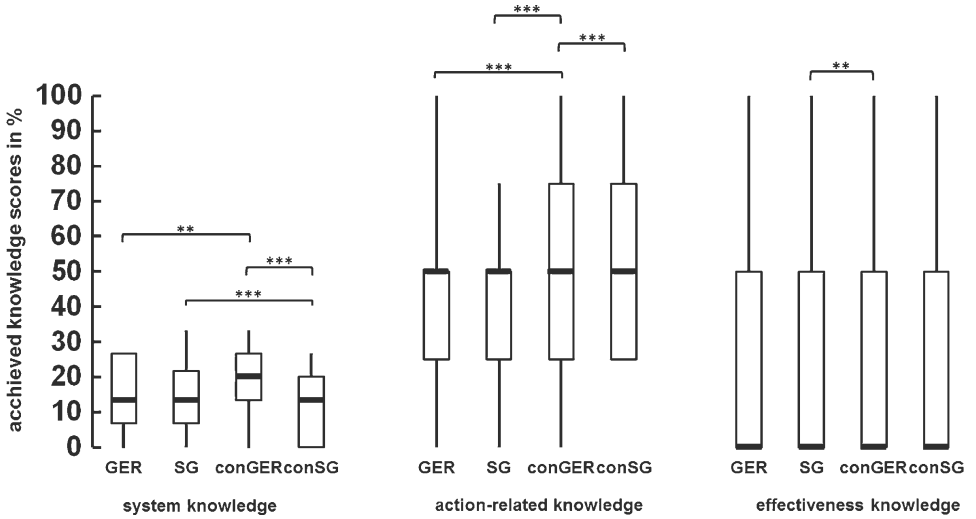

Fig. 1 Baseline knowledge dimensions of single subsamples. Significant differences are marked with ***$p < .001$; **$p < .01$; *$p < .05$. Non-significant differences are not marked. The first quartile represents the *bottom* and the third quartile is the *top* of the *boxplot*. The *ends of the whiskers* represent all data from 5% as minimum to 95% as maximum

than the Singaporean control ($p < .001$) and German experimental cohort ($p < .01$). Furthermore, the German control cohort achieved significantly higher baseline action-related knowledge scores in the results compared to German experimental and both Singaporean cohorts ($p < .05$). In effectiveness knowledge, both experimental groups scored significantly lower compared to their respective control cohorts ($p < .05$) with the German control cohort attaining significantly higher scores in effectiveness knowledge than the Singaporean experimental students ($p < .01$).

Differences in baseline environmental behaviour are highly significant ($p < .001$). As Fig. 2 illustrates, only the Singaporean experimental cohort displayed a significant shift towards a higher number of environmental-friendly actions ($p < .01$). All other groups show lower levels of environmental actions.

Outdoor Education Program Effects on Knowledge and Behaviour

After participating in the educational programme, both intervention groups immediately increased their knowledge levels in all three dimensions ($p < .05$). Figure 3 shows the shifts in all three knowledge dimensions at all test times. Additionally, Table 2 illustrates the mean scores and the standard derivation of the three environmental knowledge dimensions at the three measuring times. The mean values illustrate the shifts of the single subsamples more vividly than the median does even though for the analysis the median is the more valid resource.

As can be seen in Fig. 3, the intervention groups showed the greatest percentage increase in effectiveness knowledge ($\%_{sys} = +5.22$; $\%_{action} = +9.72$; $\%_{effectiveness} = +26.52$), although no significant differences could be detected between subgroups. Students in the German experimental group demonstrated a significantly greater increase in system knowledge compared to the Singaporean sample ($p < .05$; $d_{SG} = 0.503$; $d_{GER} = 0.774$), and the same pattern was observed for action-related knowledge ($p < .05$; $d_{SG} = 0.261$; $d_{GER} = 0.768$). Neither of the two control cohorts showed any significant increase in any knowledge dimension.

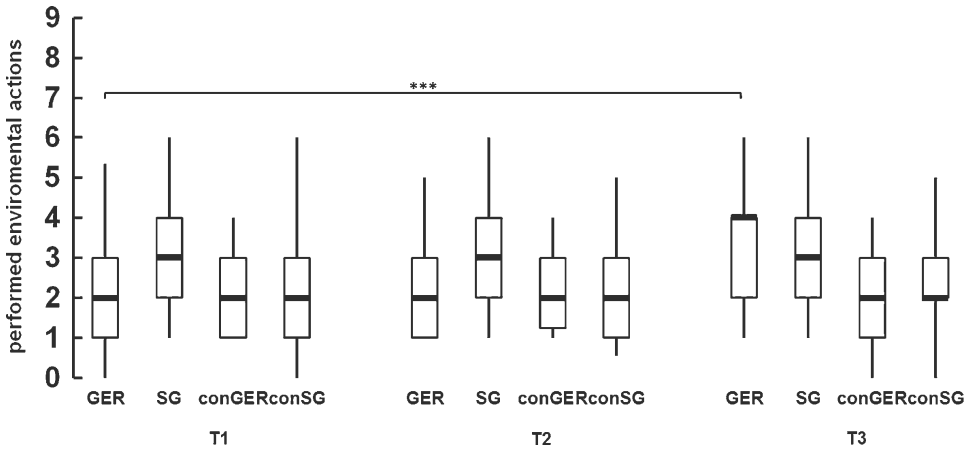

Fig. 2 Performed environmental actions at all test times. Significant differences are marked with ***$p < .001$; **$p < .01$; *$p < .05$. Non-significant differences are not marked. The first quartile represents the *bottom* and the third quartile is the *top* of the *boxplot*. The *ends of the whiskers* represent all data from 5% as minimum to 95% as maximum

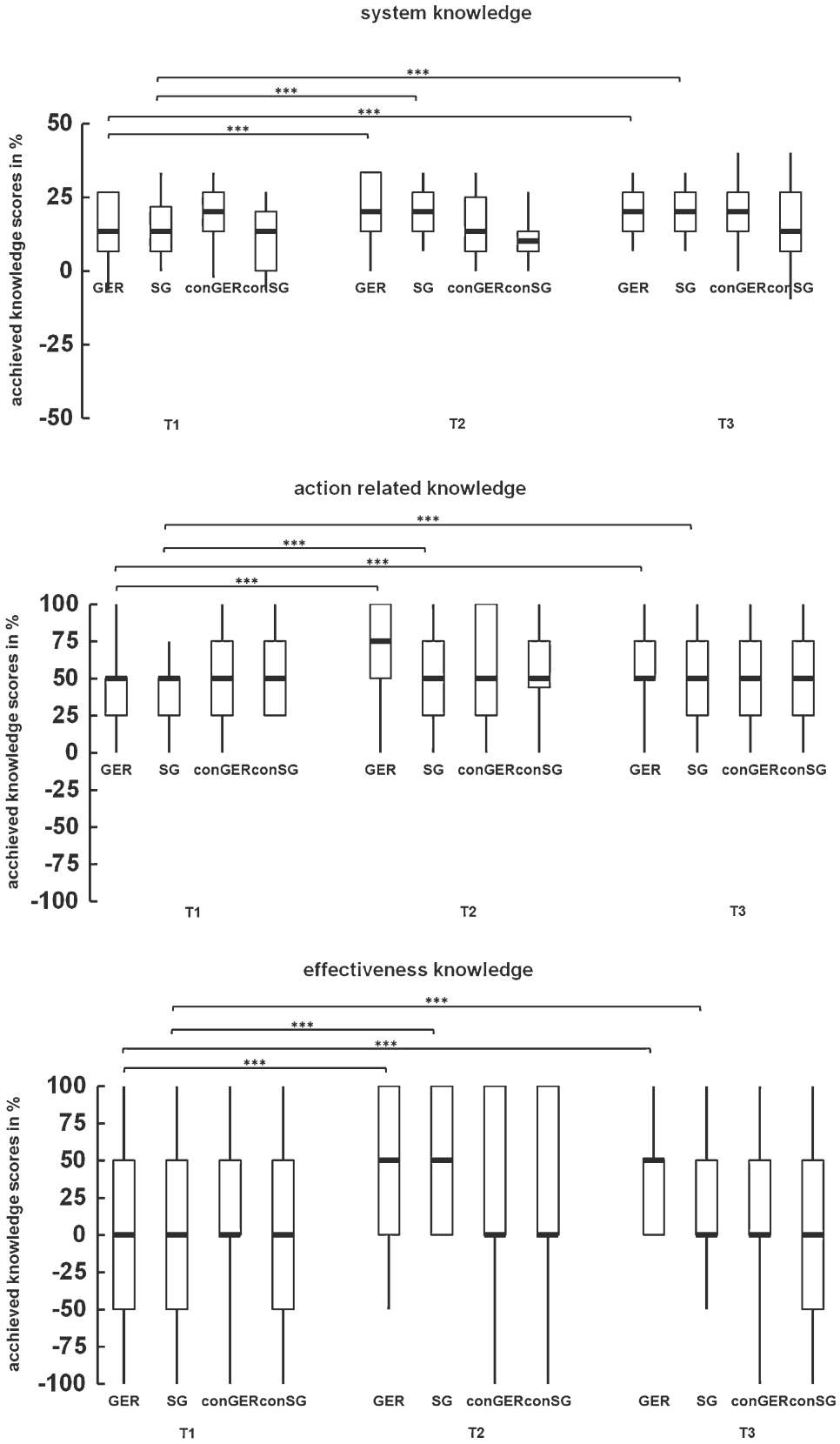

Fig. 3 Shifts in the three knowledge dimensions. Significant differences are marked with ***$p < .001$; **$p < .01$; *$p < .05$. Non-significant differences are not marked. The first quartile represents the *bottom* and the third quartile is the *top* of the *boxplot*. The *ends of the whiskers* represent all data from 5% as minimum to 95% as maximum

Table 2 Mean scores and standard deviation of environmental knowledge dimensions at the three measuring times

Knowledge dimension	Measure time		Sample			
			Experimental		Control	
			Sg	Ger	Sg	Ger
System	T1	Mean	2.35	1.97	1.62	2.62
		SD	1.596	1.742	1.503	1.766
	T2	Mean	3.12	3.25	1.56	2.28
		SD	1.464	1.559	1.237	1.507
	T3	Mean	3.25	3.04	2.21	2.86
		SD	1.525	1.454	2.091	1.621
Action-related	T1	Mean	1.66	1.55	1.99	2.34
		SD	1.029	1.199	1.117	1.243
	T2	Mean	1.94	2.53	2.18	2.33
		SD	1.115	1.349	1.045	1.293
	T3	Mean	2.15	2.34	2.14	2.14
		SD	1.120	1.174	1.087	1.347
Effectiveness	T1	Mean	−.11	.11	.23	.42
		SD	1.226	1.110	1.218	1.122
	T2	Mean	.96	.83	.43	.45
		SD	.922	1.073	1.181	1.252
	T3	Mean	.41	.74	−.08	.41
		SD	.871	.756	1.334	1.197

Programme participation led to sustained increases in all knowledge dimensions in both experimental groups ($p < 001$) with the greatest percentage increase performed in effectiveness knowledge ($\%_{sys}$ = +11.06; $\%_{action}$ = +16.12; $\%_{effectiveness}$ = +28.97). In keeping with the relatively homogenous medium strengthened effect sizes (d_{SGsys} = 0.577; $d_{SGaction}$ = 0.456; $d_{SGeffect}$ = 0.489; d_{GERsys} = 0.667; $d_{GERaction}$ = 0.666; $d_{GEReffect}$ = 0.663), the increases concerning the three knowledge dimensions do not significantly differ between either intervention groups. Non-participation by control groups failed to yield any sustainable changes in any knowledge dimension.

Immediately after the intervention, both experimental cohorts significantly increased their number of environmentally friendly actions ($p < .05$). Across all three measuring times, however, only the German intervention group displayed sustained behavioural changes from pre- to retention testing ($p < .001$), demonstrating a sustainably increased number of environmentally friendly actions. In contrast, the Singaporean experimental sample did not show marked increases in the number of environmentally friendly actions. Control cohorts showed neither immediate nor sustained shifts in behaviour. Figure 2 illustrates the performed environmental behaviour of the subgroups.

Knowledge Inter-correlation

System knowledge at T2 correlates with action-related knowledge ($r = .141$; $p < .05$) but does not affect effectiveness knowledge significantly ($r = .081$). Action-related knowledge, however, shows a weak correlation with effectiveness knowledge ($r = .138$; $p < .01$).

Table 3 Correlations between the three knowledge types (system, action-related and effectiveness) and behaviour at the three measuring times

	Knowledge type			
	Measuring time	System	Action-related	Effectiveness
Behaviour	T1	.312	.238	−.060
	T2	.134	.113	.080
	T3	.098	.129	.102

Correlation coefficients were calculated according to Spearman (r)

Correlation Between Knowledge Dimensions and Behaviour

Table 3 depicts the correlations between system, action-related and effectiveness knowledge regarding behaviour at the three measuring times. As can be seen, data from this study suggests weak correlations between the single dimensions system and action-related knowledge and baseline behaviour (r_{sys} = .312, p < .01; r_{action} = .238, p < .01). Effectiveness knowledge did yield a weak negative correlation with behaviour (r_{effect} = −.060). Increased system and action-related knowledge at T2 correlated weakly with the sustained performed behaviour at T3 (r_{sys} = .134, p < .01; r_{action} = .113, p < .05; r_{effect} = .080). Sustained system knowledge did not affect performed behavioural patterns (r_{sys} = .098). Both action-related and effectiveness knowledge at T3 weakly correlated with performed behaviour (r_{action} = .129, p < .05; r_{effect} = .102, p < .05).

Study Limitations

When it comes to teaching individuals effectiveness knowledge and attempting to make them understand how their actions impact the environment, educators must be aware that in general, people selectively process information to match their values and beliefs (Kollmuss and Agyeman 2002). Therefore, even if the goals of an educational intervention are accurately pursued and the methods are selected and implemented appropriately, the attitude of the learner might have an impact on the results (Candeias et al. 2010; Reed et al. 2010), which was not controlled within this study.

This study is broad in scope in order to yield representative results. As a consequence of the wide age range and the multinational setting, ensuring equality of the educational intervention was challenging. The study content of both interventions in Germany and Singapore was synchronized with both programmes focused on global environmental issues and individual contributions to nature conservation. Even though the general structure of ecosystems remained the same, due to the varying characteristics of biodiversity in the two distinct world regions, there were differences in the organisms to be demonstrated and examined, such as temperate deciduous vs. tropical rainforests. Of course, there are unavoidable limitations in the experimental groups when it comes to the respective ecosystems and the effect of exposure to them.

With regard to measurement, it has to be recognized that a complete exclusion of confounding factors such as random guessing cannot be guaranteed. The limitations in the *self-report* approach of behavioural measurement should also be acknowledged as a limitation—it is expected that participants will partly exaggerate performed environmental behaviour in order to be viewed favourably. This social desirability could also explain the huge baseline differences in behaviour.

Discussion

The most important findings of this study are the efficacy of the singular outdoor environmental education programme in fostering the three knowledge dimensions, system, action-related and effectiveness knowledge, as well as the correlation between single knowledge dimensions and changes in pro-environmental behaviour. These results are especially significant to the current literature base in environmental sustainability research and will give insights to a broad readership including environmental teachers and researchers.

Both experimental groups increased their knowledge levels in all three dimensions immediately after participation in the outdoor environmental education programme. This indicates the educational success of the programme in fostering knowledge. Greatest shifts were shown in effectiveness knowledge, contrarily to the weak increases in effectiveness knowledge found by Liefländer et al. (2015). However, given the weak baseline values, this dimension had the largest potential for increase. Yet, these results strongly signal that present environmental education does not encourage this type of knowledge nearly enough. Hence, we call for a clear focus on efficiency knowledge when teaching environmental content in order to provide children with the tools and the knowledge of how to contribute to a healthier environment effectively.

Moreover, both intervention groups significantly performed more environmentally friendly behaviours after programme participation which further highlights programme efficacy and calls for the implementation of regular outdoor education events into the curricula in order to achieve sustained behavioural change. We recommend that for achieving sustainable behaviour changes among individuals, the integration of diverse knowledge dimensions into educational approaches is an important method in reducing the anthropocentric conduct. External variables such as cultural, societal or structural restrictions combined with the inefficient influence of singular knowledge aspects may otherwise impose limits on behavioural change.

The results further indicate that short-term behavioural changes correlate with system and action-related knowledge. Long-term changes towards pro-environmental behaviour correspond to action-related and effectiveness knowledge which again strengthens the demand for a change of perspective in environmental education. Hence, in line with previous authors (Frick et al. 2004; Kaiser and Fuhrer 2003) who solely worked with baseline data, we suggest that system knowledge is the foundation for action-related and effectiveness knowledge and hence influences behaviour albeit on a short-term basis. We suggest that individual awareness of specific behavioural options and the knowledge of how these actions impact the environment

offered through heightened effectiveness knowledge is crucial for the prediction of environmental behaviour.

The largest increase in system knowledge was shown by the German experimental sample. This result supports the findings concerning baseline values. This way, the German sample could catch up with the Singaporean sample. Facing its function as pioneering ground, we highlight the importance of focusing on the different types of knowledge in order to enable sustainable and practicable knowledge most effectively.

Various researchers agree upon the existence of national cultural differences which are based on historical, political and societal factors (Hofstede 2001; Nankervis et al. 2002; Patrickson and O'Brien 2001). The data presented in this study suggests that country or culture of socialization and education can play a major role in pre-designating knowledge levels. But it does not necessarily predict shifts in knowledge reliably. With Singapore and Germany, this study presents two strong industrial nations in which environmental education is an obligatory part of the school curriculum. Both countries, Singapore and Germany, strongly emphasize the need for academic achievement as a means of success and wealth (Drysdale 2010; Maaz et al. 2016). Still, when watched as two study samples, students of both world regions yielded comparably low knowledge scores in the single dimensions, despite the prevalence of specific environmental issues in social media today. Only 31.06% (SG 32.12%, Ger 30.14%) of the total study sample could name the increased concentration of carbon dioxide in the atmosphere as a reason for the greenhouse effect, and just 20.46% (SG 21%, Ger 19.93%) were able to discern which food production systems were the most responsible for greenhouse emissions. Analysing the baseline differences concerning the single knowledge levels, there are few significant differences that seem interesting though for the characterization of the single emphases regarding environmental education of both countries. The Singaporean experimental sample demonstrated a significantly higher level of baseline system knowledge compared to the German group where the German control cohort showed the highest level in action-related knowledge. Singapore represents meritocratic principles, holding that prosperity is the exclusive result of success in education (Barr and Skrbiš 2008; Tan 2008). This again highlights the focus on academic achievement and could explain the high level of factual knowledge among Singaporean students. In Germany, however, the focus of environmental practice lies on the individual practicability in order to create the future which again could explain the German sample's higher level of action-related knowledge.

We suggest that there are culture-based differences in different knowledge types that can be explained through different emphases in the educational system of the respective country. Our findings do support other studies suggesting a lack of knowledge about environmental issues among the population (Diekmann and Franzen 1996; Frick et al. 2004). Given the relatively low levels of environmental knowledge types, we found that secondary school students have a higher level of action-related knowledge compared to system knowledge, with effectiveness knowledge the least available dimension. This highlights the necessity of the global promotion of environmental education through external to scholastic approaches in order to manifest sustained behavioural change. But moreover, we claim that the potential to evoke significant shifts were equal in both partaking study countries. In order to analyse culture-based differences in learning

potentials, one would need to compare countries with different structural and political pre-conditions.

The results indicate a small overall knowledge decrease from post-test to retention test which has been shown in previous works as well (Liefländer et al. 2015; Randler et al. 2005). The German intervention group showed a declining tendency in all specific dimensions and corresponded to earlier study results detecting a knowledge decrease after a certain amount of time (Randler et al. 2005). Taking into account both intervention groups, we found no significant decrease in system or action-related knowledge. Merely the level of the effectiveness dimension decreased significantly six weeks after intervention. These results are partly in line with those of the study by Liefländer et al. (2015) who explain this phenomenon by the interrelation of the three knowledge types and the dependency of effectiveness knowledge on system and action-related knowledge. Despite the shifts from post- to retention test, both experimental groups increased their levels in all three knowledge dimensions significantly over the study period. This, plus the fact that both control groups' knowledge levels did not significantly change in any specific dimension, speaks for the efficacy of the educational intervention.

This study underwrites the current research base in sustainability education through new insights into the frequency of different knowledge dimensions among students in Germany and Singapore demonstrating how these knowledge types develop after a singular educational intervention—thus the potential of outdoor environmental education. We provide further evidence that outdoor education programmes provoke increases in crucial knowledge dimensions and furthermore have the potential to foster pro-environmental behaviour.

In light of the interconnection of the single knowledge levels, the current findings indicate that the didactical design of environmental education programmes needs to address all three knowledge dimensions. Since the dimensions build on one another, we suggest that teachers should design their programmes in such a way that they include all dimensions. Students should gain factual knowledge (e.g. about environmental issues) as a basis. Carrying on, they need to gain knowledge about how to solve these problems (e.g. precise options for action). Finally, in order to be able to evaluate single options and to make aware decisions, students need knowledge about how effective these single actions would be.

It needs future studies to confirm these findings in order to extend the so far small literature base. Further research should attempt to develop more universal measuring instruments that enable more practical comparisons within cross-national studies. The development of a methodological framework to explore how specific knowledge dimensions can be promoted through applying various methods would be of interest. However, this study furthers the current literature base on the multidimensionality of knowledge and its interdependencies with environmental behaviour—a valuable concept for future sustainability research.

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Appendix

Table 4 Environmental knowledge items: system knowledge/action-related knowledge/effectiveness

system knowledge	Deforestation causes…	a change in the amount of rainfall
		destruction of habitats
		a dryer and hotter climate
		a more fertile ground
	Which of the following is the reason for the greenhouse effect?	the proceeding destruction of the ozone layer
		the increased vegetation on earth
		the increased amount of carbon dioxide in the atmosphere
		the melting of the polar ice caps
	Which of these products do not contain palm oil?	paper
		soap
		chocolate
		cosmetics
	Which are coniferous trees?	beech tree
		Douglas fir
		palm tree
		spruce
action-related knowledge	What can you contribute to the conservation of plants and animals?	feeding birds in the park with bread
		buying sustainable products (e.g. wood with the FSC seal)
		buying products of endangered species (e.g. ivory)
		planting native vegetation in the yard
	You can minimize the energy consumption by…	wasting less warm water
		using the air-condition on high level
		turning off the lights when you leave a room
		leaving electric devices on the standby mode
	What belongs into a sustainable shopping basket?	seasonal and regional products
		convenience food
		organic food
		imported goods
	How can you contribute to a healthy environment?	wash your clothes less often
		use public transport
		use plastic cups
		eat more meat
effectiveness knowledge	How much water can you safe when you take a shower instead of a bath?	up to 500 liters
		up to 120 liters
		up to 70 liters
		up to 30 liters
	By using which kind of bottle do you damage the environment the most?	one-way glass bottles
		returnable glass bottle
		one-way plastic bottle
		returnable plastic bottle
	By denying which food(s) can you save the most greenhouse gases?	fruits and vegetables
		meat
		bread and rice
		sweets
	How much electricity can you safe by using an energy-saving bulb instead of conventional bulbs?	up to 10%
		up to 20%
		up to 50%
		up to 80%

Table 5 Environmental behaviour items

For the protection of the environment I am going to...	Try to save water
	Use recycled paper
	Refuse products with unnecessary plastic wrapping
	Whenever possible, walk, take the bike or use public transport
	Pay attention to the ingredients of products
	Switch off electric devices when I do not need them

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IV. Appendix

In the appendix the reader finds the applied questionnaires in English and German.
The teaching material is not attached due to their copyright.

EvaSys	Nature study T1	Electric Paper
Goethe University Frankfurt	Tina Braun	
Ecofieldtrips Singapore	2013	

Bitte so markieren: ☐ ☒ ☐ ☐ ☐ cross the correct answer
Korrektur: ☐ ■ ☐ ☒ ☐ black out the wrong answer and cross another box

1. **Individual Code**

Thank you for taking part in this study!

For allocating your responses anonymously we need an individual coding.
For this, please fill in the boxes below.

1.1 1. When is your class going to join the field trip? (e.g. 1st October = **01**)
2. The second letter of your first name (e.g. S**a**rah = **a**)
3. The second letter of your last name (e.g. B**r**own = **r**)
4. Your birthday (e.g. **12**th of July = **12**)

2. **Background information**

2.1 Sex ☐ female ☐ male

2.2 Age ☐ 7 - 9 years ☐ 10 - 12 years ☐ 13 - 15 years ☐ 16 - 18 years

2.3 Nationality

2.4 Is there a patch of nature close by your home (e.g. a forest, a river or farmland)? ☐ yes ☐ no

2.5 Are you member of any nature group (e.g. scouts)? ☐ yes ☐ no

2.6 If yes, which one and for how long?

3. **Environmental Attitude**

3.1	Only useful plants and animals should be protected.	I strongly agree ☐	☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
3.2	Our planet has unlimited resources (e.g. drinking water, wood, coal).	I strongly agree ☐	☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
3.3	Humankind will die out if we don`t live in tune with nature.	I strongly agree ☐	☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
3.4	I think that people worry too much about environmental pollution.	I strongly agree ☐	☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
3.5	It is interesting for me to know which animals live in the rainforest.	I strongly agree ☐	☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
3.6	I enjoy trips to the countryside.	I strongly agree ☐	☐	☐	☐	☐ I strongly disagree	☐ I can`t tell

3. **Environmental Attitude** [Fortsetzung]

3.7	I save water by taking a shower instead of a bath.	I strongly agree ☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
3.8	People are more important that other creatures.	I strongly agree ☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
3.9	Weed has to be pulled up to let useful and beautiful plants grow.	I strongly agree ☐	☐	☐	☐ I strongly disagree	☐ I can`t tell
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3.16	It upsets me to see the counryside taken over by streets and buildings.	I strongly agree ☐	☐	☐	☐ I strongly disagree	☐ I can`t tell

4. **Environmental Knowledge**

Please note: Either one or more than one answer can be right.

4.1 **Which are coniferous trees?**

☐ beech tree ☐ Douglas fir ☐ palm tree
☐ spruce ☐ I don`t know

4.2 **Deforestation causes….**

☐ a change in the amount of rainfall ☐ the destruction of habitats ☐ a dryer and hotter climate
☐ a more fertile ground ☐ I don`t know

4.3 **Which of the following is a reason for the greenhouse effect?**

☐ the proceeding destruction of the ozone layer ☐ the increased vegetation on earth ☐ the increased amount of carbon dioxide in the atmosphere
☐ the melting of the polar ice caps ☐ I don`t know

4.4 **Which of these products do not contain palm oil?**

☐ paper ☐ soap ☐ chocolate
☐ cosmetics ☐ I don`t know

4.5 **In which of these regions do you find tropical rain forests?**

☐ Africa ☐ North America ☐ Europe
☐ Asia ☐ I don`t know

4. **Environmental Knowledge** [Fortsetzung]

4.6 **The temperature on earth averages +15 degrees centigrade. Where would the temperature lie without the natural greenhouse effect?**

☐ + 5 degrees centigrade ☐ + 20 degrees centigrade ☐ - 20 degrees centigrade
☐ - 40 degrees centigrade ☐ I don`t know

4.7 **Which is the biggest animal group on earth?**

☐ birds ☐ reptiles ☐ insects
☐ mammals ☐ I don`t know

4.8 **The name of which great ape species means *person of the forest* in Malaysian?**

☐ orang-utan ☐ chimpanzee ☐ gorilla
☐ gibbon ☐ I don`t know

4.9 **How many percent of the earth`s surface are covered by the sea?**

☐ 10% ☐ 40% ☐ 50%
☐ 70% ☐ I don`t know

4.10 **What are mangroves important for?**

☐ desilination of seawater ☐ coast protection ☐ water filtering
☐ fishing ☐ I don`t know

4.11 **How many seasons of the year do tropical rainforests show?**

☐ 0 ☐ 2 ☐ 3
☐ 4 ☐ I don`t know

4.12 **Which height can trees in the tropical rainforest acchieve?**

☐ 30 metres ☐ 50 metres ☐ 70 metres
☐ 100 metres ☐ I don`t know

5. **Environmental Action**

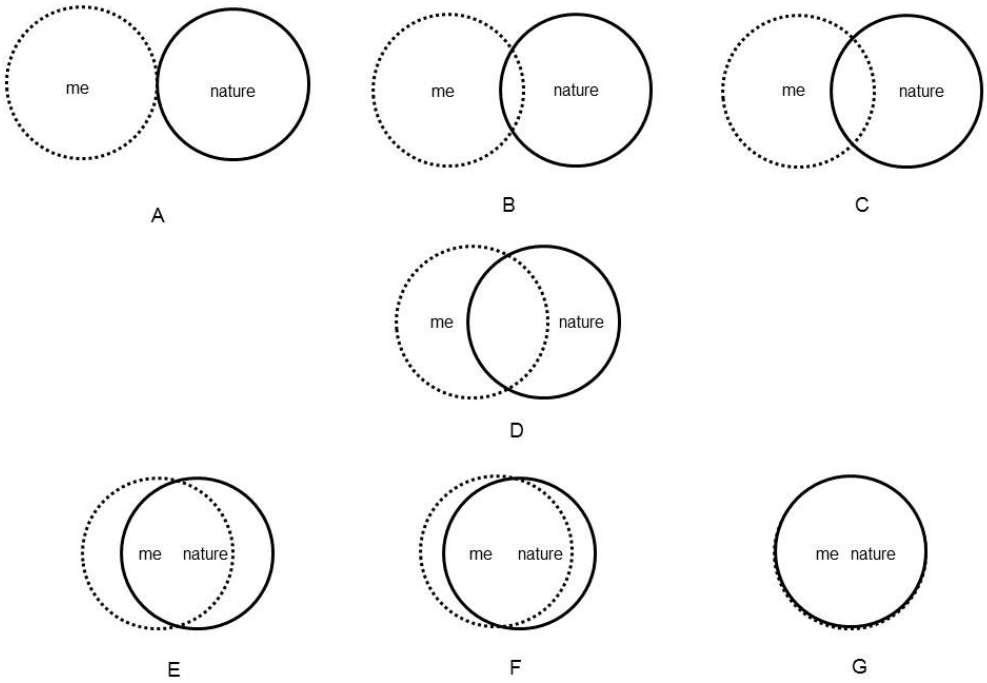
5.1 **There are many things people can do for the environment. Please say what you do for the environment.**

☐ using booklets made of recycled paper ☐ using organic bags instead of plastic bags ☐ buying organic farming products
☐ denying products with unnecessarily much plastic wrapping ☐ buying beverage in bottles instead of cans ☐ paying attention to the ingredients of products
☐ repair goods instead of dumping them ☐ support environmental organisations financially ☐ switching off electric devices instead of standby mode

5.2 **For the protection of environment I am going to....**

☐ save water ☐ use recycled paper ☐ refuse one way packings
☐ support conservation projects ☐ try to convert friends to the protection of environment ☐ whenever possible, walk, take the bike or use public transport

6. **Nature Relatedness**



6.1 **Please choose the illustration that describes your connection to nature best.**

☐ A ☐ B ☐ C
☐ D ☐ E ☐ F
☐ G ☐ I don`t know

7. **Comprehensibility of the Questionnaire**

7.1	The completion of the questionnaire was difficult for me.	I strongly agree	☐	☐	☐	☐	☐ I strongly disagree
7.2	The questions were understandable for me.	I strongly agree	☐	☐	☐	☐	☐ I strongly disagree

You made it!
Thank you for completing this questionnaire.
Please check, whether you have completed every page.

Goethe Universität Frankfurt | Tina Braun
Didaktik der Biowissenschaften | 2013

Bitte so markieren: ☐ ☒ ☐ ☐ ☐ richtige Antwort kreuzen
Korrektur: ☐ ■ ☐ ☒ ☐ falsches Feld schwärzen und neues Kreuz setzen

1. **Individueller Code**

Danke, dass du an dieser Befragung teilnimmst!

Damit wir deine Daten anonym zuordnen können, benötigen wir deinen individuellen Code. Hierzu fülle bitte die Felder unten aus.

1.1 1. An welchem Tag kommt deine Klasse zum Aktionstag? (z.B. **13**.04.13 = **13**)
2. Der zweite Buchstabe deines Vornamens (z.B. L**i**sa = **i**)
3. Der zweite Buchstabe deines Nachnamens (z.B. M**a**yer = **a**)
4. Dein Geburtstag (z.B. **12**. Juli = **12**)

2. **Zu deiner Person**

2.1 Dein Geschlecht ☐ weiblich ☐ männlich

2.2 Dein Alter ☐ 7 - 9 Jahre ☐ 10 - 12 Jahre ☐ 13 - 15 Jahre ☐ 16 - 18 Jahre

2.3 Deine Nationalität

2.4 Ist in der Nähe deines Zuhauses ein Stück Natur, z.B. ein Wald, See oder Naturschutzgebiet? ☐ ja ☐ nein

2.5 Bist du in irgendeiner Naturgruppe (z.B. Pfadfinder / Umwelt-AG in der Schule) aktiv? ☐ ja ☐ nein

2.6 Wenn ja, bei welcher und wie lange schon?

3. **Umwelteinstellung**

3.1	Nur nützliche Tiere und Pflanzen sollten unter Schutz gestellt werden.	stimme voll zu ☐	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.2	Unser Planet hat unbegrenzte Ressourcen (z.B. Trinkwasser, Holz, Kohle, Erdöl).	stimme voll zu ☐	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.3	Der Mensch muss mit der Natur in Einklang leben, um zu überleben.	stimme voll zu ☐	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen

3. **Umwelteinstellung** [Fortsetzung]

3.4	Ich finde, dass sich die Menschen zu viele Gedanken über Umweltverschmutzung machen.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.5	Es ist interessant zu wissen, welche Art von Tieren in den Streuobstwiesen leben.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.6	Es macht mir großen Spaß selbst ins Grüne (Wald, Wiese) hinausgehen zu können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.7	Ich spare Wasser, indem ich öfter dusche als bade.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.8	Menschen sind wichtiger als andere Lebewesen (Tiere und Pflanzen).	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.9	Unkraut muss beseitigt werden, damit nützliche und schöne Pflanzen uneingeschränkt wachsen können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.10	Der Mensch hat das Recht die Natur nach seinen Wünschen zu verändern.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.11	Ich schalte im Zimmer das Licht aus, wenn ich es nicht mehr brauche.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.12	Es sollten mehr Straßen gebaut werden, damit mehr Menschen in die freie Natur fahren können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.13	Ich genieße es in der freien Natur zu sein und die Ruhe auf mich wirken zu lassen.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.14	Wir müssen Gebiete schützen, um vom Aussterben bedrohten Tieren oder Pflanzen helfen zu können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.15	Um uns alle ernähren zu können, muss Wald in Felder umgewandelt werden (z.B. für den Getreideanbau).	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.16	Es stört mich, wenn die Landschaft durch Straßen oder Siedlungen bebaut wird.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen

4. **Umweltwissen**

Hinweis:
Bei den folgenden Fragen kann entweder nur eine oder aber mehrere Antworten richtig sein.

4.1 **Welche sind Nadelbäume?**

☐ Buche
☐ Fichte
☐ Douglasie
☐ weiß ich nicht
☐ Palme

4. **Umweltwissen** [Fortsetzung]

4.2 **Die Abholzung der Wälder ist verantwortlich für…**

☐ die Veränderung der Regenmenge
☐ die Zerstörung der Lebensräume für Tiere
☐ ein trockeneres, heißeres Klima
☐ fruchtbarere Böden
☐ weiß ich nicht

4.3 **Welcher der folgenden ist der Grund für den Treibhauseffekt?**

☐ die fortschreitende Zerstörung der Ozonschicht
☐ die größer gewordene Pflanzenwelt auf der Erdoberfläche
☐ die gestiegene Menge an Kohlenstoffdioxid in der Luft
☐ die immer stärker schmelzenden Polkappen
☐ weiß ich nicht

4.4 **Welche dieser Produkte enthalten kein Palmöl?**

☐ Papier
☐ Seife
☐ Schokolade
☐ Kosmetik
☐ weiß ich nicht

4.5 **In welchen dieser Regionen findet man tropischen Regenwald?**

☐ Afrika
☐ Nordamerika
☐ Europa
☐ Asien
☐ weiß ich nicht

4.6 **Die Durchschnittstemperatur auf der Erde beträgt +15 Grad celsius. Wo läge sie ohne den natürlichen Treibhauseffekt?**

☐ + 5 Grad Celsius
☐ + 20 Grad Celsius
☐ - 20 Grad Celsius
☐ - 40 Grad Celsius
☐ weiß ich nicht

4.7 **Welche ist die größte Tiergruppe?**

☐ Vögel
☐ Reptilien
☐ Insekten
☐ Säugetiere
☐ weiß ich nicht

4.8 **Welche Überwinterungsform verfolgt das europäische Eichhörnchen?**

☐ Winterstarre
☐ Winterruhe
☐ Winterschlaf
☐ keine
☐ weiß ich nicht

4.9 **Wie viel Prozent der Erdoberfläche werden vom Meer bedeckt?**

☐ 10%
☐ 40%
☐ 50%
☐ 70%
☐ weiß ich nicht

4.10 **Wie alt kann ein Ahorn werden?**

☐ 50 Jahre
☐ 100 Jahre
☐ 300 Jahre
☐ 600 Jahre
☐ weiß ich nicht

4.11 **Welche Lebensformen der Honigbiene gibt es?**

☐ Königin
☐ König
☐ Arbeiterin
☐ Drohne
☐ weiß ich nicht

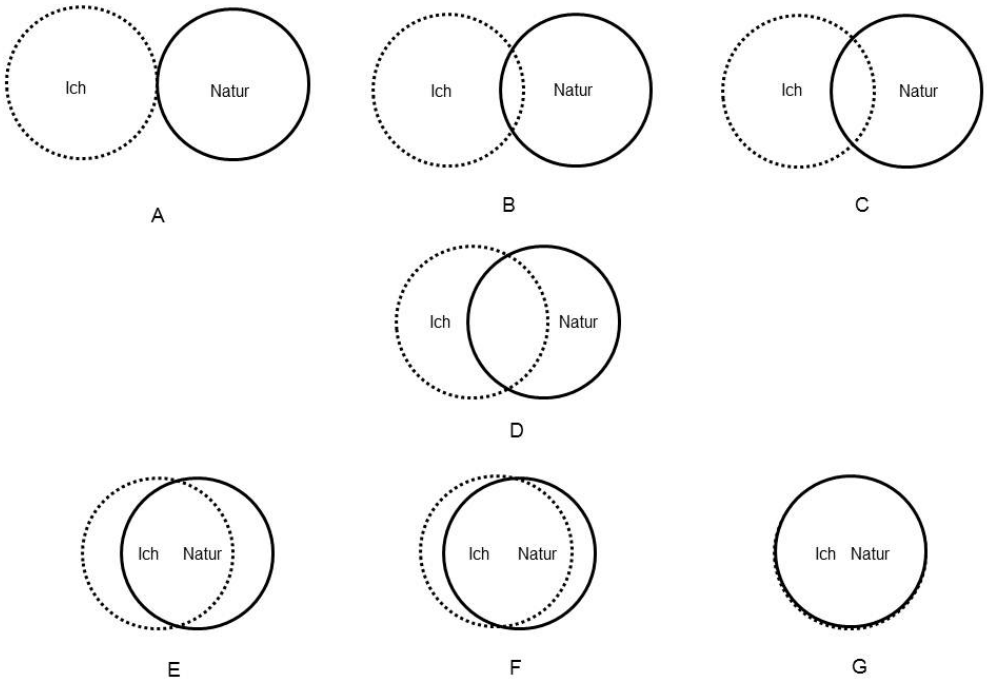
4. **Umweltwissen** [Fortsetzung]

4.12 **Woran kann man am sichersten eine Baumart bestimmen?**

☐ an der Dicke der Wurzeln
☐ an der Anzahl der Jahresringe
☐ an der Dicke der Baumrinde
☐ an der Form der Äste
☐ weiß ich nicht

5. **Naturverbundenheit**

Betrachte die folgenden Kreise. Wie verbunden fühlst du dich mit der Natur?



5.1 Wähle bitte die Darstellung aus, die dein Verhältnis zur Natur am besten beschreibt.

☐ A
☐ B
☐ C
☐ D
☐ E
☐ F
☐ G
☐ weiß ich nicht

6. **Umwelthandeln**

6.1 Es gibt viele Dinge, die Kinder und Jugendliche für die Umwelt tun können. Kreuze bitte an, was du tust.

☐ Hefte aus Recyclingpapier benutzen
☐ einen Rucksack/ Leinenbeutel mit zum Einkaufen nehmen
☐ Produkte aus biologischem Anbau kaufen
☐ Produkte ablehnen, die unnötig verpackt sind
☐ Getränke nur in Flaschen statt in Dosen kaufen
☐ vor dem Produktkauf auf die Inhaltsstoffe achten
☐ Dinge reparieren (lassen) anstatt sie wegzuschmeißen
☐ Umweltorganisationen finanziell unterstützen
☐ PC/TV/Stereoanlage nicht unnötig im Stand-by Modus laufen lassen

6.2 Zum Schutz der Umwelt werde ich künftig...

☐ sparsam mit Wasser umgehen
☐ Recyclingpapier verwenden
☐ auf Einwegverpackungen (z.B. Getränkedosen) verzichten
☐ bei Aktionen zum Arten- und Naturschutz mitmachen
☐ versuchen Freundinnen und Freunde für Aktionen im Arten- und Naturschutz zu gewinnen
☐ wann immer es möglich ist, Wege zu Fuß, mit dem Fahrrad oder mit öffentlichen Verkehrsmitteln zurücklegen

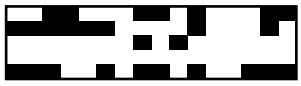
7. **Verständlichkeit des Fragebogens**

7.1	Das Ausfüllen des Fragebogens war schwierig für mich.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
7.2	Die Fragen waren verständlich für mich.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen

Geschafft!

Danke für das Ausfüllen des Fragebogens!

Bitte kontrolliere nochmal, ob du alle Seiten bearbeitet hast.



EvaSys	Nature study T1	Electric Paper
Goethe University Frankfurt	Tina Braun	
Ecofieldtrips Singapore	2014	

Bitte so markieren: ☐ ☒ ☐ ☐ ☐ cross the correct answer
Korrektur: ☐ ■ ☐ ☒ ☐ black out the wrong answer and cross another box

1. Individual Code

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2. Background information

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2.2 Age ☐ 7 - 9 years ☐ 10 - 12 years ☐ 13 - 15 years ☐ 16 - 18 years

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3.16	It upsets me to see the counryside taken over by streets and buildings.	I strongly agree ☐	☐	☐	☐ I strongly disagree	☐ I can`t tell

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4.3 **Which of the following is a reason for the greenhouse effect?**

☐ the proceeding destruction of the ozone layer ☐ the increased vegetation on earth ☐ the increased amount of carbon dioxide in the atmosphere
☐ the melting of the polar ice caps ☐ I don`t know

4.4 **Which of these products do not contain palm oil?**

☐ paper ☐ soap ☐ chocolate
☐ cosmetics ☐ I don`t know

4.5 **What can you contribute to the conservation of plants ans animals?**

☐ feeding birds in the park with bread ☐ buying sustainable products (e.g. wood with the FSC seal) ☐ buying products of endangered species (e.g. ivory)
☐ planting native vegetation in the yard ☐ I don`t know

4. **Environmental Knowledge** [Fortsetzung]

4.6 **What belongs into a sustainable shopping basket?**

☐ seasonal and regional products ☐ convenience food ☐ organic food
☐ imported goods ☐ I don`t know

4.7 **How can you contribute to a healthier environment?**

☐ wash your clothes less often ☐ use public transport ☐ use plastic cups
☐ eat more meat ☐ I don`t know

4.8 **How much water can you safe when you take a shower instead of a bath?**

☐ up to 500 litres ☐ up to 120 litres ☐ up to 70 litres
☐ up to 30 litres ☐ I don`t know

4.9 **You can minimize the energy consumption by...**

☐ wasting less warm water ☐ using the air-condition on high level ☐ turning off the lights when you leave a room
☐ leaving electric devices in the stand-by mode ☐ I don`t know

4.10 **How much electricity can you safe by using an energy-saving bulb instead of conventional bulbs?**

☐ up to 10% ☐ up to 20% ☐ up to 50%
☐ up to 80% ☐ I don`t know

4.11 **By using which kind of bottle do you damage the environment the most?**

☐ one-way glass botlles ☐ recycable glass bottles ☐ one-way plastic bottles
☐ recycable plastic bottles ☐ I don`t know

4.12 **By denying which foods can you safe the most greenhouse gases?**

☐ fruits and vegetables ☐ meat ☐ bread and rice
☐ sweets ☐ I don`t know

5. **Environmental Action**

5.1 **There are many things people can do for the environment. Please say what you do for the environment.**

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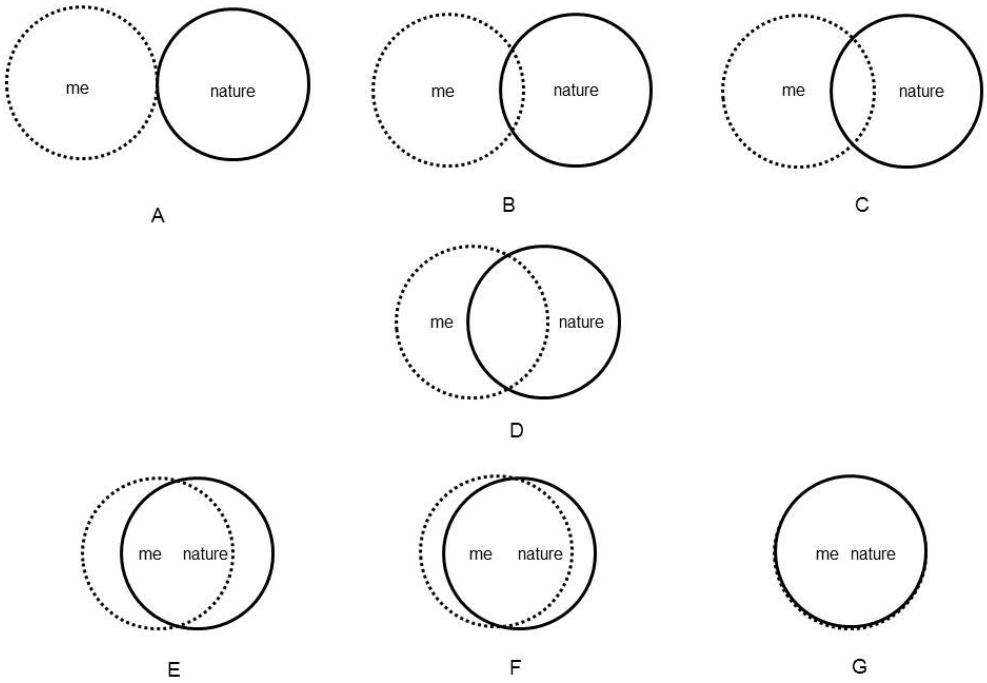

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☐ A ☐ B ☐ C
☐ D ☐ E ☐ F
☐ G ☐ I don`t know

7. **Comprehensibility of the Questionnaire**

7.1	The completion of the questionnaire was difficult for me.	I strongly agree	☐	☐	☐	☐	☐ I strongly disagree
7.2	The questions were understandable for me.	I strongly agree	☐	☐	☐	☐	☐ I strongly disagree

You made it!
Thank you for completing this questionnaire.
Please check, whether you have completed every page.

EvaSys	Naturstudie T1	Electric Paper

Goethe Universität Frankfurt — Tina Braun

Didaktik der Biowissenschaften — 2014

Bitte so markieren: ☐ ☒ ☐ ☐ ☐ richtige Antwort kreuzen

Korrektur: ☐ ■ ☐ ☒ ☐ falsches Feld schwärzen und neues Kreuz setzen

1. **Individueller Code**

Danke, dass du an dieser Befragung teilnimmst!

Damit wir deine Daten anonym zuordnen können, benötigen wir deinen individuellen Code. Hierzu fülle bitte die Felder unten aus.

1.1 1. An welchem Tag kommt deine Klasse zum Aktionstag? (z.B. **27**.06.14 = **27**)
2. Der zweite Buchstabe deines Vornamens (z.B. L**i**sa = **i**)
3. Der zweite Buchstabe deines Nachnamens (z.B. M**a**yer = **a**)
4. Dein Geburtstag (z.B. **12**. Juli = **12**)

2. **Zu deiner Person**

2.1 Dein Geschlecht ☐ weiblich ☐ männlich

2.2 Dein Alter ☐ 7 - 9 Jahre ☐ 10 - 12 Jahre ☐ 13 - 15 Jahre ☐ 16 - 18 Jahre

2.3 Deine Nationalität

2.4 Ist in der Nähe deines Zuhauses ein Stück Natur, z.B. ein Wald, See oder Naturschutzgebiet? ☐ ja ☐ nein

2.5 Bist du in irgendeiner Naturgruppe (z.B. Pfadfinder / Umwelt-AG in der Schule) aktiv? ☐ ja ☐ nein

2.6 Wenn ja, bei welcher und wie lange schon?

3. **Umwelteinstellung**

3.1	Nur nützliche Tiere und Pflanzen sollten unter Schutz gestellt werden.	stimme voll zu ☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.2	Unser Planet hat unbegrenzte Ressourcen (z.B. Trinkwasser, Holz, Kohle, Erdöl).	stimme voll zu ☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.3	Der Mensch muss mit der Natur in Einklang leben, um zu überleben.	stimme voll zu ☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen

3. **Umwelteinstellung** [Fortsetzung]

3.4	Ich finde, dass sich die Menschen zu viele Gedanken über Umweltverschmutzung machen.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.5	Es ist interessant zu wissen, welche Art von Tieren in den Streuobstwiesen leben.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.6	Es macht mir großen Spaß selbst ins Grüne (Wald, Wiese) hinausgehen zu können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.7	Ich spare Wasser, indem ich öfter dusche als bade.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.8	Menschen sind wichtiger als andere Lebewesen (Tiere und Pflanzen).	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.9	Unkraut muss beseitigt werden, damit nützliche und schöne Pflanzen uneingeschränkt wachsen können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.10	Der Mensch hat das Recht die Natur nach seinen Wünschen zu verändern.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.11	Ich schalte im Zimmer das Licht aus, wenn ich es nicht mehr brauche.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.12	Es sollten mehr Straßen gebaut werden, damit mehr Menschen in die freie Natur fahren können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.13	Ich genieße es in der freien Natur zu sein und die Ruhe auf mich wirken zu lassen.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.14	Wir müssen Gebiete schützen, um vom Aussterben bedrohten Tieren oder Pflanzen helfen zu können.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.15	Um uns alle ernähren zu können, muss Wald in Felder umgewandelt werden (z.B. für den Getreideanbau).	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
3.16	Es stört mich, wenn die Landschaft durch Straßen oder Siedlungen bebaut wird.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen

4. **Umweltwissen**

Hinweis:
Bei den folgenden Fragen kann entweder nur eine oder aber mehrere Antworten richtig sein.

4.1 **Welche sind Nadelbäume?**

☐ Buche
☐ Fichte
☐ Douglasie
☐ weiß ich nicht
☐ Palme

4. **Umweltwissen** [Fortsetzung]

4.2 **Die Abholzung der Wälder ist verantwortlich für…**

- ☐ die Veränderung der Regenmenge
- ☐ die Zerstörung der Lebensräume für Tiere
- ☐ ein trockeneres, heißeres Klima
- ☐ fruchtbarere Böden
- ☐ weiß ich nicht

4.3 **Welcher der folgenden ist der Grund für den Treibhauseffekt?**

- ☐ die fortschreitende Zerstörung der Ozonschicht
- ☐ die größer gewordene Pflanzenwelt auf der Erdoberfläche
- ☐ die gestiegene Menge an Kohlenstoffdioxid in der Luft
- ☐ die immer stärker schmelzenden Polkappen
- ☐ weiß ich nicht

4.4 **Welche dieser Produkte enthalten kein Palmöl?**

- ☐ Papier
- ☐ Seife
- ☐ Schokolade
- ☐ Kosmetik
- ☐ weiß ich nicht

4.5 **Was kannst du zum Schutz von Pflanzen und Tieren beitragen?**

- ☐ Vögel im Park mit Brot füttern
- ☐ nachhaltige Produkte kaufen (z.B. Holz mit dem FSC Siegel)
- ☐ Produkte von gefährdeten Arten kaufen (z.B. Elfenbein)
- ☐ heimische Pflanzen im Garten anbauen
- ☐ weiß ich nicht

4.6 **Welche Produkte gehören in einen nachhaltigen Einkaufskorb?**

- ☐ weiß ich nicht
- ☐ saisonale und regionale Produkte
- ☐ Fertigprodukte
- ☐ Bio-Lebensmittel

4.7 **Wie kannst du für eine gesündere Umwelt tun?**

- ☐ deine Kleidung weniger häufig waschen
- ☐ öffentliche Verkehrsmittel nutzen
- ☐ Plastikbecher verwenden
- ☐ mehr Fleisch essen
- ☐ weiß ich nicht

4.8 **Wie viel Wasser kannst du sparen, wenn du duschst statt zu baden?**

- ☐ bis zu 500 Liter
- ☐ bis zu 120 Liter
- ☐ bis zu 70 Liter
- ☐ bis zu 30 Liter
- ☐ weiß ich nicht

4.9 **Du kannst den Energieverbrauch senken durch…**

- ☐ die Verringerung des Warmwasserverbrauchs
- ☐ die Verwendung der Klimaanlage/ Heizung auf höchster Stufe
- ☐ das Ausschlaten von Licht, wenn du den Raum verlässt
- ☐ das Verbleiben von Geräten im Stand-by-Betrieb
- ☐ weiß ich nicht

4.10 **Wie viel Elektrizität kannst du einsparen, wenn du eine Energiesparglühbirne anstelle einer gewöhnlichen Glühbirne benutzt?**

- ☐ bis zu 10%
- ☐ bis zu 20%
- ☐ bis zu 50%
- ☐ bis zu 80%
- ☐ weiß ich nicht

4. **Umweltwissen** [Fortsetzung]

4.11 **Mit welcher Flasche schadest du der Natur am meisten?**

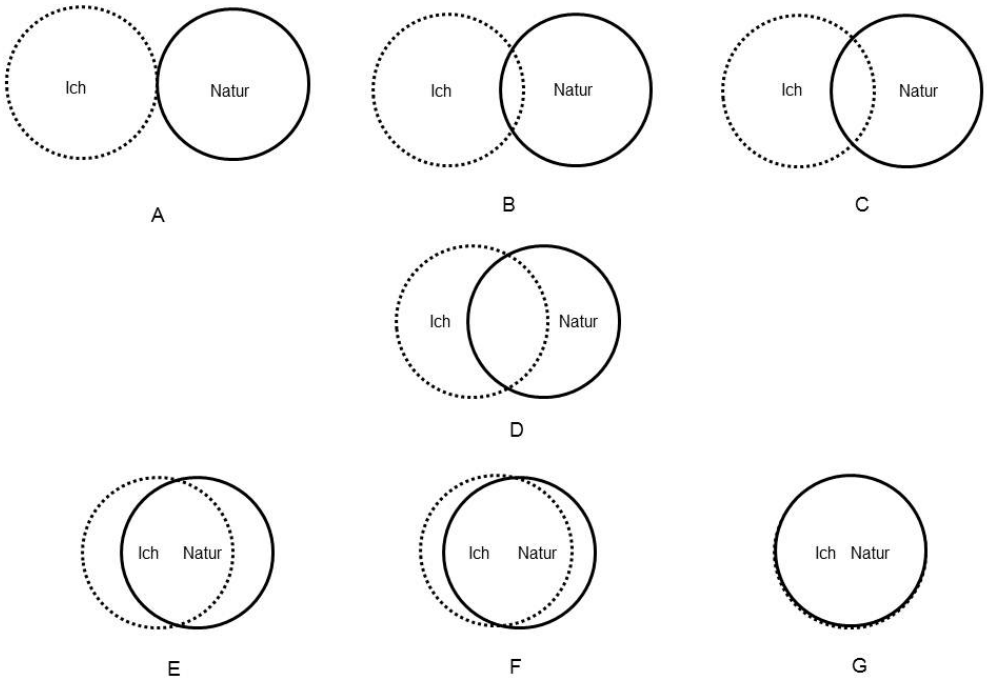
☐ Einweg-Glasflasche ☐ Mehrweg-Glasflasche ☐ Einweg-Plastikflasche
☐ Mehrweg-Plastikflasche ☐ weiß ich nicht

4.12 **Mit dem Verzicht auf welches Lebensmittel sparst du am meisten Treibhausgase ein?**

☐ Obst und Gemüse ☐ Fleisch ☐ Brot und Reis
☐ Süßwaren ☐ weiß ich nicht

5. **Naturverbundenheit**

Betrachte die folgenden Kreise. Wie verbunden fühlst du dich mit der Natur?



5.1 Wähle bitte die Darstellung aus, die dein Verhältnis zur Natur am besten beschreibt.

☐ A ☐ B ☐ C
☐ D ☐ E ☐ F
☐ G ☐ weiß ich nicht

6. **Umwelthandeln**

6.1 Es gibt viele Dinge, die Kinder und Jugendliche für die Umwelt tun können. Kreuze bitte an, was du tust.

☐ Hefte aus Recyclingpapier benutzen
☐ einen Rucksack/ Leinenbeutel mit zum Einkaufen nehmen
☐ Produkte aus biologischem Anbau kaufen
☐ Produkte ablehnen, die unnötig verpackt sind
☐ Getränke nur in Flaschen statt in Dosen kaufen
☐ vor dem Produktkauf auf die Inhaltsstoffe achten
☐ Dinge reparieren (lassen) anstatt sie wegzuschmeißen
☐ Umweltorganisationen finanziell unterstützen
☐ PC/TV/Stereoanlage nicht unnötig im Stand-by Modus laufen lassen

6. **Umwelthandeln** [Fortsetzung]

6.2 Zum Schutz der Umwelt werde ich künftig...

- ☐ sparsam mit Wasser umgehen
- ☐ Recyclingpapier verwenden
- ☐ auf Einwegverpackungen (z.B. Getränkedosen) verzichten
- ☐ bei Aktionen zum Arten- und Naturschutz mitmachen
- ☐ versuchen Freundinnen und Freunde für Aktionen im Arten- und Naturschutz zu gewinnen
- ☐ wann immer es möglich ist, Wege zu Fuß, mit dem Fahrrad oder mit öffentlichen Verkehrsmitteln zurücklegen

7. **Verständlichkeit des Fragebogens**

7.1	Das Ausfüllen des Fragebogens war schwierig für mich.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen
7.2	Die Fragen waren verständlich für mich.	stimme voll zu	☐	☐	☐	☐ stimme überhaupt nicht zu	☐ kann ich nicht sagen

Geschafft! Danke für das Ausfüllen des Fragebogens!

Bitte kontrolliere nochmal, ob du alle Seiten bearbeitet hast.