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Environment and Behavior 46 (2014) 8, S. 972-992

Article

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Environment and Behavior
2014, Vol. 46(8) 972–992

DOI: 10.1177/0013916513492416
eab.sagepub.com

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Abstract

The goal of environmental education is ultimately to enable a person to strive for and to attain a more ecological way of life. In this article, we begin by distinguishing three forms of environmental knowledge and go on to predict that people's attitude toward nature represents the force that drives their ecological behavioral engagement. Based on data from 1,907 students, we calibrated previously established instruments to measure ecological behavior, environmental knowledge, and attitude toward nature with Rasch-type models. Using path modeling, we corroborated our theoretically anticipated competence structure. While environmental knowledge revealed a modest behavioral effect, attitude toward nature turned out to be, as expected, the stronger determinant of behavior. Overall, we propose a competence model that has the potential to guide us into more evidence-based ways of promoting the overall ecological engagement of individuals.

Keywords

environmental education, proenvironmental competence, environmental knowledge, conservation (ecological behavior), attitude toward nature

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The goal of education is ultimately to provide individuals with abilities and to advance their aptitudes in ways that enable them to eventually cope with real-life challenges (McClelland, 1973; Organization for Economic Cooperation and Development—OECD, 2003). Accordingly, we expect a properly educated physician not only to know anatomy and pathology but also to cure people from diseases. Stated differently, the purpose of education is to advance competences, which can be seen as a composite of aptitudes that allow people to successfully master real-life tasks (e.g., Weinert, 2001). Two features are central from this angle: (a) there is a real-life goal to attain and (b) there are interrelated aptitudes that are necessary to ensure a successful action.

Therefore, and in accordance with others (e.g., Kollmuss & Agyeman, 2002; Monroe, 2003), we argue for a proenvironmental competence conception that involves intellectual and motivational aptitudes that ultimately advance a person's propensity to act in an ecological manner. Kaiser, Roczen, and Bogner (2008) recently proposed such a competence model that consists exclusively of aptitudes that others have corroborated as being directly relevant for the ecological performance pattern of individuals. In contrast to other proposals in environmental education (e.g., Heimlich & Ardoin, 2008; Kollmuss & Agyeman, 2002), Kaiser et al.'s model is comparatively simple, with a rather small number of behavioral determinants. To achieve this simplicity, Kaiser et al. had to make the degree to which people embrace an ecological lifestyle as their prime educational objective. The ambition to embrace an ecological way of life across various performance domains—the overall ecological behavior pattern of an individual—is in contrast, however, with what is generally perceived to represent proper behavioral targets in contemporary environmental education. While some researchers suggest promoting prudently selected specific behaviors (e.g., political action; for example, Chawla & Cushing, 2008), others retreat from behavior to advocate sustainable decision making (e.g., Heimlich & Ardoin, 2008). Still others opt for a variety of models that match the heterogeneity of behavioral domains to the plurality of people's motives (e.g., Monroe, 2003).

In the present study, we empirically tested Kaiser et al.'s (2008) model with a large sample of 12- to 15-year-old students. This test was expected not only to provide a better understanding of the origins and role of the anticipated aptitudes in shaping the ecological lifestyles of adolescents but also to represent a starting point for a more effective and more evidence-based promotion of a generally improved ecological pattern of behavior in adolescents.

Types of Proenvironmental Competences

In the discourse on environmental education to date, we typically find conceptual, sometimes normative, but predominantly synthetic debates about

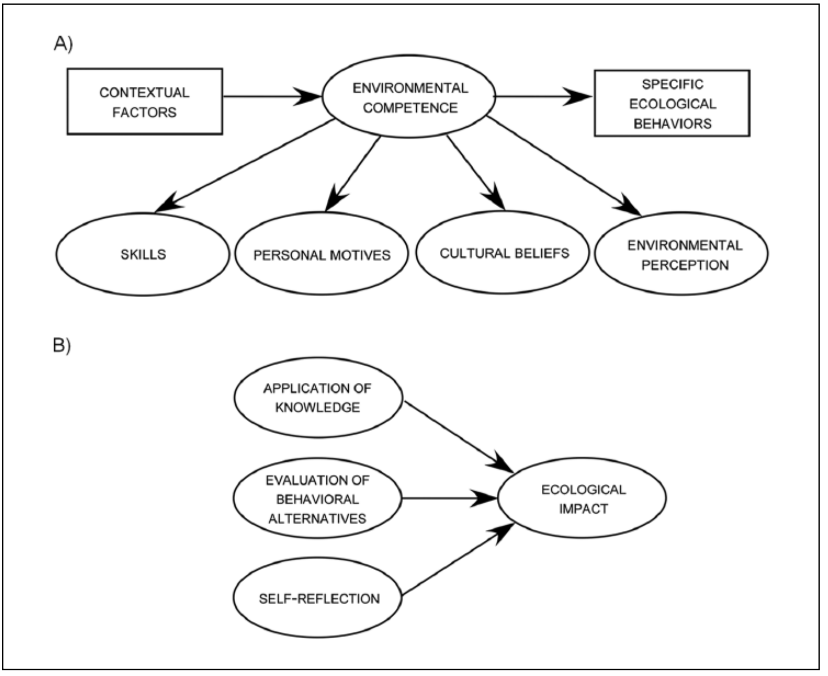

Figure 1. Two prototypical alternative notions of proenvironmental competence.
Note. Boxes represent observable variables; ovals stand for latent variables.

the nature of proenvironmental competence. However, these debates typically lack links to manifest gains in terms of behavior, energy, and/or CO_2 revenues (see, for example, de Haan, 2006; Jensen & Schnack, 2006). From a synthetic perspective, a person can, strictly speaking, become more environmentally competent without manifesting benefits in terms of ecological behavior and/or fewer ecological side-effects. Noteworthy exceptions consist of two generic types of competence models that we found in the psychological literature; these will be presented next. Interestingly, these models represent two rather distinct notions of what proenvironmental competence is. While the first model speaks of competence as a single second-order disposition (i.e., a latent common factor), the second describes competence as a structure (i.e., a composite of interrelated factors) of rather broad aptitudes that are relevant for the ecological side-effects of individuals. It is noteworthy that these aptitudes are general and, thus, not specific to the environmental domain.

Corral-Verdugo's (2002) model represents the first type of proenvironmental competence (see Figure 1, Panel A). According to his model, competence can be regarded as a latent disposition that feeds into certain skills (e.g., knowing how to carry out different ecological behaviors such as saving water) and aptitudes such as personal motives, cultural beliefs, and awareness of the environmental situation (i.e., environmental perception). Simultaneously, competence is the cause behind specific ecological actions such as water consumption. In Corral-Verdugo's version of this type of model, contextual factors (e.g., real water scarcity) are anticipated to trigger competence in the first place.

Technically, proenvironmental competence is a second-order common factor in this type of model. First-order factors such as skills, motives, beliefs, and perceptions must be correlated, and as first-order factors are presumed to exclusively or mainly depend on a person's competence level, no directed influences among first-order factors are anticipated. In this kind of a model, a second-order competence differs from a first-order aptitude only formally—in its level of abstraction—but not in essence.

One example of the second type of proenvironmental competence model that we found in the literature comes from Gräsel (2001; see Figure 1, Panel B). To our knowledge, this model has not been rigorously empirically tested. Gräsel describes competence as a structure of interrelated factors rather than a single latent disposition. Gräsel's version of this type of model identifies three aptitudes: (a) the ability to make use of one's knowledge (i.e., application of knowledge), (b) the ability to comparatively assess behavioral alternatives in terms of feasibility and consequences (i.e., evaluation of behavioral alternatives), and (c) the ability to critically reflect upon one's own actions and thoughts (i.e., self-reflection). These ecology-unspecific general intellectual aptitudes are in turn seen as preconditions for reducing the ecological side-effects of individuals, for example, a person's overall energy consumption.

Conceptually, intellectual aptitudes—and not motivational aptitudes—are exclusively recognized in the latter type of competence model. Moreover, focusing on ecological side-effects rather than behavior carries the risk of underestimating the significance of personal aptitudes and subsequently of environmental education (see Midden, Kaiser, & McCalley, 2007). In other words, if we do not want to underestimate the effects of environmental instruction and other types of education, we need to consider the ecological behavior of individuals as intermediary between individuals' aptitudes and the ecological side-effects of people's behavior in terms of pollution, CO_2 emission, or amount of energy consumed (Kaiser et al., 2008). In the following section, we present Kaiser et al.'s (2008) recently proposed proenvironmental competence model, which we believe not only retains the advantages of previous such models but also represents a sound foundation on which empirically guided education programs for increasing the overall ecological engagement of individuals can be based.

An Evidence-Based Proenvironmental Competence Model

Similar to Gräsel (2001), Kaiser et al. (2008) propose that proenvironmental competence represents a structure of interrelated performance-relevant aptitudes. This time, however, the aptitudes are ecology specific rather than general and unspecific. In other words, they have previously been corroborated to be significant for the ecological engagement of individuals. Simultaneously and in contrast to Gräsel, Kaiser et al.'s proposal is aimed at a person's entire range of ecological behaviors (i.e., the degree to which a person exhibits an ecological way of life) and not at the person's ecological side-effects. While environmental knowledge forms the intellectual basis, the attitude toward nature represents the motivational source behind a person's ecological lifestyle.

In environmental psychology, behavioral engagement has most often been measured with single acts or within specific domains of behavior, such as conserving resources and saving energy (e.g., Gatersleben, Steg, & Vlek, 2002). However, a focus on specific domains disregards the idea that people will behave consistently across domains if the contextual influences on each single behavior are integrated into the measurement model (e.g., Kaiser, 1998; Kaiser & Wilson, 2004). The focus on single acts, moreover, neglects the fact that a person's living circumstances are usually rather unique and that people have many behavioral options from which they can choose to implement their individual ecological ambitions. Instead of commuting by bike, a person can choose to switch to a vegetarian diet or focus more on conserving heating energy. Personal choices and life circumstances create behavioral opportunities that can differ from person to person and from situation to situation. Thus, because of the multitude of these choices and circumstances, indeterminacy with regard to intentions and goals of specific behaviors may be produced. This motivational indeterminacy can be overcome by considering—what Heimlich and Ardoin (2008) call individual constellations of behaviors—a person's general ecological pattern of behavior (Kaiser, Byrka, & Hartig, 2010). This overall behavioral propensity represents an individual's disposition to act proenvironmentally in general, irrespective of the specifics of each behavior. Focusing on such a general disposition ultimately shifts the focus away from specific behaviors to a person's entire way of living and, thus, the degree to which a person adopts an ecological lifestyle.

Even though, with regard to empirical evidence, environmental knowledge does not seem to have a strong effect on behavior (e.g., Hines, Hungerford, & Tomera, 1986/87), knowledge provides—at least in some models—a necessary precondition for ecological behavior (e.g., Schultz, 2002b).[1] Kaiser and Fuhrer (2003) conceptually distinguish between three different forms of factual environmental knowledge (for supporting evidence, see Frick, Kaiser, & Wilson, 2004): (a) knowledge about how the environmental system works and how natural processes operate (i.e., environmental system knowledge—for example, knowledge about how CO_2 affects the earth's climate); (b) knowledge about how to achieve resource conservation and environmental preservation (i.e., action-related knowledge—for example, how one can reduce household waste); and (c) knowledge about how to best achieve resource conservation—that is, knowledge about the effectiveness of various behaviors in terms of energy savings or reduced CO_2 emissions (i.e., effectiveness knowledge—for example, what has a greater influence on energy conservation: buying a fuel-efficient car or curtailing one's driving?).

According to Frick et al. (2004), environmental system knowledge does not trigger ecological behavior directly, but it can motivate the acquisition of action-related knowledge and effectiveness knowledge. As people have to be aware of their different ecological behavior options before they can learn about differential effectiveness, action-related knowledge also precedes effectiveness knowledge. Action-related and effectiveness knowledge, jointly, promote a person's ecological behavior.

While environmental knowledge provides the intellectual basis, a person's appreciation for nature has been corroborated to be a formidable motivational force linked with the overall ecological performance of individuals (e.g., Kaiser, Hartig, Brügger, & Duvier, 2013). In the literature, different concepts seem to address a person's appreciation for the natural environment and the person's relationship with it. Clayton (2003) and Schultz (2002a), for example, expect that the extent to which nature is important to a person (i.e., nature is indispensable to a person's self-concept) and how one sees himself or herself (i.e., when a person holds an environmental identity) are vital. Others (e.g., Nisbet, Zelenski, and Murphy, 2009) anticipate that emotional ties to nature and an understanding of the interconnectedness of all forms of life on earth are essential. Despite these and other conceptual differences and despite the distinct views that different scholars hold about how to capture the essence of people's appreciation for the natural environment, Brügger, Kaiser, and Roczen (2011) recently empirically demonstrated that the different concepts converge and, thus, they basically reflect a single psychological phenomenon that is measurable as attitude toward nature.

Nevertheless, and although attitude toward nature has been corroborated as being behavior relevant, we can only speculate about the ties between attitude toward nature and environmental knowledge. It seems, however, rather plausible that a person's appreciation for nature and for the environmental system—apart from encouraging the person to care—also motivates the person to search for more information about nature and about particular environmental systems (which feeds into environmental system knowledge) and vice versa. It seems similarly plausible that—possibly mediated by fascination—existing knowledge about nature and environmental processes triggers an appreciation for nature and, thus, eventually causes environmental protection as well (see, for example, Kaiser & Frick, 2002). With a growing appreciation for nature, we hence must anticipate an increase in the desire to effectively protect an esteemed object if it is recognized as endangered (see, for example, Kaiser et al., 2013). In other words, we expect people to begin searching for possible behavioral remedies (i.e., action-related knowledge) and their particular effectiveness (i.e., effectiveness knowledge) once people have achieved a certain level of appreciation for the environmental system.

Research Goals

In this study, we aimed to corroborate the anticipated proenvironmental competence model that was originally proposed by Kaiser et al. (2008; see Figure 2). Specifically, (a) we tested whether adolescents' environmental knowledge could be empirically divided into environmental system knowledge, action-related knowledge, and effectiveness knowledge. (b) We expected that attitude toward nature—in addition to environmental knowledge, the necessary basis for action—would be the motivational force behind the degree to which individuals would exhibit ecological lifestyles. In comparison to knowledge, we thus expected attitude toward nature to be a far more substantial determinant of behavior. (c) With respect to attitude toward nature's influence on environmental knowledge, we anticipated that attitude toward nature would exert an effect on both action-related and effectiveness knowledge. For environmental system knowledge, in contrast, we did not formulate a specific expectation.

Method

Participants and Procedure

In total, seven schools participated in our study: three grammar and four secondary schools. All schools were located in Southern Germany. In each school, all sixth, seventh, and eighth graders completed questionnaires during class hours (maximally 45 min). Of the 2,300 questionnaires distributed to students, 1,907 were returned. Participants came from 82 classes; 57% of all participants were female; the median age was 14 (M = 13.72, SD = 1.15) years.

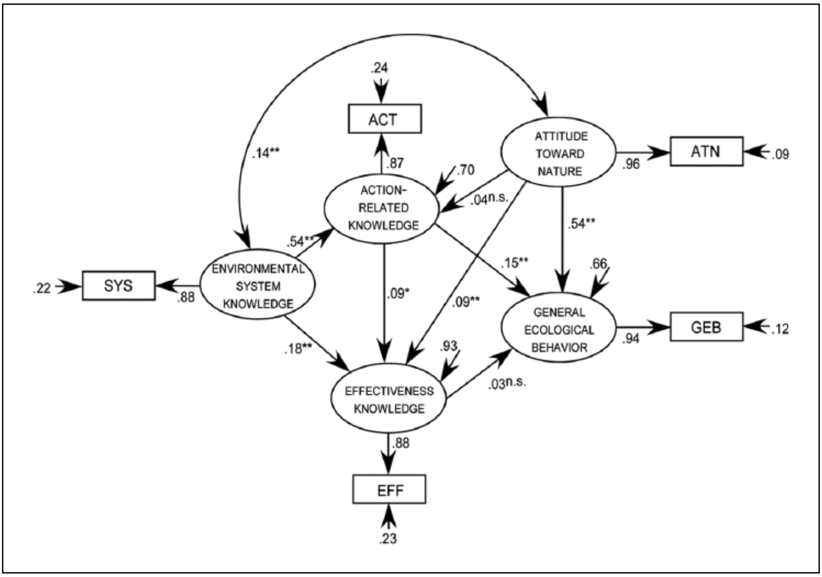

Figure 2. Proenvironmental competence in adolescents.
Note. Boxes represent observable variables, in this case scales with known reliabilities (see Table 1). Numerical values are standardized multiple regression coefficients (i.e., β-weights), factor loadings (all of which were statistically significant at $p < .01$), or a Pearson correlation coefficient (i.e., double-headed arrow). These coefficients indicate the strength of a relation and the extent of the overlap between two variables. Arrows without origins (all of which were statistically significant at $p < .01$) represent an error or residual variances. They indicate proportions of unexplained variances. $N = 1{,}907$. $^*p < .05$. $^{**}p < .01$.

To fit the assessment into a 45-min lesson, we applied a rotation plan to make ample use of the 170 items of the previously developed measurement instruments of this study. Each student received one of 13 different booklets. Each booklet contained four clusters, and each cluster contained approximately 16 items. Thus, each booklet held about 64 items. In total, we had 13 clusters of items to choose from. Each of these clusters appeared four times, in the 1st, 2nd, 3rd, and 4th place, respectively, and each combination of two clusters was used only once in the 13 booklets (for a similar approach, see, for example, OECD, 2009).

Measures

In our research, we used three different instruments: (a) an ecological behavior scale, (b) an attitude-toward-nature measure, and (c) a three-dimensional environmental knowledge measure. All instruments were originally developed in German. *Not applicable* was a response option when an answer was for whatever reason not possible for items assessing ecological behavior or attitude toward nature. *Not applicable* answers were treated as missing values. In the following text, we will describe the instruments we used.

General ecological behavior was measured by a comprehensively tested and validated 40-item self-report instrument (Kaiser, Oerke, & Bogner, 2007). To our knowledge, there is no currently available general performance measure that is similarly well developed and specifically designed to be used with adolescents. The behavioral self-reports can be grouped into six domains: recycling, waste avoidance, consumerism, mobility and transportation, energy conservation, and vicarious conservation behaviors. Item examples are "I refrain from using battery-powered devices" or "I keep gift wrapping paper for reuse." Of the 40 behaviors, 14 represent unecological activities; they were reverse coded. Engagement in seven behaviors could be acknowledged by a *yes*/*no* statement. For 33 of the behavioral self-report items, we used a five-point scale ranging from 1 (*never*) to 5 (*always*). In line with Kaiser et al. (2007), the responses to the polytomous behavior items were recoded into a dichotomous format by collapsing *never, seldom*, and *occasionally* into *a rather unecological propensity. Often* and *always*, in contrast, were combined into *a rather ecological propensity*. Of all possible behavior statements that were presented to students, 7% were left unanswered by them. Due to the 45-min constraint, we were able to present only about 35% of the available items to each student (i.e., in absolute numbers, we presented 64 of the 170 total items comprising of 40 ecological behavior, 40 attitude toward nature, and 90 environmental knowledge items; see section "Participants and Procedure"). As a consequence, approximately 65% of the data were missing by design.

A person's *attitude toward nature* was assessed by the 40-item measure established by Brügger et al. (2011). Responding to this instrument is not intellectually demanding, and it has been corroborated to overlap with other instruments that measure similar concepts: for example, the Connectedness to Nature Scale (Mayer & Frantz, 2004), Environmental Identity (Clayton, 2003), and inclusion-of-nature-in-one's-self measure (Schultz, 2002a). At the same time, Brügger et al.'s instrument has been shown to be technically superior in terms of conceptual purity (i.e., unidimensionality) and incremental validity (for details, see Brügger et al., 2011). Item examples are "I get up early to watch the sunrise" or "I talk to animals." These items too were presented with two different response formats. For 23 items, a dichotomous *yes*/*no* format was used, and for 17 other items, a five-point frequency scale ranging from 1 (*never*) to 5 (*very often*) was used. Like Brügger et al. (2011), we also recoded the responses from a five-point to a three-point format by collapsing *seldom* and *occasionally* as well as *often* and *very often. Never* was retained as *never*. Of the 40 items, three expressed a negative attitude toward nature and were thus reverse coded. Six percent of all attitude-toward-nature items that were presented to students had missing responses.

For the measurement of attitude toward nature—and, strictly speaking, for the measurement of general ecological behavior—we adopted what Kaiser et al. (2010) call the Campbell paradigm to frame the attitude–behavior relation. Within the Campbell paradigm, behavior and attitude are conceptually fused (for more details, also see Kaiser et al., 2013). This fusion ensures that an attitude measure represents a measure of a person's general performance as much as it represents an attitude (Kaiser et al., 2007); this is because the extent of an individual's attitude toward nature, for example, is exclusively observable through behaviors that (verbally or otherwise) imply how much the person values nature. This notion is in contrast with the assumption of a causal relation between an attitude and its corresponding behavior in the "behavior-explanation paradigm" now conventionally used in attitude research (for an example of the traditional notion, see, for example, Kollmuss & Agyeman, 2002).

Knowledge involves accomplishment: namely, correctly solving tasks. Thus, to explore interindividual differences in knowledge, one needs to present individuals with differentially demanding tasks. As the Rasch model is the measurement model that is focused on this notion, not surprisingly, it is often the model of choice in the educational assessment of knowledge differences (e.g., Wilson, 2005). To our knowledge, the only environmental knowledge measure that was developed as a Rasch scale comes from Frick et al. (2004).

We tested a person's environmental knowledge with 90 items. Forty-eight of these items came from Frick et al. (2004), from which 28 were adapted for adolescents. The remaining 42 questions had to be newly developed for this particular research. Using input from teachers and experts in biological education, we created a set of new environmental system knowledge, action-related knowledge, and effectiveness knowledge items. Questions were designed to fit the presumed proficiency range of adolescents (all knowledge items can be found in the Online Appendix at http://eab.sagepub.com/).

Environmental system knowledge was assessed with 38 items; 23 items were used to measure *action-related knowledge* and 29 to measure *effectiveness knowledge*. Item examples are as follows: "What are problematic issues with ozone?" (environmental system knowledge); "Where can someone dispose of old batteries?" (action-related knowledge); and "What percentage of energy can be saved by using steamers instead of conventional cooking pots?" (effectiveness knowledge). Sixty-four of these items were presented in a multiple-choice format, of which 17 actually allowed multiple responses. Another 26 items were presented as dichotomous *true/false* statements. Unanswered questions were coded as missing; 2% of all answers to the knowledge questions presented to students had missing responses.

Statistical Analysis

All five scales (i.e., ecological behavior, attitude toward nature, environmental system knowledge, action-related knowledge, and effectiveness knowledge) were calibrated using either the simple Rasch model (SRM; Rasch, 1960/1980) or the partial-credit Rasch model (PCM; Masters, 1982; for a recent account, see Bond & Fox, 2007). The type of calibration depended on whether a scale made use of exclusively dichotomous items (SRM) or whether it also included polytomous items (PCM).

Person scores were derived as weighted maximum-likelihood estimates, which is a conventional way to score people when using approaches based on the Rasch model (for more details, see Wang & Wang, 2001; for computational details, see Wu, Adams, & Wilson, 1998). Person estimates were used as input variables to confirmatorily test (i.e., without any data-driven model modifications) our theoretically anticipated structural equation model (using a maximum-likelihood approach; for computational details, see Muthén & Muthén, 2009).

Because we used nested data (i.e., students were clustered in classes and schools), standard statistical regression procedures might have underestimated standard errors due to restrictions of interpersonal differences as students were exposed to similar contexts (i.e., being in the same classroom, taught by the same teacher, etc.; see Muthén & Sartorra, 1995). Intraclass correlations are used to appraise the extent of such context effects. The intraclass correlations for our five scales were nontrivial (ranging from .04 for effectiveness knowledge to .13 for system knowledge); thus, we employed an approach—using the intraclass correlations—that was designed to correct the standard errors and χ^2 statistic, which would have been biased otherwise because of the nested and, thus, dependent nature of our data (for computational details, see Muthén & Muthén, 2009, p. 18).

The χ^2 statistic is sensitive to the sample size; thus, relying exclusively on this statistic with large samples would not be sensible when assessing a model fit. Alternatively, we computed the following additional fit indices: the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). The CFI ranges from 0 to 1 with higher values indicating a better fit. Values higher than .90 represent an acceptable fit (Bentler & Bonett, 1980; Browne &

Table 1. Formal Scale Features of the Measurement Instruments.

	General ecological behavior	Attitude toward nature	Environmental system knowledge	Action-related knowledge	Effectiveness knowledge
Number of items	40	40	38	23	29
Rasch-model type	SRM	PCM	PCM	PCM	SRM
Item fit statistics:					
M (*MS*)	0.99	1.00	1.00	1.00	1.00
SD (*MS*)	0.08	0.10	0.06	0.06	0.03
Minimum (*MS*)	0.92	0.87	0.95	0.96	0.97
Maximum (*MS*)	1.08	1.14	1.06	1.06	1.02
Person fit statistics:					
M (*MS*)	0.99	1.01	0.99	0.99	1.00
SD (*MS*)	0.43	0.48	0.33	0.46	0.32
Persons with poor fit (t > 1.96)	4.1%	0.3%	1.1%	2.8%	2.7%
Separation reliability	0.88	0.91	0.78	0.76	0.77
Descriptive statistics for person abilities:					
M	−0.26	−0.03	0.02	−0.04	−0.10
SD	1.12	1.31	0.74	0.91	0.78
Kurtosis	0.92	0.78	3.81	2.67	0.98

Note. SRM = simple Rasch model; PCM = partial-credit Rasch model; *MS* = mean squares. Estimates of the separation reliabilities are based on simulated, complete data. *N* = 1,907.

Cudeck, 1993). For the RMSEA and the SRMR, values smaller than .08 indicate an adequate fit.

Results

We will present our results in two parts. First, we will report scale calibration details of the employed measurement instruments, including fit statistics and reliability information. Second, we will present the details of our confirmatory test of the theoretically anticipated relations between environmental knowledge and attitude toward nature on the one hand and ecological behavior on the other hand.

Calibration of the Measurement Instruments

With regard to item fit for the measurement instruments, we generally found that Rasch model expectations closely matched the observed responses to items (see Table 1). To assess a model fit, we used mean square (*MS*) values. Note that *MS* values represent the residuals between the Rasch model expectations and the actually observed response vectors. Ideally, *MS* scores have a value of 1.00. *MS* values of 1.10 correspond to a 10% excess in variation, for example; values greater than 1.00 represent underfit. *MS* values below 1.00 indicate overfit (see Bond & Fox, 2007).

A reasonable fit was indicated in our study by the fact that the *MS* values of the scales were all close to 1.00 on average. As another indication of a reasonable fit, the standard deviations of the *MS* values of the scales were narrow (i.e., ≤ 0.10). For single items, the *MS* values were fairly reasonable too as none of them exceeded the range of an acceptable fit ($0.75 < MS < 1.30$; see Bond & Fox, 2007).

We also found a very reasonable fit of the Rasch model expectations to the actual responses of the participants, and this became apparent in the fact that for all five scales, the percentage of people with a statistically significant poor fit did not exceed 5% (see Table 1). Simultaneously, the average *MS* value at the scale level—this time for people—was also close to or equal to 1.00. The standard deviations of the *MS* values of the participants for the five measures were, this time, comparatively narrow (i.e., between 0.30 and 0.50), again reflecting that the results of only a small fraction of the participants deviated from the expectations of the Rasch model.

Using the item and person estimates, we simulated data for the systematically—by design—missing values to explore our instruments' potential reliability. In other words, for each scale, we estimated the reliability that would have been expected if we had attained responses from all persons to all items. These Rasch-model-based separation reliabilities for the five scales are presented in Table 1. Overall, the reliabilities were quite acceptable as they ranged from $rel = .76$ (action-related knowledge) to $rel = .91$ (attitude toward nature).

Scale means for students fell between $M = -0.26$ (general ecological behavior) and $M = 0.02$ (environmental system knowledge), and the standard deviations ranged from $SD = 0.74$ (environmental system knowledge) to $SD = 1.31$ (attitude toward nature). Apparently, some of our knowledge measures suffered from slightly restricted variances, also apparent in the somewhat elevated kurtosis values of some of our measures (see Table 1). With regard to knowledge, there was not only restricted variability in two of the three scales but also an apparent general lack of knowledge across all domains.

Following the rule of thumb used in the PISA study (see OECD, 2009), we could assume that a student dependably possessed the particular knowledge assessed by a specific question if the response probability of the item exceeded $p = .62$. Applying this rule of thumb to our data, we had to conclude that the average knowledge level was rather low. The average student was, for example, capable of correctly answering only twelve out of 38 environmental system knowledge questions, seven out of 23 action-related knowledge questions, and nine out of 29 effectiveness knowledge questions (for more details, see Roczen, 2011). Specifically, students could correctly recount that Brazil, and not Spain or Germany in comparison, is the country with the largest contiguous forest (environmental system knowledge), that houses are aired properly for short periods of time with the heat radiator switched off (action-related knowledge), and that energy-saving light bulbs consume, in comparison with conventional light bulbs, 80% less energy for the same lumen light (effectiveness knowledge).

Confirmatory Test of the Competence Model

Because we had to present items in 13 booklets that did not contain the same items, we had to deal with an incomplete data set. Such a substantial number of missing values rendered the simultaneous estimation of the measurement and theoretically substantive models difficult to perform. Thus, we decided to estimate our model based on the previously established reliabilities of our scales (see Table 1). In other words, we corrected our model for potential measurement error attenuation; to do so, we used scale scores as single indicator variables (see Figure 2).

Our structural equation model test revealed a significant discrepancy between the observed and model-implied figures: $\chi^2 = 9.06$, $df = 1$, $p = .003$. Note that the model fit indicators, which are relatively independent of sample size, suggested either an acceptable fit (i.e., RMSEA = .07) or a good fit (i.e., CFI = .99 and SRMR = .02) to the observed covariances. All theoretically anticipated paths were found to be significant with two exceptions: effectiveness knowledge turned out to be a nonsignificant determinant of general ecological behavior, and attitude toward nature did not significantly affect action-related knowledge as revealed by the standardized multiple regression weights of $\beta = .03$ and of $\beta = .04$ (see Figure 2). The strongest effect in our competence model was the one between attitude toward nature and general ecological behavior ($\beta = .54$). Together with action-related knowledge ($\beta = .15$), attitude toward nature accounted for 34% of the variance in a person's ecological behavior. Moreover, 7% of the variance in effectiveness knowledge was jointly explained by action-related knowledge ($\beta = .09$), environmental system knowledge ($\beta = .18$), and attitude toward nature ($\beta = .09$). Environmental system knowledge ($\beta = .54$) determined 30% of a person's action-related knowledge. The correlation between environmental system knowledge and attitude toward nature was $r = .14$; this positive association indicates either that a higher attitude toward nature inspires a person to acquire more knowledge about the environmental system or the other way around: elevated environmental system knowledge makes a person appreciate nature even more.

Discussion

In our research, we confirmatorily tested the anticipated proenvironmental competence structure that Kaiser et al. (2008) originally proposed (see Figure 2). Specifically, we found that attitude toward nature—in comparison with environmental knowledge—was the crucial force behind the degree to which adolescents embraced ecological lifestyles, attesting—even in its magnitude—to what has been reported previously for older participants (e.g., Brügger et al., 2011; Kaiser et al., 2013). Nonetheless, environmental knowledge—namely, action-related knowledge—turned out to be effective in promoting, however, to a small degree, a person's overall ecological behavior pattern directly as well. Although environmental system knowledge was not expected to directly trigger general ecological behavior, effectiveness knowledge, in contrast, was. The latter turned out to be one of only two theoretically unanticipated findings from our model test; however, the lack of behavioral relevance of effectiveness knowledge is not without precedence in the literature (see Frick et al., 2004).

Overall, the direct as well as indirect behavioral relevance of environmental knowledge was weaker than what we had expected. There is, however, a possible explanation for this finding. Because our students knew so little about environmental issues, how systems work, behavioral remedies, and the relative effectiveness of actions, range restrictions due to floor effects seem to have occurred (see Table 1). In other words, the seemingly small knowledge effects that we found might have been due to our students' extremely restricted levels of environmental knowledge because restricted variances of variables often lead to artificially deflated correlations with other variables as well (e.g., Tabachnick & Fidell, 2006). From our results, we should not conclude that intellectual abilities (i.e., environmental knowledge) can be abandoned and that the motivational ability (i.e., attitude toward nature) should be exclusively targeted for an effective promotion of the ecological lifestyles of individuals. A general increase in environmental knowledge might in fact already be able to alleviate the weak relations between knowledge and behavior (cf. Kaiser & Frick, 2002).

With the surprisingly low level of and rather narrow variability in our German adolescents' environmental knowledge—a finding that is again not without precedence in the literature (see Frick et al., 2004)—the development and implementation of specialized programs to teach environmental system knowledge, action-related knowledge, and effectiveness knowledge might, thus, be critical. This is because systematic instruction will probably not only increase the average knowledge level, but will also likely increase variability in this knowledge. This increase in variability implies that assessing and distinguishing adolescents' environmental system knowledge, action-related knowledge, and effectiveness knowledge will become easier as well.

Our students' apparent lack of knowledge and/or behavior could also have resulted from the fact that we had asked them questions that were irrelevant to them and/or to the circumstances of their lives. For example, the question about battery-powered devices might be irrelevant because adolescents interested in, for instance, a game console would probably ask their parents for it as a gift; in other words, they would have no control over the power particulars of the device selected by their parents. As all our measurement instruments were not only adapted to make them suitable for adolescents but were also previously verified—as reliable and valid—measures of the concepts of interest (Brügger et al., 2011; Kaiser & Frick, 2002; Kaiser et al., 2007; for details on the particular items, see the original publications), the apparent relevance or irrelevance of individual items is only a minor issue because it could not have affected any of the theoretically substantive findings or conclusions of our research.

Due to the limited variability that we found in the measurement of adolescents' environmental knowledge, we could not expect that the influence of attitude toward nature on environmental knowledge and vice versa would be very strong. In contrast, all relations were small—in terms of effect size—even when they were statistically significant (see Figure 2). Nevertheless, a person's appreciation for nature seems relevant for motivating the search for more information about nature and environmental systems (i.e., environmental system knowledge) and the other way around: learning about the workings of natural and environmental processes feeds into a person's appreciation for nature and ultimately into more environmental protection. With a growing appreciation for nature and an increasing desire to protect natural environment, people also seem to seek more knowledge about the particular effectiveness of possible behavioral remedies (i.e., effectiveness knowledge). Interestingly and in contrast, no direct effect on action-related knowledge was found. Apparently, appreciation for nature does not lead to an immediate search for more and better ways to protect the environment (i.e., the second of the two unanticipated findings). Appreciation for nature does, however, evidently lead to an indirect search for such behavioral remedies by way of environmental system knowledge (see Figure 2).

Our study is, as empirical research normally is, plagued with shortcomings that could have affected our results and interpretations: (a) due to time constraints—our data collection had to fit into a 45-min lesson period—we had to deal with a substantial amount of missing data by design. This systematically truncated our data set, and we had to simulate the omitted data and to anticipate the reliabilities of our measurement instruments before exploring the significance of the theoretically important relations. To do so, however, we used well-established procedures. (b) The criterion of our research consisted of behavioral self-reports. Often, the accuracy of such self-reports is challenged. Note that in previous research, we found that self-reported behaviors—from the adult version of our behavior measure—had a reasonable overlap with people's overt behaviors (Kaiser, Frick, & Stoll-Kleemann, 2001). (c) Cross-sectional and retrospective data provide only a rather tentative trial of the theoretically anticipated directed influences. Future research, based on experiments, will have to further establish the causal nature and directions of the various relations.

The amendment of real-life ecological behavior is the aim that turns competence formation into an objective and evidence-based endeavor. To attain the ultimate target (i.e., proenvironmentally competent people), we apparently must explore the potential of environmental education to improve environmental knowledge and to advance appreciation for nature. Both advancements in knowledge and in people's appreciation for nature have the potential to effectively promote the general behavioral engagement of individuals. With our competence model, we provide a means by which environmental education can become at least a more evidence-based endeavor for promoting more ecological ways of life in individuals.

Acknowledgment

We wish to thank Jane Zagorski for her language support and SvenjaVieluf, Birgit Harks, Jan Hochweber, Johannes Hartig, Siegmar Otto, Barbara Brown (the editor), and two anonymous reviewers for their technical and methodological support and for their comments on earlier drafts of this article.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: this research was financially supported by Grant BO944/5-1 from the German Research Foundation (DFG) as part of the Priority Research Program 1293 (Models of Competences for the Assessment of Individual Learning Outcomes and the Evaluation of Educational Processes).

Note

1. In our research, environmental knowledge is narrowly defined and does not include "social environmental knowledge." This is the case for two reasons. First, we are unaware of a measure of social environmental knowledge in the form of an attainment test. Second, social environmental knowledge, in the form of social norms, has typically been found to only be indirectly significant for ecological behavior (e.g., Bamberg & Möser, 2007).

References

Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, & Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, *27*, 14–25.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*, 588–606.

Bond, T. G., & Fox, C. M. (2007). *Applying the Rasch model: Fundamental measurement in the human sciences* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

Brügger, A., Kaiser, F. G., & Roczen, N. (2011). One for all? Connectedness to nature, inclusion of nature, environmental identity, and implicit association with nature. *European Psychologist*, *16*, 324–333.

Chawla, L., & Cushing, D. F. (2008). Education for strategic environmental behavior. *Environmental Education Research*, *13*, 437–452.

Clayton, S. (2003). Environmental identity: A conceptual and an operational definition. In S. Clayton & S. Opotow (Eds.), *Identity and the natural environment: The psychological significance of nature* (pp. 45–65). Cambridge, MA : MIT Press.

Corral-Verdugo, V. (2002). A structural model of proenvironmental competency. *Environment & Behavior*, *34*, 531–549.

de Haan, G. (2006). The "BLK 21 program" in Germany: A "Gestaltungskompetenz"-based model for education for sustainable development. *Environmental Education Research*, *12*, 19–32.

Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences*, *37*, 1597–1613.

Gatersleben, B., Steg, L., & Vlek, C. (2002). The measurement and determinants of environmentally significant consumer behavior. *Environment & Behavior*, *34*, 335–362.

Gräsel, C. (2001). *Ökologische Kompetenz: Analyse und Förderung* [Ecological competence: Analysis and promotion] (Unpublished habilitation thesis). Ludwig Maximilian University, Munich, Germany.

Heimlich, J. E., & Ardoin, N. M. (2008). Understanding behavior to understand behavior change: A literature review. *Environmental Education Research*, *14*, 215–237.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *Journal of Environmental Education*, *18*(2), 1–8.

Jensen, B. B., & Schnack, K. (2006). The action competence approach in environmental education. *Environmental Education Research*, *12*, 471–486.

Kaiser, F. G. (1998). A general measure of ecological behavior. *Journal of Applied Social Psychology*, *28*, 395–422.

Kaiser, F. G., Byrka, K., & Hartig, T. (2010). Reviving Campbell's paradigm for attitude research. *Personality and Social Psychology Review*, *14*, 351–367.

Kaiser, F. G., & Frick, J. (2002). Entwicklung eines Messinstrumentes zur Erfassung von Umweltwissens auf der Basis des MRCML-Modells [Development of an environmental knowledge measure: An application of the MRCML model]. *Diagnostica*, *48*, 181–189.

Kaiser, F. G., Frick, J., & Stoll-Kleemann, S. (2001). Zur Angemessenheit selbstberichteten Verhaltens: Eine Validitätsuntersuchung der Skala Allgemeinen Ökologischen Verhaltens [Accuracy of self-reports: Validating the General Ecological Behavior scale]. *Diagnostica*, *47*, 88–95.

Kaiser, F. G., & Fuhrer, U. (2003). Ecological behavior's dependency on different forms of knowledge. *Applied Psychology: An International Review*, *52*, 598–613.

Kaiser, F. G., Hartig, T., Brügger, A., & Duvier, C. (2013). Environmental protection and nature as distinct attitudinal objects: An application of the Campbell paradigm. *Environment & Behavior*, *45*, 369–398.

Kaiser, F. G., Oerke, B., & Bogner, F. X. (2007). Behavior-based environmental attitude: Development of an instrument for adolescents. *Journal of Environmental Psychology*, *27*, 242–251.

Kaiser, F. G., Roczen, N., & Bogner, F. X. (2008). Competence formation in environmental education: Advancing ecology-specific rather than general abilities. *Umweltpsychologie*, *12*(2), 56–70.

Kaiser, F. G., & Wilson, M. (2004). Goal-directed conservation behavior: The specific composition of a general performance. *Personality and Individual Differences*, *36*, 1531–1544.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *8*, 239–260.

Masters, G. N. (1982). A Rasch model for partial credit scoring. *Psychometrika*, *47*, 149–174.

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, *24*, 503–515.

McClelland, D. C. (1973). Testing for competence rather than intelligence. *American Psychologist*, *28*, 1–14.

Midden, C. J. H., Kaiser, F. G., & McCalley, L. T. (2007). Technology's four roles in understanding individuals' conservation of natural resources. *Journal of Social Issues*, *63*, 155–174.

Monroe, M. C. (2003). Two avenues to conservation behavior. *Human Ecology Review*, *10*, 113–125.

Muthén, B., & Sartorra, A. (1995). Complex sample data in structural equation modeling. *Sociological Methodology*, *25*, 267–316.

Muthén, L. K., & Muthén, B. O. (2009). Mplus statistical modeling software (Version 5.21). Los Angeles, CA: Author.

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2009). The nature relatedness scale: Linking individuals' attitude toward nature to environmental concern and behavior. *Environment & Behavior*, *41*, 715–740.

Organization for Economic Cooperation and Development. (2003). *Definition and selection of competencies: Theoretical and conceptual foundations* (Summary of the final report "Key competencies for a successful life and a well-functioning society"). Neuchâtel, Switzerland: Author.

Organization for Economic Cooperation and Development. (2009). *PISA 2006* (Tech. Rep.). Paris, France: Author.

Rasch, G. (1980). *Probabilistic models for some intelligence and attainment tests*. Chicago, IL: University of Chicago Press. (Original work published 1960)

Roczen, N. (2011). *Environmental competence—The interplay between connection with nature and environmental knowledge in promoting ecological behavio*r (Doctoral dissertation). Eindhoven, The Netherlands: Eindhoven University of Technology.

Schultz, P. W. (2002a). Inclusion with nature: The psychology of human-nature relations. In P. Schmuck & P. W. Schultz (Eds.), *The psychology of sustainable development* (pp. 61–78). New York, NY: Kluwer.

Schultz, P. W. (2002b). Knowledge, information, and household recycling: Examining the knowledge-deficit model of behavior change. In T. Dietz & P. C. Stern (Eds.), *New tools for environmental protection: Education, information, and voluntary measures* (pp. 67–82). Washington, DC: National Academy Press.

Tabachnick, B. G., & Fidell, L. S. (2006). Using multivariate statistics (5th ed.). Boston, MA: Allyn & Bacon.

Wang, S., & Wang, T. (2001). Precision of Warm's weighted likelihood estimates for a polytomous model in computerized adaptive testing. *Applied Psychological Measurement*, *25*, 317–331.

Weinert, F. E. (2001). Concept of competence: A conceptual clarification. In D. S. Rychen & L. H. Salganik (Eds.), *Defining and selecting key competences* (pp. 45–65). Seattle, WA: Hogrefe & Huber.

Wilson, M. (2005). *Constructing measures: An item response modeling approach*. Mahwah, NJ: Lawrence Erlbaum.

Wu, M. L., Adams, R. J., & Wilson, M. (1998). ACER ConQuest: Generalized item response modeling software [Computer software and manual]. Camberwell, Victoria, Australia: Australian Council for Educational Research.

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