

Research Article:

From Children's Direct Nature Experiences to Conservation Willingness: Mediating Effects of Biodiversity Knowledge and Affective Attitudes

Faruhana Abdullah^{1,2}, Mohammad Zohir Ahmad^{1,3} and Nor Asniza Ishak*

¹School of Educational Studies, Universiti Sains Malaysia, 11800 USM Pulau Pinang, Malaysia

²Faculty of Engineering, Science and Technology, The Maldives National University, Ameenee Magu Malé, 20405 Maldives

³Faculty of Human Sciences, Universiti Pendidikan Sultan Idris, 35900 Tanjung Malim, Perak, Malaysia

*Corresponding author: asnizaishak@usm.my

ABSTRACT

Childhood direct nature experiences (DNEs) are crucial to create lasting relationships with nature that will in turn influence long-term biodiversity conservation. However, as children increasingly become urbanites, they also get progressively separated from nature. A loss DNEs of is worrisome because it can influence conservation willingness (CW) in multiple ways that are not fully understood. This study aimed to examine the serial mediation of biodiversity knowledge (BK) and affective attitudes (AA) in the relationship between DNE frequentness and CW. Data was gathered using an online survey questionnaire administered to 429 11–12 years old schoolchildren in the Maldives. A two-serial mediation analysis confirmed an underreported, predictive sequential pathway from DNEs through BK to AA to CW. Also, DNE frequentness exerted positive direct effects on BK and AA. While BK exerted neither significant direct nor independent mediating effects on CW, AA exerted both effects on CW. The direct effects of BK on AA are vital to re-orient innate, misconstrued, or biased negative attitudes to promote CW. Overall, DNE frequentness has positive effects on CW due to indirect effects rather than direct ones. The findings have implications for educators and other stakeholders to facilitate appropriate, contextually meaningful DNEs that enhance understanding of BK and stimulate positive shifts in attitude as a means to promote CW. This is an indispensable step towards successful education for sustainable development and long-term biodiversity conservation.

Keywords: direct nature experiences, biodiversity knowledge, affective attitudes, conservation willingness, education for sustainable development

Received: 30 January 2022; **Accepted:** 13 May 2022; **Published:** 29 July 2022

To cite this article: Abdullah, F., Ahmad, M. Z., & Ishak, N. A. (2022). From children's direct nature experiences to conservation willingness: Mediating effects of biodiversity knowledge and affective attitudes. *Asia Pacific Journal of Educators and Education*, 37(1), 193–212. <https://doi.org/10.21315/apjee2022.37.1.10>

INTRODUCTION

With the world in a state of environmental crisis, particularly stemming from unprecedented biodiversity loss (Ceballos et al., 2017; Lyle, 2021, sustainable solutions to this predicament remain elusive.). Considering it a crucial tool to address sustainability challenges, many countries have adopted education for sustainable development (ESD) as an integral component of their curricula (Hedefalk et al., 2015; Laurie et al., 2016). It is envisaged that, ESD will inculcate sustainable practices in children as a step towards attaining a sustainable future for all (Hedefalk et al., 2015). This will require children to be competent in multiple conservation-related attributes, including knowledge, attitudes, skills, and values that will enable them to tackle the volatile, yet escalating environmental issues, both at a local and global level (Laurie et al., 2016; Selby, 2017). However, Selby (2017) argues that a fundamental flaw in implementing ESD today is the marginalisation of nature experiences and emotional connections with nature. Hence, the predominantly de-natured pedagogies of ESD currently in practice must be transformed to increase children's direct nature experiences (DNEs) for a successful internalisation of the required attributes. Meanwhile, other experts call upon global policymakers to address the growing disconnect between people and nature in their sustainability-targeted plans, particularly by promoting experiential learning through increased DNEs to strengthen nature connections since childhood as a foundation to maintain thriving ecosystems for future generations (Convention on Biological Diversity, 2018). These views are supported by strong evidence that childhood nature experiences are pivotal to create sustained relationships with nature that will impact long-term biodiversity conservation (Beery & Jørgensen, 2018; Imai et al., 2018; Kellert et al., 2017; Mohamed, 2012; Sugiyama et al., 2021). Nonetheless, there is little empirical research focusing specifically on how DNEs lead to appropriate conservation-related behaviours, particularly in willingness to conserve biodiversity.

LITERATURE REVIEW

Despite the growing voices to increase children's DNEs, contemporary children are increasingly confined to small spaces within intensely urbanised environments (Charles et al., 2018; Soga & Gaston, 2016; Zhang et al., 2014), subjected to the fast pace and challenges of current times (Novotný et al., 2021). This plight of modern-day children has been aptly portrayed as the "bubble-wrap generation" (Malone, 2007, p. 513), and the "apartment child" (Ceylan, 2018, p. 669). This situation would not only deprive children of engaging in meaningful DNEs voluntarily with nature, but also pose challenges for facilitating such experiences through formal or informal means.

DNEs typically involve direct, first-hand interactions that engage the senses, although there are notable (Gaston & Soga, 2020; Longbottom & Slaughter, 2016), and sometimes conflicting, variation in definitions across research (Soga & Gaston, 2020). DNE frequentness, i.e., how often children engage in DNEs, is usually explored in terms of time spent outdoors (Hand et al., 2018; Larson et al., 2018), rural-urban differences (Almeida

et al., 2018; Mustapa et al., 2018) or nature-based educational programs (Otto & Pensini, 2017). Most importantly, DNE frequentness can influence many conservation-related attributes, although this study focuses on biodiversity knowledge (BK), affective attitudes and conservation willingness (CW).

Many studies illustrate the positive influences of increased DNE frequency on multiple dimensions of children's BK. Examples include increased knowledge of wild species taxonomy (Lindemann-Matthies, 2005), spider morphology (Otto & Pensini, 2017), plant and animal life, species interactions, and behaviour (San Jose & Nelson, 2017), endangered species, their habitats (Barthel et al., 2018), and identification of birds (White et al., 2018) and spiders (Albo et al., 2019) after planned experiences. Increased BK has also been linked to an increased frequency of habitual, unplanned DNEs in less urban areas, such as threats to species (Paraskeva-Hadjichambi et al., 2012), morphology of plants (Villarroel et al., 2018), identification of arthropods (Cornelisse & Sagasta, 2018), and native mammals (Almeida et al., 2018). Nonetheless, such experiences do not always produce the expected effects (Mulder et al., 2009; Schlegel et al., 2015). Furthermore, it is unclear whether these are direct or indirect effects of DNEs. Notably, BK also influences multiple dimensions of affective attitudes towards biodiversity and conservation-related behaviours as elaborated in the next paragraph. below.

Attitude is a complex, multidimensional concept, one of which is affective attitudes, which involve feelings towards an object or an issue (Albarracín et al., 2005). Multiple studies demonstrate that increasing DNE frequentness has a positive influence on various measures of affective attitudes towards biodiversity. One example is connectedness to nature (CTN), which has been significantly correlated with nature around children's homes, which enhances DNEs (Cheng & Monroe, 2012). Likewise, children living in less urban districts, with higher species observations, have a stronger CTN than their urban counterparts (Imai et al., 2018). Furthermore, hands-on experiences with animals are associated with sustained positive shifts in children's CTN, such as enhanced empathy towards salamanders and concern for nature (Barthel et al., 2018). They also enhance biophilic shifts towards animals, including decreased fear (Albo et al., 2019; Ballouard et al., 2012; Ferreira, 2012; Giusti, 2019; Tomažič, 2011), disgust (Giusti, 2019; Tomažič, 2011), negative perceptions, evasion, and destructive thoughts (Albo et al., 2019). Similarly, habitual DNEs improve affective attitudes towards species (Lindemann-Matthies, 2005; Soga et al., 2016; Zhang et al., 2014). Some findings also show that the effects of increased DNEs on affective attitudes are direct (e.g., Collado et al., 2015; Duron-Ramos et al., 2020). Conversely, decreased DNE frequency increases negative attitudes, for instance, towards invertebrates (Cornelisse & Sagasta, 2018; Soga et al., 2020).

In addition to DNEs, affective attitudes are strongly associated with BK (Albo et al., 2019; Cornelisse & Sagasta, 2018; Schlegel et al., 2015; Soga et al., 2020). For instance, Albo et al. (2019) found that while knowledge increased after brief direct experiences with unpopular animals, attitudes remained unchanged. Rather, as knowledge increased with repeated interaction, children's fears decreased, and attitudes improved remarkably. Such shifts

suggest that BK have direct effects on affective attitudes. One possible explanation for these effects is that some negative attitudes, like fear and disgust, that may originate from biases associated with culture or prejudice towards unpopular species, can undergo positive re-orientation with appropriate experiential learning (Breuer et al., 2015). The influence of experiential learning on shifting attitudes is emphasised by other authors (Meidenbauer et al., 2019; Yli-Panula et al., 2018) as well. That being said, it must be noted that affective attitudes towards biodiversity are influenced by ambient contexts such as work (Collado et al., 2015), wildlife exploitation (Mulder et al., 2009), utility values, sustenance, and safety (Pam et al., 2021). Notably, a confirmed rise in indifference towards unpopular species like insects regardless of their environs (Imai et al., 2018) indicates emerging negative trends in attitudes among children towards biodiversity that must be curbed. Understanding the influences of DNEs on attitudes is important because they reflect perceptions about biodiversity, which can form the motivational basis for protecting biodiversity (Yli-Panula et al., 2018) which can be mirrored in adulthood (Beery & Jørgensen, 2018; Kellert et al., 2017; Sugiyama et al., 2021).

DNE frequentness in diverse contexts can influence multiple conservation-related behaviours. Willingness to conserve biodiversity, or CW, represents one such conservation behaviour. CW is usually targeted at animals. In this regard, planned interactive experiences with animals have been found to enhance children's CW, as exemplified by increased willingness to protect snakes (Ballouard et al., 2012) and the intention to continue feeding birds (White et al., 2018). Also, the increased frequency of habitual DNEs invokes positive CW towards animals (Cornelisse & Sagasta, 2018; Soga et al., 2016; Zhang et al., 2014). Findings suggest that the influence of DNEs on conservation-related behaviours is not straightforward. Although not commonly and specifically evident in the context of willingness among children, Cheng and Monroe (2012) demonstrated that DNEs and attitudes have positive direct effects on conservation-related behaviours. In contrast, Collado et al. (2015) demonstrated that children's frequency of DNEs has both direct and indirect effects on conservation-related behaviours, which can be negative or positive depending on the context (Collado et al., 2015). However, most evidence supports that the positive effects through increasing the DNE frequency on conservation-related behaviours occur indirectly through mediators rather than directly. Often, these effects are independently mediated through affective attitudes (Collado et al., 2015; Duron-Ramos et al., 2020; Soga et al., 2016; Zhang et al., 2014), and on occasion, through BK (Cheng & Monroe, 2012; Otto & Pensini, 2017). Parallel mediation effects of BK and affective attitudes (Otto & Pensini, 2017) are also demonstrated. Meanwhile, direct, independent effects of increased BK on CW (Cornelisse & Sagasta, 2018) are also found. The influence of appropriate knowledge on CW is highlighted by findings that relate the lack of adequate knowledge about local wildlife with negative conservation behaviour (Genovart et al., 2013; Pam et al., 2021). While some authors emphasise that feelings are more important than knowledge to develop concern and positive attitudes towards animals (Ballouard et al., 2011), others stress on the importance of considering knowledge and affective attitudes as complementary factors that drive behaviour (Otto & Pensini, 2017).

Understanding the influences of DNEs on CW directly or indirectly through mediators is important for several reasons. One reason is that some experiences can have negative impacts on this behaviour. An example is the prioritisation of exotic species for CW by children based on vicarious experiences (Ballouard et al., 2011), which, according to Truong and Clayton (2020), reflects a disconnection from local biodiversity. The authors further caution about the challenges vicarious experiences may pose to biodiversity conservation in a world increasingly transformed by technology that is the norm for contemporary children. Another reason is that since human actions are the prime threat to biodiversity (Ehrlich & Pringle, 2008; Raven & Wackernagel, 2020; Schultz, 2011), positive changes in behaviour are key to mitigating this crisis (Schultz, 2011). As noted by Ehrlich and Pringle (2008) a few decades ago, the fate of biodiversity rests solely on the actions of humans in

The literature discussed shows that DNEs can influence CW via multiple pathways that are not well-understood in the context of DNEs in children. There is a noted lack of mediated effects of BK in this relationship. Given the diverse interrelationships as evidenced, a long sequential pathway whereby DNE influences BK, which in turn affects AA thus ultimately impacts CW, is plausible. There is a lack of literature that explores this relationship involving two mediators in sequence. By exploring these understudied routes, this study contributes towards a better understanding of how DNEs exert their effects of CW. This understanding can contribute towards designing the most effectual experiences that will help realise the foremost target, stimulating favourable changes in CW even within the limits of nature affordances surrounding children.

Two theories support the groundwork for contextual experiential learning, attitude development, and behaviour through DNEs: the modified Experiential Learning Theory (ELT) (Morris, 2019) and the Model of Modes of Learning in Childhood Development (Kellert, 2005). The contextually grounded learning cycle of the revised ELT supports that these experiences can lead to changes in attitudes and behaviour through learning. Kellert's (2005) model supports that DNEs influence multiple dimensions of learning and attitudes. The rationale for multiple relationships among the variables is better supported by the Environmental Competency Model (ECM) (Kaiser et al., 2008; Roczen et al., 2014) that is typically applied in environmental education. According to the ECM, both environmental knowledge and CTN interact to influence conservation behaviour. Knowledge and attitudes form the intellectual and motivational basis for conservation behaviour. Furthermore, attitudes exert a stronger influence on behaviour than knowledge (Roczen et al., 2014). This study importantly contributes to extending the application of these theories and models to the realm of DNEs among children, towards a better understanding of the relationship between their DNEs and CW.

This study aimed to examine the mediating effects of BK and AA in the relationship between DNEs frequentness and CW. Considering the relationships identified in the literature and supporting theories, the following hypotheses were formulated and tested:

H1: Experience frequentness (EF) will have significant direct and positive effects on CW without passing through either BK or affective attitude (AA).

H2: BK will have a significant positive mediating effect on the relationship between Experience frequentness and CW.

H3: AA will have a significant positive mediating effect on the relationship between EF and CW.

H4: BK (mediator 1) and AA (mediator 2) in this sequence will have significant positive mediating effects on the relationship between EF and CW.

The null hypotheses claimed zero effects.

METHODS

Participants and Study Sites

The participants in this study were children recruited from public schools in seven islands in the Maldives. The final sample consisted of 429 children ($M = 11.8$ years; $SD = 0.42$) of which 45.5% were males and 54.5% were females. The sample was drawn using a proportionate stratified random sampling method, with each island considered as one stratum. This method allows each stratum to be represented more appropriately than simple random sampling (Cohen et al., 2018; Creswell & Plano Clark, 2018;. Additionally, a power calculation was run using G*Power 3.1. Based on settings recommended by scholars (Murray et al., 2021; Wan Muhamad et al., 2018), the F -test family for linear multiple regression involving three predictor variables was chosen. With alpha set at 0.05, power at 0.80 and effect size at medium ($f^2 = 0.15$) the analysis recommended a minimum sample size of 77. For a smaller effect size, a larger sample would be necessary. Hence, the sample size in this study was sufficient for a medium effect size.

Data Collection Tool

Data for this study was collected using a survey questionnaire. The questionnaire comprised of four topics: (1) frequentness of DNEs, (2) BK, (3) AA, and (4) CW. Except for the DNE frequentness, the items were based on large, coloured photographs of 20 animals (caterpillar, frog, snail, butterfly, hermit crab, crab, waterhen, lizard, spider, bat, gecko, wasp, centipede, dragonfly, earthworm, rhinoceros beetle, bee, cotton stainer bug, grasshopper, & tadpole) and 10 plants (screw pine, mangrove, Indian almond, mangrove apple, sea hibiscus, Jamaican cherry, banyan tree, ball nut tree, sea lettuce, and breadfruit). Most were common to many study sites while few were important to biodiversity in the Maldives.

Direct nature EF

To measure the direct nature EF, or simply EF, each child was asked about how many times they participated in three nature-based activities in nearby natural places: (1) visit (2) interact with plants and (3) interact with animals. Responses to each question were scored on a four-point scale as Never (0), Less than once a month (1), At least one or more times every month (2), or Almost every day (3). The mean of the three activities represented an (EF Score). The scale in this study showed a Cronbach alpha coefficient of 0.53. While this value is typically considered poor, it was deemed acceptable based on criteria in supporting literature (Cho & Kim, 2015; Pallant, 2016; Taber, 2018). This variable was assessed using questions and scale adapted from Soga et al. (2016, 2018).

Biodiversity knowledge (BK)

BK measured the species identification knowledge by asking children to name the organisms presented in the 30 photographs described earlier. Each correct identification was scored as (+1). The mean score represented as the BK Score ranged from 0 to +30 per child. The internal consistency of the scale was good (Kuder Richardson 20 test score = 0.87). Earlier studies have also used similar methods to measure the identification of mammals (Almeida et al., 2018) and invertebrates (Schlegel et al., 2015).

AA

To measure AA, three questions were framed to assess feelings towards each species in the 30 photographs. The responses were scored on a 3-point scale: Like (2), No feelings (1), and Dislike (0). The mean of these items expressed as an AA Score ranged from 0 to 60. This score represented a measure of AA towards biodiversity. The scale showed excellent internal consistency (Cronbach alpha coefficient = 0.96). This method is adapted from Soga et al. (2016) although the present study included plants as well. Similar methods have been used in other studies to measure AA, for instance, towards invertebrates (Schlegel et al., 2015).

CW

CW measured children's willingness to protect the species shown in the photographs. Adapting from Soga et al. (2016) a single question asked whether the child would like to protect the animal or plant shown in the photo. The responses were scored on a 3-point scale as like (2), no feelings (1), and dislike (0). The CW Score also ranged from 0 to 60. The scale indicated excellent internal consistency (Cronbach alpha coefficient = 0.94). A similar method was also used by Zhang et al. (2014) to determine CW.

Validity

Before data collection, the content validity, i.e., the sufficiency of depth and breadth of the topic and the construct validity i.e., whether the instrument measures the proposed

constructs (Cohen et al., 2018) was established. The first was attested by four independent experts using a rating tool. The latter was confirmed by a Kaiser-Meyer-Olkin (KMO) test, as suggested by scholars (Massey, 2019).

Research Procedure

This study was approved by the ethics committee of Universiti Sains Malaysia. Data was collected online using a Google survey questionnaire. Class-teachers from Grade 6 of each school arranged for children to meet online at a scheduled time. The purpose and instructions were explained to the children by author 1 and the link to the questionnaire was provided to them. The teachers and author 1 (on video) remained online until the children finished, to address issues and ensure (as best as possible) that the data collection process was reliable, and children were in safe settings.

Data Analysis

The data was initially analysed with IBM SPSS statistics for Windows version 26. Normality of data was confirmed by conducting skewness and kurtosis tests (cut-off value of ± 1), the Kolmogorov-Smirnov test and Shapiro-Wilk test ($p > 0.5$), and visual assessments of the distributions of data in a histogram, based on guidelines (Cohen et al., 2018; Pallant, 2016; Tabachnick & Fidell, 2013). Descriptive statistics were applied to each variable. Preliminary Pearson product moment-correlation coefficient analyses were run to determine the relationship between EF, BK, AA, and CW scores.

To determine serial mediation of BK and AA in the relationship between DNEs frequentness and CW, a serial mediation analysis was performed using the two serial multiple mediation model (Model 6) of Hayes PROCESS (version 3.5). For it to be suitable for mediation, outcome variables must be continuous. The errors in estimation must also meet the statistical assumptions of OLS regression which includes normality, linearity, and homoscedasticity (Hayes, 2012; Kane & Ashbaugh, 2017). These assumptions were therefore verified. PROCESS macro enable examining both direct (effects of X on Y independent of the mediator) and indirect effects (effects of X on Y through mediators) (Demming et al., 2017; Hayes, 2018). This method has the advantage of being simpler than more widely applied analyses like Structural Equation Modelling, yet producing practically similar results for models based only on observed variables (Hayes, 2018; Hayes et al., 2017). Another advantage is that the Hayes PROCESS uses a regression-based bootstrapping approach to mediation analysis. This non-parametric method, unlike normal theory approaches, does not require normally distributed data but allows the testing of hypotheses with greater power (Hayes, 2018).

The two serial mediation model hypothesises that two mediators sequentially influences the relationship between X and Y with the assumption that a justifiable causal chain exists in the specified direction. (Hayes, 2012). The model tested in this study and the direct and indirect effects, are shown in Figure 1.

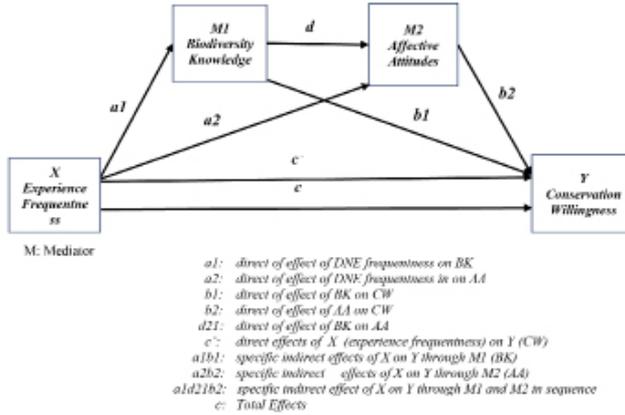


Figure 1. Path diagram depicting the hypothesised relationships between DNE, BK, AA, and CW using Hayes PROCESS Model 6 involving two mediators

According to the model in Figure 1, controlling for demographic factors and islands, BK (mediator 1) and AA (mediator 2) in sequence are predicted to mediate the relationship between experience frequentness (IV) and CW (DV). The model was tested using 10,000 bootstrap samples set at 95% confidence intervals and $p = .05$ according to recommendations by Hayes (2018). The null hypothesis assumes that indirect effects are zero. To claim statistical significance, the bootstrap CI generated must not cross zero. In this case, H_0 is rejected, and significant indirect effects are claimed. If the CI crosses 0, the H_0 fails to reject and indicate no significant effects.

RESULTS

A summary of the means, standard deviations, and correlations for each of the study variables are shown in Table 1.

Table 1. Descriptive statistics and correlation analysis results

Variables	Mean	SD	1	2	3	4
Pearson correlation between DNE frequency and other variables						
1 EF Score	1.74	0.71	–			
2 Total BK Scores	17.15	5.55	.166**	–		
3 Mean attitude score	34.01	10.72	.207**	.225**	–	
4 Total CW score	41.37	13.08	.128**	.195**	.787**	–

Note: ** Correlation is significant at the $p < 0.01$ level (2-tailed). N= 429 small (r between 0.10 to 0.29); medium (r between 0.30 to 0.49), large (0.50 to 1.0)

As seen in Table 1, the Pearson correlation analysis showed significant positive correlations among the variables.

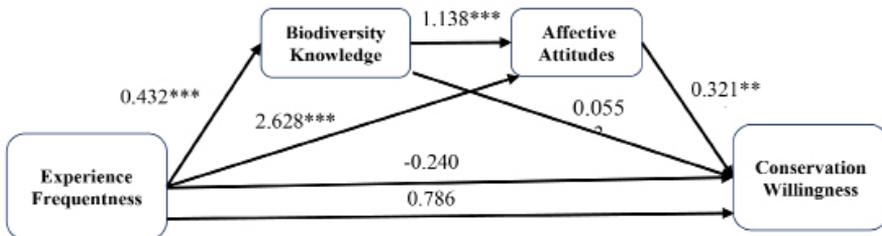
Effects of BK and AA in the Relationship between DNE Frequentness and CW Table 2 shows the results of the mediation analysis for the tested model.

Table 2. Effects of BK and AA on relationship between experience frequentness and CW

Paths	Model pathways	Coefficient <i>b</i>	SE	<i>t</i>	<i>p</i>	95% CI	
						LL	UL
a1	Direct effect of EF on BK	0.43	0.12	3.48	0.001***	0.19	0.68
a2	Direct effect of EF on AA	2.63	0.71	3.70	0.000***	1.23	4.02
d21	Direct effect of BK on AA	1.14	0.27	4.17	0.000***	0.60	1.68
b1	Direct effect of BK on CW	0.06	0.07	0.76	0.448	-0.09	0.20
b2	Direct effect of AA on CW	0.32	0.01	25.36	0.000***	0.30	0.35
c'	Direct Effect of (EF on CW)	-0.24	0.19	-1.27	0.203	-0.61	0.13
c	Total model effects (EF on CW)	0.79	0.29	2.67	0.008**	0.21	1.36
		effect	boot se			bootll	bootul
a1b1	Indirect effect: EF → BK → CW	0.02	0.03			-0.04	0.10
a2b2	Indirect effect: EF → AA → CW	0.84	0.25			0.36	1.33
a1d21b2	Indirect effect: EF → BK → AA → CW	0.16	0.07			0.05	0.31
	total indirect effects (EF → CW)	1.03	0.25			0.55	1.52

Note: ** pathway significant $p < 0.01$; *** pathway significant at $p < 0.001$. Significant pathways are noted in bold (95% CI does not cross zero). All pathways are unstandardised, indirect effects were computed using 10,000 bootstrap samples.

The relationships among the variables, non-standardised beta (*b*) values and the significance levels associated with the relationships for Model 1 are depicted in Figure 2.



Note: ** pathway significant $p < .01$. *** pathway significant at $p < .001$.

Figure 2. Two serial multiple mediation of BK and AA in the relationship between EF and CW with non-standardised beta (*b*) values

As seen from Table 2 and Figure 2, the direct effect of EF on BK, $t(427) = 3.48, p < 0.001$; ($b = 0.43$; $SE = 0.12$; 95% CI [0.19, 0.68]) and on AA $t(426) = 3.70, p < 0.001$; ($b = 2.63$, $SE = 0.71$, 95% CI [1.23, 4.02]) were significant and positive. However, the direct effect of EF on CW was not significant, $t(425) = -1.27, p = 0.2034$; ($b = -0.24$, $SE = 0.19$, 95% CI [-0.61, 0.13]). The direct effect of BK on CW is not significant, $t(425) = 0.76, p = 0.448$; ($b = 0.06$, $SE = 0.07$, 95% CI [-0.09, 0.20]). The direct effect of AA on CW was significant and positive, $t(425) = 25.36, p < 0.001$; ($b = 0.32$, $SE = 0.01$, 95% CI [0.30, 0.35]). The direct effect of BK on AA was significant and positive, $t(426) = 4.17, p < 0.001$; ($b = 1.14$, $SE = 0.27$, 95% CI [0.60, 1.68]).

Using the bootstrap confidence intervals, the indirect effect of EF on CW mediated only by BK, was not statistically significant (effect: 0.02, 95% CI [-0.04, 0.10]) but the indirect effect of EF on CW mediated only by AA, was statistically significantly positive (effect = 0.84, 95% CI [0.36, 1.33]) The indirect effect of EF on CW, mediated by BK and AA in series, with BK influencing AA, which in turn influences CW, was also statistically significant (effect = 0.16, 95% CI [0.046, 0.31]). The total indirect effect of EF on CW was significant (effect = 1.03, 95% CI [0.55, 1.52]). The total model effects of EF (sum of direct and indirect effects) on CW were significant $t(427) = 2.67, p = 0.008$; ($b = 0.79$, $SE = 0.29$, 95% CI [0.21, 1.36]).

DISCUSSION

The present study aimed to examine the mediating effects of BK and AA in the relationship between DNE frequentness and CW. In this analysis, several direct effects, which represents causal effects of one variable on another independent of the mediator (Hayes, 2018) were also uncovered. These can help explain relationships among variables and how mediators may exert their influences.

Consistent with literature that support similar associations (Collado et al., 2015; Duron-Ramos et al., 2020; Soga et al., 2016; Zhang et al., 2014), this study found significant positive associations between experience frequentness and CW. However, contrary to expectations H1 and similar to findings by Soga et al. (2016) and Zhang et al. (2014), the mediation analyses failed to signify direct effects of experience frequentness on CW, i.e., increasing the frequency of DNEs does not directly lead to CW. Together, these two results support the involvement of other factors in explaining positive association.

Like many past studies (Almeida et al., 2018; Cornelisse & Sagasta, 2018; Freeman et al., 2018; Otto & Pensini, 2017) ($N = 255$, and in contrast to others (Schlegel et al., 2015), this study revealed significant positive associations between increased experience frequentness and BK. Unlike these studies, the present findings also confirmed that experience frequentness exerted significant, positive direct effects on BK. Hence, experience frequentness significantly and positively predicts BK. In other words, frequent DNEs can cause positive changes in BK.

Supporting other studies (Ballouard et al., 2011; Cornelisse & Sagasta, 2018; Otto & Pensini, 2017), the present study did confirm significant, positive correlations between BK and CW. However, the results do not support significant direct effects of BK on CW. Although unexpected considering supportive evidence of this relationship (Cornelisse & Sagasta, 2018), it is not unusual given that observed positive associations between environmental knowledge and behaviour are often disputed and fail to confirm or only weakly confirm direct influences (Otto & Pensini, 2017). Notably, the dimensions of biodiversity examined (animals' ecosystem functions) and the experience contexts (planned interactive) by Cornelisse and Sagasta (2018) were different from this study. Also in contrast to some studies (Otto & Pensini, 2017), the findings did not support H2, the hypothesised significant independent mediating effect of BK in the relationship between experience frequentness and CW. The differences in dimensions of knowledge examined, specifically, knowledge about fauna, flora, and systems in the cited study and species identification knowledge in the present one, as well as the contexts of experiences may contribute to the differences in results. These findings suggest that the effects of DNEs on CW via BK is complex. Nonetheless, experiences must be encouraged to achieve positive effects.

Reflecting literature that supports positive associations between experience frequentness and AA (Cheng & Monroe, 2012; Cornelisse & Sagasta, 2018; Gaston & Soga, 2020; Soga et al., 2016; Zhang et al., 2014), the present results also evidenced significant positive associations between these variables. Furthermore, as indicated in other studies (Collado et al., 2015; Soga et al., 2016; Zhang et al., 2014), the results confirmed significant direct effects of experience frequentness on AA. The results also support that AA exert significant and positive direct effects on CW and hence are positive predictors of CW. Similar predictive effects of attitudes on children's pro-environmental behaviours have been reported (Cheng & Monroe, 2012). Thus, experiencing nature frequently can cause direct positive changes in AA, while attitudes can cause direct positive changes in CW.

As expected in H3, AA were found to exert independent, significant positive mediating effects in the relationship between experience frequentness and CW. Hence, experiencing DNEs frequently can lead to positive effects on CW through AA. These results are congruous with multiple others which illustrate that the effects of DNEs on many conservation-related behaviours are mediated by affective attitudes (Cheng & Monroe, 2012; Duron-Ramos et al., 2020; Otto & Pensini, 2017), in particular, conservation willingness (Soga et al., 2016; Zhang et al., 2014). Possibly, increased DNE frequentness enhance CW by promoting positive effects on multiple dimensions of AA including biophilia (Ballouard et al., 2012; Zhang et al., 2014). Nonetheless, the confirmation of both direct and indirect effects of DNE frequentness on behaviour depending on context (Collado et al., 2015) underscores the importance of contexts in examining relationships.

The results support the hypothesised H4 serial mediation of BW and AA on the relationship between experience frequentness and CW. Hence, the results confirm little known causal sequential pathway whereby experience frequentness influence BK, which in turn influences AA, and subsequently influences CW in children. A crucial link in this

path is the significant direct of BK on AA found in this study. This confirmation is also important because, by establishing such direct effects that are not evident in literature, it supports the experiential learning effects on attitudes discussed by scholars (Meidenbauer et al., 2019; Yli-Panula et al., 2018). Although specific direct effects are not reported in the studies, the effects of knowledge on attitudes may be best explained based on the effects of live experiences. For instance, Albo et al. (2019) demonstrated that as children's knowledge of spiders increased with interactive experiences, their attitudes towards them also became more positive. One explanation is that improved knowledge with experiences enhances understanding of species (Ballouard et al., 2012; Soga et al., 2020) which may then have positive effects on multiple dimensions of biophilia. Specifically, authors explain that appropriate knowledge could reduce fear perceptions (Albo et al., 2019), dispel false negative attitudes, correct misconceptions (Soga et al., 2020), biases and myths (Breuer et al., 2015) among many other negative attitudes. Supporting these ideas further, a lack of knowledge has been associated with negative attitudes (Imai et al., 2018; Pam et al., 2021) and behaviours (Pam et al., 2021; Yli-Panula et al., 2018) towards species.

Although the direct effects of DNE frequentness on CW were insignificant, its total indirect effects were. This combination of effects (insignificant direct plus significant total indirect effects) support full mediation (Demming et al., 2017). Additionally, the total model effects of DNE frequentness (sum of direct and indirect effects) were significant. Therefore, this study demonstrates that overall, DNE frequentness has positive effects on CW attributed to significant indirect effects mediated independently by AA and BK and AA sequentially, with BK influencing AA, rather than direct effects.

Limitations

The main limitation of this study is collecting data online because children's self-reports could be influenced to some extent despite the efforts made to secure reliability of the data collection process. Another is that responses to pictures, even if it is of good quality, would be different compared to real, hands-on experiences. Live experiences may change the outcomes like attitudes and behaviours following sensory engagements; hence, responses to live experiences including dimensions of attitudes like fear and disgust require further investigation.

CONCLUSIONS AND RECOMMENDATIONS

Increased frequentness of DNEs positively influences CW. In this relationship, AA stand out as key mediating factor. This relationship can also be explained via a sequential pathway whereby DNEs have positive effects on BK which positively influences AA which then brings about positive changes in CW. Establishing this indirect serial path gives crucial insight into how DNEs, BK, and AA link up to effectuate positive CW. Hence, although independently, CW does not exert either direct or mediating effects on CW, its role is no less important in regard to its influences on CW. Overall, these findings show that

DNE frequentness influences CW indirectly rather than directly. Taken together, the findings support the view that children must have DNEs frequently in ways that stimulate knowledge to evoke positive attitudes and thereby elicit positive CW.

The findings clearly point to the fact that focusing on attitudes is key to positive CW and that BK is a means to bring about this change. Hence, it is recommended that collaborative efforts are made among stakeholders to encourage and facilitate contextually rich direct nature experiences for children in a way that foster BK through active learning to elicit positive AA, and CW. In particular, it is recommended that schools play a proactive role in facilitating these experiences, either formally or informally, through environmental education and curriculum design to shift the focus from mere knowledge transmission to nurturing AA with the aspiration to promoting long-lasting effects on CW. The findings suggest that focusing on multiple theories are necessary in designing education towards SD. Further work is necessary to identify factors that influence DNEs in their local environments to fully understand the contextual basis of relationships so that optimal experiences can be facilitated for children. Moreover, it is also recommended that the ways in which children experience nature and their influences on outcomes are examined.

ACKNOWLEDGEMENTS

The authors are grateful to the school children who participated in this study and the school staff who facilitated data collection in the most trying times of COVID-19. This study received no external funding.

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