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Effects of vicarious experiences of nature, environmental beliefs, and attitudes on adolescents' environmental behavior

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ABSTRACT

This study explores the relationship between vicarious experiences of nature, environmental behavioral beliefs, environmental attitudes and adolescents' environmental behavior. Based on a sample of 1476 adolescents from five high schools in Jiangsu Province, China, we proposed a model that was supported by structural equation modelling analysis. The model suggests that vicarious experiences of nature are positively associated with adolescents' environmental behavior. Environmental attitudes and environmental behavioral beliefs play partial mediator roles in the relationship of vicarious experiences of nature and environmental behavior. In addition to the significant direct impact of vicarious experiences of nature on environmental behavior, indirect effects are also achieved through behavioral beliefs, environmental attitudes and the serial multiple mediation effect of the two variables. These research results imply that we must pay attention to the important role of vicarious experiences of nature in cultivating adolescents' environmental behavior. In addition, the theoretical and practical implications of this research are discussed, as well as the limitations and potential for future research.

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Vicarious experiences of nature; environmental behavior; environmental beliefs; environmental attitudes; adolescents

Introduction

Environmental problems are becoming increasingly serious, threatening human health and even the survival and development of the whole society. In China, domestic pollution has become an important environmental problem as a consequence of the behavior and lifestyles of billions of humans, rather than the result of malicious intent (Schulz 2011). Therefore, in China, a significant focus of environmental protection efforts is individual environmental behavior. Adolescents are at the initial stage of their lives as active citizens and future leaders (Ginwright and James 2002) and are also in the critical period of forming habits and behavioral patterns (Moreno et al. 2008). It is important to study the causation and cultivation of their environmental behaviors. Since adolescent education is mainly carried out in schools, schools have assumed a great responsibility for environmental education, which even affects societal sustainable development

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(Jing 2017). In our previous research, we found that participation in environmental protection related experiences has a greater impact on high school students' environmental behavior than environmental knowledge and external policies (Sun et al. 2018). Research from different fields such as environmental education, youth development and experiential learning illustrate that direct interaction with nature, such as natural observation, camping and exploration, play an important role in positive environmental behavior development (Byrka, Hartig, and Kaiser 2010; Cheng and Monroe 2012; Collado and Corraliza 2015). However, the construction of cities and the advent of the electronic age has changed people's living places especially for adolescents, who increasingly use electronic devices to replace outdoor activities (Pergams and Zaradic 2008). Moreover, under the current COVID global pandemic, the closure of some outdoor places makes adolescents less likely to pursue outdoor activities.

In this situation, vicarious experiences are effective ways to seek indoor activities that can also cultivate adolescents' environmental behavior to replace outdoor activities, or so called vicarious experiences of nature. Vicarious experiences of nature occur through classroom settings, books/magazines, and other media (e.g. TV programs, videos, Internet), such as reading nature books, browsing through environmental magazines or viewing an environmental protection exhibition (Kellert 2002), which can also expose individuals to natural environments in an abstract way (i.e. not actually being in the natural environment). As a more feasible environmental education program type, vicarious experiences of nature are very likely to be an important way for schools to promote environmental behaviors in adolescents. Kil (2016) considers that vicarious (e.g. environmental poster making) and non-vicarious (e.g. experiential outdoor) environmental educational experiences can promote positive environmental behavior. Soga and Gaston (2016) conducted a questionnaire survey of elementary schoolchildren and found that both direct and vicarious experiences of nature affect children's willingness to conserve biodiversity. An earlier study indicated that such vicarious experiences can help to form environmental behavioral beliefs and inspire pro-environmental attitudes and behaviors (Hsu and Roth 1998). However, additional empirically validated studies are still needed and the psychological mediators of vicarious experiences have yet to be clarified.

Based on the Theory of Planned Behavior (TPB; Ajzen 1991), factors indirectly influence behavior through behavior intention. As shown in Figure 1, personal attitudes are one of the factors that determine behavioral intentions, and behavioral beliefs can play a role in the formation of personal attitudes. Attitudes refers to the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question (Ajzen 1991). Experience can indirectly affect behavioral attitudes through influencing behavioral beliefs, and ultimately affect behavioral intentions and behaviors. This is one of the paths that influence behavior in TPB theory. We argue that vicarious environmental experiences support environmental behavior and that this relationship is mediated by environmental behavioral beliefs and environmental attitudes. Environmental behavior here refers to the activities that individuals or society exert

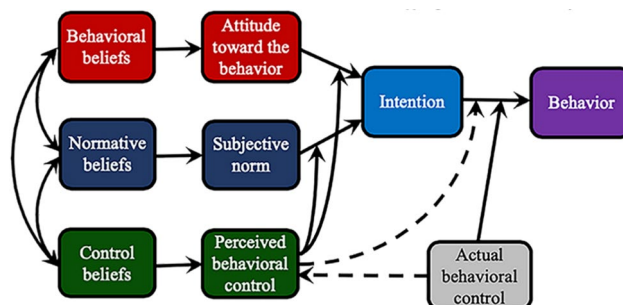


Figure 1. TPB schematic representation (Copyright©2019 Icek Ajzen).

directly and indirectly on the environment. Environmental behavior beliefs refer to the individual's tendency and firmness to implement environmental behavior. Environmental attitudes refer to the positive or negative views (including feelings and perceptions) that an individual holds towards implementing environmental behaviors. The study aims to verify the effect of vicarious experiences of nature on environmental behavior and the specific impact path between them. The results of this study may help to provide a theoretical basis and direction for the use of vicarious environmental education experiences to foster environmental behavior and also help to establish an environmental education curriculum.

Literature review

Vicarious experiences of nature and environmental behavior

Environmental education aims to assess environmental issues, propose feasible measures, and promote responsible environmental behavior (Mangas, Martinez, and Pedauy  1997; Pooley and O'Connor 2000). Direct, indirect, and vicarious experiences in nature are all ways to implement environmental education (Kellert 2002). Research has shown that contact with nature in wilderness and pristine areas far away from man-made facilities (direct environmental experience) and contact with nature in man-made natural areas such as zoos and urban parks (indirect environmental experience) can better promote a positive personal environmental behavior (Ewert, Place, and Sibthorp 2005; Van Liere and Noe 1981; Van der Linden 2015).

For example, by allowing students to visit natural areas on university campuses, researchers found that students establish emotional connections with nature and cultivate responsible environmental behaviors (Lawrence 2012). They also found through sub-group experiments that there is no significant difference in the impact of environmental protection activities in classroom teaching on students' environmental behaviors and direct experiences in nature (Kals and Ittner 2003; Duerden and Witt 2010). However, research on the predictive effect of vicarious experiences of nature on environmental behavior are still scarce (Kil 2016). Based on an experimental study, Arendt and Matthes (2016) found that watching environment protection documentaries (e.g. *An Inconvenient Truth*, *The Cove*) can increase nature connectedness and promote the implementation of environmental protection behaviors. Reading books related to natural environment protection (e.g. *Walden*, *Silent Spring*) which is a form of vicarious environmental experience, can enhance environmental protection intention and influence behavior (Mobley, Vagias, and DeWard 2010). Additionally, virtual experiences (i.e. visceral simulation experiences that feel like the real world) are widely noticed by researchers because of effective environmental behavior promotion (Hartmann and Apaolaza-Ib a ez 2008; Ahn et al. 2015). Moreover, this environmental education method through electronic products is more popular among young people (Pergams and Zaradic 2006). Based on the above conclusions, we propose the following hypothesis:

H1: Vicarious experiences of nature are positively associated with adolescents' environmental behavior.

The mediating role of environmental behavioral beliefs and environmental attitudes

Some experimental studies show that vicarious experiences of nature such as reading classic environmental protection books can cultivate environmental sensitivity and pro-environmental attitudes (Mobley, Vagias, and DeWard 2010), and lead to a tendency toward pro-environmental behaviors (Kil 2016). In Finland, Uitto, Boeve-de Pauw, and Saloranta (2015) investigated how school environmental experiences related to environmental sustainability influence adolescents' environmental intentions and behaviors, and found that pro-environmental values and self-efficacy play an important intermediary role. These findings show that vicarious environmental

experiences not only directly affect adolescents' environmental behavior, but also indirectly affect it through complex psychological variables. As intermediate variables, environmental behavior beliefs and environmental attitudes have attracted researchers' attention. Their research results also provide a basis for our research hypothesis.

For example, Uitto, Boeve-de Pauw, and Saloranta (2015) thought that in-school environmental experiences promoted students' out-of-school general ecological intentions and behaviors through enhancing students' pro-environmental behavioral beliefs. They suggested that school environmental education should not only provide environmental experiences, but more importantly, let students cultivate pro-environmental behavior beliefs through environmental experience. Additionally, Collado and Corraliza (2015) studied the relationship between positive experiences of nature in school grounds and children's environmental behaviors, and found this relationship was completely mediated by environmental attitudes. All kinds of environmental experiences will cause the growth of students' environmental attitudes and influence environmental behavior (Hartmann and Apaolaza-Ibáñez 2008; Duerden and Witt 2010; Ferreira 2012). The kind of experience gathered in a natural school yard is considered closer to vicarious experiences of nature because it promotes activities in a campus environment close to nature and obtains a positive environmental experience in the process, which differs from real nature. Therefore, we argue that environmental behavioral beliefs and attitudes play mediating roles between vicarious experiences of nature and adolescents' environmental behavior and propose the following hypotheses:

H2: Vicarious experiences of nature have an indirect, positive effect on environmental behavior through their influence on environmental behavioral beliefs.

H3: Vicarious experiences of nature have an indirect, positive effect on environmental behavior through their influence on environmental attitudes.

However, other studies suggest that behavioral beliefs are insufficient to induce environmental behavior. For example, researchers used a structured questionnaire to randomly sample whether tourists' environmentally responsible behaviors during travel were affected by their environmental beliefs, and found that tourists hold positive environmental beliefs to a large extent, but were not ready to transfer their environmental beliefs into environmentally responsible behaviors (Ramchurjee and Suresha 2015). Therefore, we consider whether there are other variables between environmental beliefs and environmental behavior. According to planned behavior theory, environmental attitudes are formed on the basis of environmental behavioral beliefs. When adolescents believe that adopting environmentally sustainable behaviors can produce positive outcomes, their attitudes towards environmental behavior will be favorable. Conversely, if they associate environmental behavior with mainly negative consequences, their attitudes will be unfavorable. Following planned behavior theory, our research also argues that environmental behavioral beliefs and environmental attitudes play a role in promoting development of adolescents' environmental behavior. This leads to the following hypothesis:

H4: Vicarious experiences of nature have an indirect, positive effect on environmental behavior. It is achieved by influencing environmental behavioral beliefs, beliefs affecting environmental attitudes, and attitudes affecting environmental behavior.

Methodology

Sampling

Data were collected from five middle schools in Jiangsu Province, namely Haizhou, Sinpu, Ganyu, and Lizhuang High Schools, and the Hexi Branch of Nanjing Foreign Language School. The

sample schools include both urban and rural schools, and comprise both good and ordinary schools in different regions. Samples within each school included students of different grades - classes in each grade are divided into two levels according to their grades, namely key classes and ordinary classes. Furthermore, to make the sample diverse and representative, we randomly selected a class of students from the key classes and the ordinary classes in each grade. A total of 1600 questionnaires were issued and 1476 were recovered, with an effective recovery rate of 92.3%. All participants are aged 12 to 16 years (M age = 15, SD = 1.19), of which 49% were boys, and 51% were girls. The survey was carried out during classroom time. Researchers went to all classes in the school to explain the intention and content of the survey to students, and students who agreed to participate voluntarily signed up. To guarantee participant interest, our investigation was implemented in accordance with the requirements of the Human Subject Protection Committee of East China Normal University.

Measurement scales

The environmental behavior scale

Before conducting this research, our team had already measured the level of high school students' environmental behavior and revised a scale for measuring it (Sun, Lu, and Pan 2019). The scale used in this study is based on the previous results. It took the form of a choice on a 5-point Likert-type scale ranging from 1 (Extremely inconsistent) to 5 (Extremely consistent). The scale is composed of 15 items and 4 subscales used to measure different kinds of environmental behavior, including financial (A), persuasive (B), ecological management (C) and civic behavior (D). All environmental behavior scale items are listed in the appendix. The Cronbach's α coefficient of the scale in our study was 0.90.

The vicarious experiences of nature scale

This scale was used to evaluate adolescents' level of vicarious experiences of nature and was taken from an environmental experiences scale of high school students (Sun, Lu, and Pan 2019). It consists of 5 items, mainly activities related to environmental protection experienced in the form of classrooms and networks. To better distinguish the frequency of different participant's participation in alternative environments, each item was assessed by participants as Never (0), Occasionally (3), and Often (5). A previous study found that the internal consistence reliability of the scale for Chinese high school students was 0.88 (Sun et al. 2018), and the Cronbach's α coefficient in our study was 0.83. All items of the vicarious experiences of nature scale are listed in the appendix.

The environmental attitudes scale

The environmental attitudes scale was used to evaluate adolescents' level of environmental behavioral attitudes ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). It contains 10 items, which are taken from the New Ecological Paradigm Scale (NEP) (Dunlap et al. 2000). The selection of NEP scale items referred to Pan's (2017) research result on the measurement of senior high school students' environmental attitudes, and also used in the Chinese version of Hong's translation (Hong 2006). Actually, the NEP scale is generally considered to measure attitudes towards the environment more generally, but because of the correlation between environmental attitudes and environmental behavioral attitudes, we also believe that the scale can reflect 'degree of support for solving environmental problems or willingness to contribute to solving environmental problems'. Therefore, we used it as an indirect measure of attitude toward environmental behavior. A past study reported the internal consistence reliability of the scale for Chinese high school students was 0.73 (Pan et al. 2017). The Cronbach's α

coefficient in our study was 0.71. All items of the environmental attitudes scale are listed in the appendix.

The environmental behavioral beliefs scale

This scale was used to evaluate adolescents' level of environmental behavioral beliefs ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). It contains 4 items, which were taken from the high school students environmental beliefs scale (Sun, Lu, and Pan 2019). The previous study reported the internal consistence reliability of the Chinese high school students scale was 0.62 (Pan et al. 2017). The Cronbach's α coefficient in our study was 0.63. All items of the environmental behavioral beliefs scale are listed in the appendix.

To reduce deviation, before the investigation began we also gave guidance to the participants. Concurrently, we also tested the accuracy of the results by setting repeated items in the scale and paying attention to whether the participants' choices under the same two items were consistent. It should be noted that the scales used in the study were all self-rating scales, that is, students' self-reports of their behavior, not their actual behavior.

Data analysis

First, we calculated the environmental behavior (dependent variable) score, vicarious experiences of nature (independent variable 1) score, environmental behavioral beliefs (independent variable 2) score and the environmental attitudes (independent variable 3) score of each participant according to the survey results. Due to the different number of scale items, scores were uniformly converted to a percentile system.

Data management and analysis were performed using SPSS (Statistical Package for the Social Sciences for Windows, IBM, Armonk, NY, USA) Version 22.0 and AMOS (Analysis of Moment Structures, IBM, Armonk, NY, USA) version 21.0. Descriptive statistics were used to describe the correlations and distinctions between different variables. Structural equation modelling was used to validate the established relationship model between vicarious experiences of nature and adolescents' environmental behaviors. The bias corrected percentile Bootstrap CI method was used to calculate the 95% confidence intervals (95% CIs) for the coefficients for the total, direct, and indirect effects (Wang et al. 2018). If the 95% CIs did not cross zero, the coefficients were considered to be statistically significant (Preacher and Hayes 2004). Statistical significance was set at $p < 0.05$, all the tests were two-sided. The theoretical model is shown in Figure 2.

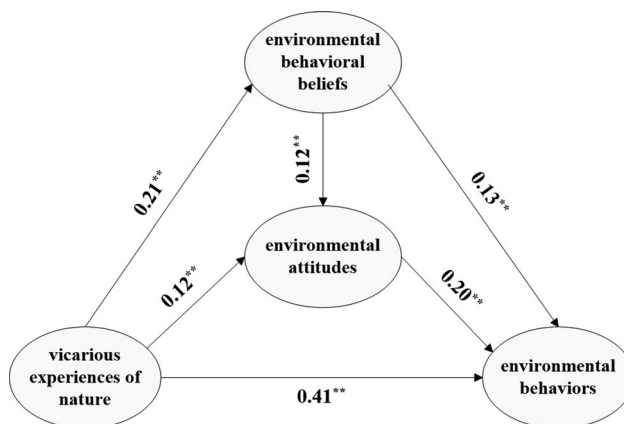


Figure 2. Parameters estimates for our research model. (* $p < 0.05$, ** $p < 0.01$).

Table 1. Zero-order correlations.

Construct	1	2	3	4
1.Vicarious experiences of nature				
2.Environmental Behavioral Beliefs	0.25**			
3.Environmental Attitudes	0.27**	0.25**		
4.Environmental Behaviors	0.48**	0.24**	0.26**	
Mean	3.31	3.42	4.16	3.80
SD	0.97	0.81	0.56	0.80

Note: * $p < 0.05$, ** $p < 0.01$.

Results

Reliability, validity, and common method bias

The reliability of the resulting measurement scales were assessed using Cronbach's alpha coefficient, which ranged from 0.63 to 0.90, which is an acceptable range (Nunnally 1978). To test whether these variables are suitable for measuring different concepts, we applied confirmatory factor analysis (CFA) to evaluate the convergent and discriminant validity for constructs included in the model. From the model fitting statistics, it can be seen that except for the RMSEA which is slightly higher than the standard value (0.04), and this result is acceptable ($\chi^2 = 131.56$; $p < 0.01$, NFI = 0.92, CFI = 0.90, GFI = 0.91, RMSEA = 0.05, SRMR = 0.04). Additionally, the results of the zero-order correlations between the variables are shown in Table 1. Except for the correlation of vicarious experiences of nature and environmental behaviors of 0.48, correlations generally ranged from 0.25 to 0.27. This indicates the relationships between variables in the model, indicating that the hypothetical model can be further verified. Therefore, our constructs showed good measurement properties.

Most empirical studies that use a self-assessment questionnaire face a risk of CMB (Common Method Bias), especially with a single time/source survey, and our study is no exception (Podsakoff, MacKenzie, and Podsakoff 2012). A Harman's single-factor test was conducted to determine CMB extent in the current data. Thus, we compared the one-factor Harman's confirmatory factor analysis solution to the four-factor solution, and found that the single-factor model had an extremely poor fit ($\chi^2 = 1153.78$; $p < 0.05$, NFI = 0.61, CFI = 0.53, GFI = 0.57, RMSEA = 0.22, SRMR = 0.17), and was indeed significantly worse than the four-factor solution ($\Delta \chi^2 = 1010.26$, $p < 0.01$). While the results of these analyses do not preclude the possibility of CMB, they do indicate that it is unlikely to confound our interpretation of the results.

Hypothesis testing

Using structural equation model analysis, we estimated all the path coefficients, simultaneously controlling for student age, gender, school type (Leonidou et al. 2013; Laroche, Bergeron, and Barbaro-Forleo 2001; Pérez et al. 2013). Figure 2 shows the hypothesized theoretical model and the results of the data analysis. The model tested for direct effect and three mediation effects through environmental behavioral beliefs and environmental attitudes between vicarious experiences of nature and adolescents' environmental behavior. The results of the measurement model and the data fitting are shown in Table 2. The closer to 1.0 the indices (such as NFI, CFI, GFI) statistical value is, the better the model fits the data, although it is generally believed that when the values are above 0.9, the model should be considered potentially useful (Cheung and Rensvold 2002). The results showed that our structural model fit the hypothesis model reasonably well (Wu 2010; Roczen et al. 2014). As predicted in Hypothesis 1, vicarious experiences of nature are positively associated with adolescents' environmental behavior. And the four influence paths are statistically significant and show that vicarious nature experiences have: (1) a direct

Table 2. CFI verification results.

Fitting Index	CMIN/DF	NFI	CFI	GFI	RMSEA
Actual value	1.78	0.93	0.91	0.92	0.04
Ideal value	<2	>0.9	>0.9	>0.9	<0.05

Table 3. Hypothesis testing results.

Hypothesis	Effect	Path	Value	CI _{low}	CI _{high}
H1	Total	Vicarious Experiences of Nature → Environmental Behavior	0.566	0.443	0.531
	Direct	Vicarious Experiences of Nature → Environmental Behavior	0.410	0.414	0.467
H2	Indirect	Vicarious Experiences of Nature → Environmental Behavioral Beliefs → Environmental Behavior	0.027	0.038	0.060
H3	Indirect	Vicarious Experiences of Nature → Environmental Attitudes → Environmental Behavior	0.024	0.021	0.043
H4	Indirect	Vicarious Experiences of Nature → Environmental Behavioral Beliefs → Environmental Attitudes → Environmental Behavior	0.005	0.004	0.008

Note: CI = 95% confidence level (bootstrapping).

impact on adolescents' environmental behavior (H1); (2) an indirect, positive effect on environmental behavior through its influence on environmental behavioral beliefs (H2); (3) an indirect, positive effect on environmental behavior through its influence on environmental attitudes (H3); and (4) an indirect, positive effect on environmental behavior through their influence on environmental behavioral beliefs and environmental attitudes in serial (H4). All four hypotheses are supported. This is consistent with previous research conclusions (Mobley, Vagias, and DeWard 2010; Arnocky and Stroink 2011), that vicarious experiences of nature have a significant direct and indirect impact on adolescents' environmental behavior (Kellert 2002; Kil 2016), and environmental behavioral beliefs and environmental attitudes are important variables with significant mediating effect (Mobley, Vagias, and DeWard 2010).

Simultaneously, the study tested the significance of mediation effects using bootstrapping ($n=5000$) (Hayes 2013). The results also support the four assumptions. Bootstrapping is a statistical resampling method that estimates model parameters and their standard errors strictly from the sample (Baron and Kenny 1986). As Table 3 shows, vicarious experiences of nature have a strong predictive effect on environmental behavior ($\beta=0.566$) and a 95% confidence interval around the unstandardized, bootstrapped estimate of the direct effect confirmed that it was statistically significant (95% CI [0.443, 0.531]). More specifically, the direct impact of vicarious experiences of nature on environmental behavior is the greatest ($\beta=0.410$), and the bootstrapped direct effect estimate confirmed that they are statistically significant (95% CI [0.414, 0.467]). The indirect effect from vicarious experiences of nature on environmental behavior through environmental behavioral beliefs and environmental attitudes, respectively, are medium, the mediating effects of two variables are similar ($\beta=0.027$, $\beta=0.024$), although the bootstrapped estimate confirmed that they are statistically significant (95% CI [0.038, 0.060], 95% CI [0.021, 0.043]). Moreover, the serial multiple mediation effect through behavioral beliefs and environmental attitudes is minimal ($\beta=0.005$), but the bootstrapped estimate showed that it is also statistically significant (95% CI [0.004, 0.008]). The results further support the results of previous studies (Hartmann and Apaolaza-Ibáñez 2008; Duerden, &Witt, 2010; Uitto, Boeve-de Pauw, and Saloranta 2015), and support the importance of environmental behavioral beliefs and environmental attitudes in the relationship between vicarious experiences of nature and adolescents' environmental behavior.

Discussion

From our above analysis, we can speculate that vicarious experiences of nature play an important role in the cultivation of adolescents' environmental behavior. Vicarious experiences have a

direct effect on environmental behavior, but also have an indirect effect on environmental behavior through mediating variables such as environmental behavioral beliefs and environmental attitudes. By constructing the relational model, this study concluded four vicarious nature experience paths that influence adolescents' environmental behavior.

Past research on the predictive influence of general vicarious environmental experience on the formation of positive environmental behavior is limited. This study provides a basis for the relationship between the two. Our results indicate that vicarious experiences of nature can facilitate connections with nature. Vicarious experiences of nature can directly influence environmental behavior, as shown by our predictive effect on environmental behavior of $R^2 = 36.8\%$. Compared to the indirect path through environmental behavioral beliefs and environmental attitudes, this direct impact is greater, although they are equally important. The finding shows that vicarious environmental experiences have a significant positive relationship with environmental behavioral beliefs and environmental attitudes, which corroborates previous findings on the effect of specific environmental literature readings on environmental attitudes (Boubonari, Markos, and Kevrekidis 2013; Mobley, Vagias, and DeWard 2010). Also, adolescents who engaged with general vicarious environmental experiences, such as reading environmental literature, appear to be more likely to express behavioral beliefs and affect environmental attitudes. Higher levels of environmental behavioral beliefs and environmental attitudes may foster actions that prevent or minimize negative impacts on the environment or be beneficial to the environment (Liefländer and Bogner 2014). Therefore, vicarious environmental experiences can indirectly influence environmental behavior through the mediating effect of environmental behavioral beliefs or environmental attitudes. Additionally, based on the influence of behavioral beliefs on attitudes in planned behavior theory, vicarious experiences of nature may affect environmental attitudes by influencing environmental behavioral beliefs, and ultimately promote environmental behavior, as our research has also verified.

All mediating effects were statistically significant, suggesting an ongoing important role for vicarious experiences in the development of adolescents' environmental behavior in environmental education. Vicarious experiences (e.g. nature enjoyment, books/magazines, TV programs) of nature create a process to achieve environmental benefits without direct participation in outdoor activities or actual physical presence in natural environments (Kil 2016). Moreover, compared with the high risk and cost of direct environmental experience, such as strolling through primeval forest, vicarious experiences of nature, such as a course in environmental education, are easier to popularize and implement. However, in the current COVID pandemic, and with a zero COVID policy to curtail the spread of the virus in China, 'not going out unless necessary' makes it difficult for schools to organize large-scale outdoor experiences. Therefore, the implementation of vicarious environmental experience courses is necessary. In these courses, attention should be paid to the guidance of environmental behavioral beliefs and environmental attitudes. Overall, this study not only makes improvements to the theory of adolescents' environmental behavior development, but also provides a theoretical basis and scientific guidance for the development of adolescents' environmental behavior through vicarious environmental education curricula.

Notably, there are many limitations in the research, which provide several opportunities for future research. Firstly, the study did not integrate direct and indirect environmental experiences into the established theoretical model and failed to compare the impact of different kinds of environmental experiences on adolescents' environmental behavior. Future studies could compare differences in effects on environmental behavior between vicarious nature, and other environmental experiences and use this to adjust the proportion of different kinds of environmental experiences in environmental education courses, to maximize comprehensive benefits. Secondly, this study did not investigate the effects of vicarious experiences of nature on specific environmental behavior dimensions. Therefore, future studies could determine the different effects of

vicarious nature experiences on different aspects of environmental behavior (financial, persuasive, ecological management, and civic).

Thirdly, the scales used in the study can be further improved. For example, there were too few items in the environmental behavioral beliefs scale, which may have relatively low internal consistence reliability (0.63). This could have produced an inaccurate measure of the level of environmental behavioral beliefs in this study. Additionally, since the NEP scale is treated as a measure of environmental worldviews, but we used it as an indirect measure of attitude toward environmental behavior. This may have some impact on the measurement results of environmental attitudes that focus on behavior. Measurements of vicarious experiences of nature, focus more on frequency of experiences, and less so on the impact of experience quality on other variables as it is difficult to measure. In conclusion, the development and revision of the above scales should be the focus of future research. Here, there is another question worth exploring. To some extent, vicarious nature experiences also belong to behavior, and the correlation test data (Table 1) indicated a strong correlation between vicarious nature experiences and environmental behaviors (correlation 0.48). Although they are different by definition an explanation that in our study vicarious experiences were measured at the same time as behaviors, so it is not know if they were causal. To further verify this, we could conduct a set of controlled experiments in the future. One group of samples would be subjected to intervention of vicarious experiences of nature and the other group left without intervention. To verify the role of vicarious experiences of nature, the beliefs, attitudes, and environmental behavior levels of the two sample groups would be compared, and the levels of the intervention group before and after intervention also compared.

Additionally, since sample selection from different schools was based on classes and did not cover the whole school, the data may be nested. It is hoped that follow-up studies can improve sample selection to improve its representativeness. Furthermore, there are great differences between schools at different levels, especially because of school culture, which may lead to significant differences in students' vicarious experiences of nature. This was not specifically analyzed in this study, and could be used as a research angle in the future.

Conclusions

The purpose of this study was to examine whether vicarious experiences of nature can impact adolescents' environmental behavior. The results indicate that vicarious experiences of nature have a certain impact on adolescents' environmental behavior, in addition to directly affecting environmental behavior, it can also indirectly affect environmental behavior through environmental behavioral beliefs, and attitudes.

Based on our validated model, cultivating students' environmental behavior teachers could increase students' vicarious environmental experiences and improve their environmental behaviors, and attach importance to the guidance of students' environmental beliefs and attitudes in the process of experiencing environmental experience, to drive adolescents' positive environmental behavior cognitively. Specific ways, for example, would be to encourage students to read books and watch documentaries which could lead to pro-environmental behavior beliefs and pro-environmental attitudes, and allow students to participate in exhibitions with the theme 'pro-environmental behavioral beliefs or pro-environmental attitudes'. These are all preferable measures in the implementation of vicarious environmental experience courses.

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Author contributions

Yuyu Sun devised the original idea for this article and wrote the paper; Xiaoxu Lu designed the theoretical model and collected the data; Jian Cui and Ke Du polished the article. All authors read and approved the final version. Shumin Xie played important roles in paper revision, such as explaining the concept and interpretation of measurement results.

Disclosure statement

The authors declare that they have no conflicts of interest.

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Appendix

1. The Environmental Behavior Scale

Items	1	2	3	4	5
	Extremely inconsistent	Relatively inconsistent	Neutral	Relatively consistent	Extremely consistent
1. A1 I usually pay attention not to buy products that are harmful to the environment.	1	2	3	4	5
2. A2 I often choose to buy products produced by manufacturers that attach importance to environmental protection.	1	2	3	4	5
3. A3 I often bring my own shopping bag when I buy daily necessities.	1	2	3	4	5
4. B1 I often encourage others to implement environmental behaviors (such as energy and water conservation, waste recycling, etc.).	1	2	3	4	5
5. B2 I often advise others to stop damaging the environment (such as littering, sewage discharge, etc.).	1	2	3	4	5
6. B3 I often advise others not to violate environmental regulations or inform them that their behavior has violated environmental regulations.	1	2	3	4	5
7. B4 I often take the initiative to discuss with others how to solve environmental problems.	1	2	3	4	5
8. C1 I often classify recyclable garbage (such as recycled paper, plastic bottles, waste batteries, etc.).	1	2	3	4	5
9. C2 I often save energy (such as turning off the lights, using air conditioning sparingly, etc.).	1	2	3	4	5
10. C3 I don't often use disposable personal items (such as plastic bags, chopsticks, paper towels, paper cups, etc.)	1	2	3	4	5
11. D1 I often donate money to the cause of environmental protection.	1	2	3	4	5
12. D2 I often participate in environmental protection activities organized by the school.	1	2	3	4	5
13. D3 I often participate in environmental publicity and education activities organized by the government.	1	2	3	4	5
14. D4 I participated in the signing of environmental protection initiatives.	1	2	3	4	5
15. D5 I lodged a complaint about environmental problems (such as calling the mayor's hotline or the environmental protection hotline).	1	2	3	4	5

2. The Vicarious Experiences of Nature Scale

Items	1	2	3
	Never	Occasionally(1-3 times)	Often (more than three times)
1.I often watch TV programs, documentaries and performances about environmental protection.	0	3	5
2.I often read about environmental protection.	0	3	5
3.I often listen to radio programs and lectures on environmental protection.	0	3	5
4.I visited exhibitions on environmental protection.	0	3	5
5.I often receive leaflets or brochures to publicize environmental protection knowledge.	0	3	5

3. The Environmental Attitudes Scale

Items	1	2	3	4	5
	Strongly disagree	Partially disagree	Uncertain	Partially agree	Strongly agree
1. We are approaching the limit of the number of people the earth can support	1	2	3	4	5
2. When humans interfere with nature it often produces disastrous consequences	1	2	3	4	5
3. Humans are severely abusing the environment	1	2	3	4	5
4. Plants and animals have as much right as humans to exist	1	2	3	4	5
5. Despite our special abilities humans are still subject to the laws of nature	1	2	3	4	5
6. The so-called "ecological crisis" facing humankind has been greatly exaggerated	1	2	3	4	5
7. The earth is like a spaceship with very limited room and resources	1	2	3	4	5
8. The balance of nature is very delicate and easily upset	1	2	3	4	5
9. Humans will eventually learn enough about how nature works to be able to control it	1	2	3	4	5
10. If things continue on their present course, we will soon experience a major ecological catastrophe	1	2	3	4	5

4. The Environmental Behavioral Beliefs Scale

Items	1	2	3	4	5
	Strongly disagree	Partially disagree	Uncertain	Partially agree	Strongly agree
1. I have the responsibility to protect the environment and am willing to sacrifice my personal interests	1	2	3	4	5
2. Environmental problems can be improved or partially solved as long as individuals are willing to do their best.	1	2	3	4	5
3. I have the responsibility to protect the environment and even offend some people.	1	2	3	4	5
4. The actions taken by ordinary people can affect the solution of environmental problems.	1	2	3	4	5