JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

COGNITION AND ATTITUDE TOWARD SUSTAINABLE DEVELOPMENT BEHAVIOR: COLLEGE STUDENTS' INFORMAL ONLINE LEARNING AS A MODERATION EFFECT

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Abstract. *The social responsibility of college students in the later stages of adolescence for sustainable development is emphasized, and the role of universities has become a crucial task. This study aimed to explore the level of college students' cognition, attitude, and behavior towards sustainable development and the association among them through the moderation effect of informal online learning. The difference verification and structural equation modeling were applied to 559 students who majored in science, and statistical validity was confirmed. Regarding the sustainable development level of college students, there was a significant difference in cognition, attitude, and behavior towards sustainable development between males and females, formal education, and informal online learning. Further, college students' attitudes towards sustainable development played a significant mediating role between cognition and behavior. The study also found a significant moderation effect of informal online learning on students' cognition and attitude toward sustainable development behavior. Accordingly, this study suggests that universities should systematically design educational programs to promote college students' behavioral change toward sustainable development through personal life-oriented learning courses.*

Keywords: *sustainable development behavior, sustainable development cognition, sustainable development attitude, college student, informal online learning*

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Introduction

As society continues to prioritize rapid economic development and growth, excessive development, and consumption have led to the depletion and degradation of resources, environmental destruction and pollution, and global warming. These ecological problems have become important global issues (Andersen et al., 2018; Choi et al., 2010; UNESCO, 2005). To address these issues, it is necessary to strengthen education for awareness and understanding of sustainable development. Especially for college students, as the backbone of future society, their cognition and behavior have a crucial impact on the sustainable development of future society (Ávila et al., 2019; Wals & Jickling, 2002; Walshe, 2017).

Many universities offer courses on sustainable development to educate students on how to contribute to society and the environment (Tilbury, 2004; Veidemane, 2022). The significance of conducting sustainable development education in universities lies in the fact that the college's responsibility extends beyond imparting knowledge, as it also involves cultivating the personality and values of its students.

In addition, as part of society, college students have a direct impact on the environment and society through their behavior and habits. Providing sustainable development education and training for college students can cultivate their environmental awareness and sustainable development concepts, guiding them to adopt sustainable lifestyles and make contributions to the future sustainable development of society (Min, 2019; Shephard, 2008).

Furthermore, the current use of digital media is recognized as an important communication tool, and it is attracting attention as an optimal tool for realizing social learning as it enables knowledge and information sharing, dissemination, communication, and collaboration (Lim et al., 2012). College students obtain information related to sustainable development through mass media and provide opportunities for activities related to sustainable development through methods such as online forums (Hori & Fujii, 2021).

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

With this social trend, personal learning using information and communication technology (ICT) is increasing and evolving as a tool for informal learning (Kim & Yi, 2011).

Nevertheless, sustainable development is still mostly at a theoretical level, and students' perceptions and actions toward the environment need to match the current environmental problems (Shephard, 2008; Vandemoortele, 2018). Most previous studies have tended to separate the cognition, attitude, and behavior of sustainable development (Michalos et al., 2011; Min, 2019; Torbjörnssona, 2011), and empirical studies on the association between these factors have been limited. In this context, this study explores the association between personal characteristics and factors influencing sustainable development to enhance the sustainable development behavior of college students.

Literature Review

College Students' Sustainable Development

Ever since the World Commission on Environment and Development (WCED) defined sustainable development in 1987 as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs', the complexity of sustainable development due to its characteristics, there have been various interpretations and criticisms in its definition. Among them, this study conceptualizes sustainable development as the comprehensive development strategy for the 21st century that emphasizes the integration and balance among the environment, economy, and society, based on the global agenda of the UN (2015) and the Triple Bottom Line theory (TBL theory) of Elkington and Rowlands (1997).

In particular, the Chinese government and the Ministry of Education recognize the importance of sustainable development as a national and global agenda and are implementing a series of policies and measures to promote the sustainable development of university students. In this regard, in 2019, the China Center for Environmental Protection and Publicity and Education issued the '*Guidance Opinion on Strengthening the Construction of Ecological Civilization in Higher Education*' to strengthen ecological civilization education in universities and cultivate students' awareness of environmental protection. It has been announced that university education will promote the construction of an ecological civilization.

In addition, in China, influenced by the Rio Conference in 1992, education for sustainable development tends to be discussed centering on environmental education (Qu, 1993), and education for sustainable development for college students also emphasizes environmental protection and resource conservation (Pan, 2015). Recently, in order to promote a sustainable development policy called *'Green Walk'*, sustainable development using eco-friendly transportation is supported (Chen, 2014; Wang et al., 2018). For example, there are attempts by college students to reduce resource waste and carbon emissions by using new transportation methods such as shared bicycles and carpools (Shen & Liu, 2017; Wang et al., 2018).

Nevertheless, there are still some limitations in the cultivation of sustainable development among Chinese college students. First, many college students have received less education on sustainable development due to the lack of curriculum and educational resources (Huang, 2014; Yang et al., 2017). Second, as some college students lack in-depth thinking about sustainable development, they tend to underestimate the value of the environment and resources and lack action and initiative to promote sustainable development (Hu, 2013; Zhang, 2020). In addition, studies that can further strengthen the combination of theory and practice in the field of sustainable development to improve the practical ability of college students for sustainable development are needed (Yang et al., 2017; Yi & Lu, 2022; Yu & Yang, 2019).

Accordingly, it is important for all stakeholders, including government, civil society organizations, corporations, and universities, to collaboratively design and implement practical plans that incorporate sustainable development principles and visions. Additionally, educating individuals about sustainable development should be a priority (Hesselink, 2000; UNESCO, 2005).

Factors Influencing Sustainable Development

Sustainable development has become a critical issue in higher education institutions worldwide, as they are not only responsible for equipping students with knowledge and skills to address global sustainability challenges but also must lead by example and implement sustainable practices themselves. However, implementing sustainable practices in higher education institutions has its challenges (Tilbury, 2004; Veidemane, 2022). According

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

to Ávila et al. (2019), higher education institutions around the globe face a multitude of challenges that hinder students' promotion of sustainable development, and this is equally true for Asia. Among those challenges, this study explored the structural association between sustainable development cognition, attitude, and behavior among college students.

Firstly, Michalos et al. (2011) argued that the association between cognition and attitude toward sustainable development is stronger than other associations and that the association between cognition and behavior is also significant. It has been shown that there is a statistical correlation between cognition and behavior (Yoo & Lee, 2014), and that there is also a significant correlation between attitude and behavior (Min, 2019; Walshe, 2017). In addition, studies conducted by Yoo and Lee (2014) and Yoo and Oh (2016) provided evidence supporting the view that cognition has a substantive impact on behavior. The research conducted by Yoo and Oh (2016) also suggested that attitudes play an important role in shaping individual behavior. In other words, even in the absence of external pressure or incentives, an individual's views on a particular issue or behavior strongly influence their actions.

When considering previous studies, one thing to consider in studies of college students' cognition and related behaviors on sustainable development is whether there is a difference in gender, formal education (sustainable development learning experience in college) and informal online learning (using ICT for sustainable development).

Recent studies have shown that females are more interested in the environment and more sensitive to environmental issues than males, resulting in a significant difference in females' cognition and behaviors for sustainable development compared to males (Min, 2019). Furthermore, previous studies have demonstrated that individual value systems can also play a significant role in shaping attitudes towards sustainable development. For instance, individuals who prioritize human-centered values, such as care for others and social justice, tend to have more positive attitudes towards sustainable development than those who prioritize self-enhancement values, such as achievement and power (Torbjörnssona, 2011).

In addition, classes related to sustainable development at school can help college students understand the concepts and principles of sustainable development, and through these classes, college students can understand the meaning and background of sustainable development, thereby contributing to raising awareness of sustainable development (Mahtab & Asghar, 2021). Similarly, Janmaimool and Khajohnmanee (2019) found that students with a learning experience in sustainable development have more positive attitudes than students without a learning experience and related to sustainable development in school can promote positive attitudes, and the attitude influences environmental behavior.

Hori and Fujii (2021) suggested that due to the rapid development of ICT, an increasing number of students are learning about sustainable development through the Internet or mobile phones and that college students actively collect information related to sustainable development. It can positively influence the values of people to support sustainable development and take more action on sustainable development (Gu, 2022).

Understanding these associations and differences, this study can provide insights into how college can better educate and engage students on sustainable development, and how individuals can be encouraged to adopt more sustainable behaviors in their daily lives. Therefore, the following three research questions were posed:

1. Are there differences in cognition, attitude, and behavior of sustainable development among college students?
2. Is there a mediating effect of attitude between cognition and behavior of sustainable development?
3. Do influences of sustainable development attitudes on behavior differ according to gender and learning experiences?

To address these questions, the study formulated an analytical model, using "the cognition of sustainable development" as the independent variable, "attitude" as the mediating variable, and "behavior" as the dependent variable. The association between the variables is illustrated in Figure 1. Building on the prior studies, this study constructed both partial and full mediating analytical models, considering the findings of some studies that indicate no direct effect of the cognition of sustainable development on behavior. Min (2019) suggested that an association that could affect behavior is inconclusive in a state where the knowledge level of sustainable development is low. This may be because sustainable development cognition is transferred to action only when it is internalized into an attitude. Therefore, this study also included a *full mediating model* (Figure 2) that suggests that cognition does not have a direct impact on behavior. Finally, in order to further verify the model validity, this study considered the moderation effect on the structural model of gender, formal education experiences, and informal online learning

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

related to sustainable development (Figure 3). By verifying the statistical significance of the moderation effect, the study intended to enhance the explanatory and predictive power of the research model.

Figure 1
Partial Mediating Model

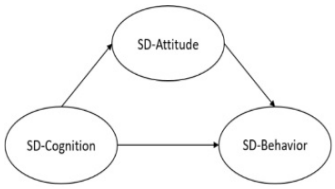


Figure 2
Full Mediating Model

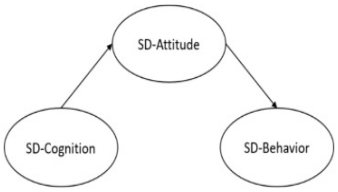
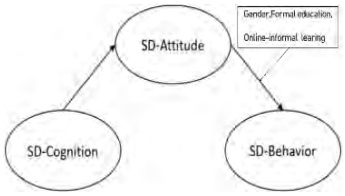


Figure 3
Meditation Model by Multi-group



Research Methodology

Research Design

This study is quantitative research aimed at examining the levels of college students' cognition, attitude, and behavior towards sustainable development and the associations among these variables. A survey questionnaire was administered to undergraduate students from a comprehensive university in China, and a structural equation modeling approach was used to analyze the data.

The survey was conducted for one month from May to June 2022. The questionnaire was distributed during the night self-study time of the students, and before completing the questionnaire, the students read and signed the informed consent form that explained the purpose of the study and the confidentiality of the survey responses.

Participants

Study participants are recruited from the only four-year university in C City, a city abundant in natural resources. The university has established departments related to sustainable development and carries out related activities to promote cognition, attitude, and behavior of sustainable development among students majoring in science-related fields. In this study, a sample was chosen from this university to obtain representative data on sustainable development. Students enrolled in grades 1 to 4 were included in the sample to reflect the various levels of sustainable development. There were slightly more male students (308, 55.1%) than female students (251, 44.9%). By grade, the sample consists of 169 first-year students (30.2%), 134 second-year students (24.0%), 125 3rd-year students, and 131 4th-year students (24.4%). Finally, the study analyzed the distribution of students with prior formal educational experience and informal online learning. Of the students surveyed, 216 students (38.6%) had prior formal educational experience, while 343 (61.4%) students did not have such experience. Regarding informal online learning, 310 students (55.5%) indicated a higher level of informal online learning than the overall average, while the rest, 249 students (44.5%) had a lower-than-average level.

This study collected 580 questionnaires, of which 559 copies were put into the analysis, excluding 21 questionnaires that were answered insincerely. Although the sample size is small, this study adopted a rigorous sample selection process and ensured the representativeness and diversity of the sample.

Measurements

The study adopts a measure of cognition, attitude, and behavior of sustainable development targeting young people, developed by Michaelos et al. (2011). This measurement tool is considered reliable and consistent: the overall reliability of the cognition tool is Cronbach's $\alpha = \theta.790$, the attitude tool is Cronbach's $\alpha = 0.770$, and the behavior tool is Cronbach's $\alpha = 0.630$. This measurement tool consists of 47 items, but this study uses items found to be reliable, removing the items with values less than 0.6 on the reliability index. The measurement tool used in this study consists of a total of 24 items, comprised of 9 items for cognition, 5 items for attitude, and 10 items for

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

behavior. To ensure the content validity of the measurements, three education experts reviewed the contents of each item and confirmed the suitability of the final 24 items. Each item is reported on a Likert 5-point scale (1 = not at all; 5 = very much), where higher scores signify higher levels of awareness, attitude, and practice of sustainable development.

To verify the validity of the measurement tools, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted (shown in Table 1). In the process of exploratory factor analysis, principal component analysis was performed to extract three factors. Twenty-four items with factor loadings exceeding 0.5 and no cross-loading were maintained. The goodness of fit of the KMO sample is judged to be acceptable when it is 0.6 to 0.7 or higher, and the factor analysis result is 0.966, and in Bartlett's sphericity test, the significance probability is 0.000 and the significance level $p < 0.001$, and the model is confirmed to be suitable. Next, CFA was performed to evaluate the structure of factors derived by EFA. The model fit index was $\chi^2/df = 2.284$ (< 3), TLI = 0.960 (> 0.9), CFI = 0.964 (> 0.9), and RSMEA = 0.048 (< 0.05), confirming that the model was appropriate. In addition, in CFA, the factor loading is between 0.550 and 0.780, the average variance extraction (AVE) value is between 0.467 and 0.565, and the combined reliability (CR) value is between 0.867 and 0.905. The measurement tool of this study was found to be appropriate.

The Cronbach's alpha values of the last question on the survey for the cognition, attitude, and behavior measurements were 0.928, 0.898, and 0.917 respectively, which met the acceptance standard of over .6 for reliability. This study performed confirmatory factor analysis to evaluate the fit of the measurement model.

Table 1
Validities of the Sustainable Development Items

Items	Mean	EFA	CFA
SD-Cognition (Cronbach's α 0.928, CR 0.905, AVE 0.514)			
C1. Economic development, social development and environmental protection are all needed for sustainable development	3.75	0.651	0.698
C3. Sustainable development is about both future needs and what we need today	4.00	0.708	0.741
C5. China's overall use of energy remains to be improved	3.93	0.778	0.849
C9. Sustainable development tries to balance human and economic success with cultural traditions and respect for the earth's natural resources	4.48	0.764	0.809
C10. We can slow the rate of climate change	3.53	0.692	0.751
C12. Conservation of fresh water is not important in China because we have plenty	3.69	0.717	0.792
C13. Maintaining biodiversity is essential to the health of ecosystems	3.64	0.738	0.802
C15. Non-renewable resources should not be used faster than the rate at which we find substitutes that are renewable	3.71	0.666	0.755
C16. It is useful to estimate the monetary value of the services that the ecosystem provides to us	3.69	0.731	0.772
SD-Attitude (Cronbach's α 0.898, CR 0.867, AVE 0.565)			
A3. Companies should try to avoid making design disposable products	3.57	0.764	0.831
A5. Laws and rules to protect the environment need to be more strict than they are now	3.29	0.751	0.793
A8. Companies that are environmentally responsible are more likely to make a profit over the long run	3.57	0.755	0.832
A10. Governments should encourage greater use of fuel-efficient vehicles	3.62	0.780	0.704

https://doi.org/10.33225/jbse/23.22.900

Items	Mean	EFA	CFA
A13. Taxes on polluters should be increased to pay for damage to communities and the environment	2.67	0.707	0.837
SD- Behavior (Cronbach's α 0.917, CR 0.897, AVE 0.467)			
B1. I walk or bike to places instead of going by car	3.89	0.739	0.779
B2. I use reusable containers in order to reduce waste	2.85	0.669	0.69
B3. At home, I try to recycle as much as I can	3.23	0.622	0.707
B5. I have taken a course in which we talked about sustainable development	3.36	0.703	0.799
B7. I pick up litter when I see it in a park or a natural area	2.53	0.664	0.712
B8. I often look for signs of damage to our environment	2.53	0.750	0.830
B10. I sort the trash before I throw it away	3.32	0.665	0.687
B12. I try to avoid purchasing goods from companies with a poor track record on caring about their workers or the environment	4.09	0.705	0.784
B13. I have changed my personal lifestyle to reduce waste	3.03	0.550	0.675
B14. I have studied some issues related to climate change	2.90	0.744	0.759

Data Analysis

To ensure the quality and reliability of the collected data, several statistical analyses were conducted. Firstly, descriptive statistical analysis was conducted to obtain the basic information of the data, such as the mean, standard deviation, and range of each variable. In addition, Cronbach's alpha coefficient was calculated to measure the internal consistency of the items and ensure the reliability of the measurement tool. Moreover, the questionnaire was translated back into Chinese, and CFA was conducted for the validity of the measurement tool. In this study, the hypothesized latent constructs were cognition, attitude and behavior of sustainable development, and the observed variables were the items in the questionnaire. Furthermore, the study explored the differences in sustainable development according to personal background variables such as gender, formal education, and informal online learning by conducting independent t-tests. By examining the differences in sustainable development between different groups, the study can gain insights into how personal background variables affect sustainable development behaviors. To explore the association between cognition, attitude and behavior of sustainable development, a structural equation model (SEM) was constructed, and the mediating effect of attitude was verified. Finally, a multi-group analysis was conducted to verify the moderation effects of gender, university class experience related to sustainable development, and informal online learning. All of the aforementioned analyses were conducted using SPSS 26.0 and AMOS 26.0 programs, which are commonly used statistical analysis software.

Research Results

Differences in Sustainable Development Behavior

In order to understand the level of cognition, attitude, and behavior of university students on sustainable development, the study examined the differences by gender, class experience, and ICT activity (shown in Table 2). Overall, the behavior of sustainable development (M = 3.17) was the lowest.

The disaggregated analyses show that there are statistically significant differences in cognition (t = -3.14),

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

attitude (t = -2.72), and behavior (t = -2.14) of sustainable development by gender. The findings indicate a significant difference by gender, with higher levels of cognition, attitude, and behavior of sustainable development of female students than those of male students. With regard to SD-related formal education experience, there were statistically significant differences in cognition (t = 8.40), attitude (t = 4.88), and behavior (t = 7.62) about sustainable development. It was confirmed that students with experience taking SD-related classes have higher levels of cognition, attitude, and behavior than students without class experience. With regard to informal online learning, the study found a statistically significant difference in the cognition of sustainable development (t = -9.44), attitude (t = -7.79), and behavior (t = -9.02). The findings confirm that the students with informal online learning have higher levels of sustainable development.

Table 2
Comparing the Differences based on Personal Characteristics

Distinction		SD-Cognition		SD-Attitude		SD-Behavior	
		M(SD)	*t*	*M(SD)*	*t*	*M(SD)*	*t*
Total		3.82(0.69)	-	3.34(0.96)	-	3.17(0.74)	-
Gender	Male	3.74(0.68)	-3.14**	3.24(0.97)	-2.72**	3.11(0.74)	-2.14*
	Female	3.93(0.69)		3.46(0.93)		3.25(0.74)	
Formal education experience	Yes	4.11(0.53)	8.40***	3.59(0.89)	4.88***	3.46(0.70)	7.62***
	No	3.64(0.72)		3.19(0.96)		2.99(0.71)	
Informal online learning	High level	4.06(0.53)	9.44***	3.61(0.83)	7.79***	3.41(0.70)	9.02***
	Low level	3.54(0.76)		3.01(0.99)		2.88(0.69)	

Note. *p < .05, **p < .01, ***p <.001

Verification of the Mediating Effect of Sustainable Development Attitude

In order to further analyze the association among sustainable development cognition, attitude and behavior, this study set the attitude towards sustainable development as the mediating variable and compared the fit of the partial mediating model and the full mediating model as shown in Table 3. Both models met the criteria of being less than .08 for root mean square error of approximation (RMSEA) and higher than .90 for Tucker Lewis index (TLI) and comparative fit index (CFI). The difference in chi-square values between the partial mediating model and the full mediating model was 125.767, which was significant as it was larger than the threshold of 3.84 for the difference of 1 degree of freedom. However, the chi-square test can only verify whether the model is significant but cannot determine which model is better. Therefore, other indicators, such as the Akaike information criterion (AIC) were needed to evaluate the models. The smaller the AIC value, the more simplified and the better fit the model (Akaike, 1974). The full mediating model has the smaller AIC value in this study, so it was determined to be the more suitable model.

Table 3
The Fitness of the Mediating Research Model

Model	df	χ^2/df	**TLI**	**CFI**	RSMEA	**AIC**
Partial Mediating	250	2.778***	0.945	0.950	0.056	842.381
Full Mediating	249	2.284***	0.960	0.964	0.048	718.614

Note. ***p < 0.001

The result of the path coefficient analysis in the final model, which is the full mediation model, as seen in Figure 4, showed that all path coefficients were significant at p < 0.001. It indicates that cognition of sustainable

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

development has a positive effect on attitudes (β = 0.74, $p < 0.001$) and attitudes have a positive effect on behaviors (β = 0.76, $p < 0.001$). This suggests that as students' cognition of sustainable development increases, their attitudes towards sustainable development also strengthen. In turn, as their attitudes towards sustainable development strengthen, their sustainable behaviors also increase. These findings provide valuable insights for educators and policymakers to develop effective strategies to promote sustainable development among college students.

This study used bootstrapping to verify the mediation effect, and the sampling time was 2000. As shown in Table 4, the mediating variable, attitude, had a significant effect between cognition and behavior, and the indirect effect value was 0.556 (Bias-corrected 95% *CI* = 0.490 ~ 0.616). The confidence interval did not include 0 and the p-value was less than .001, which confirmed that attitude had a mediating effect. Therefore, the results highlight the importance of promoting positive attitudes towards sustainability to encourage sustainable behavior among college students.

Figure 4
Path Diagram and Standardized Estimate of Research Model

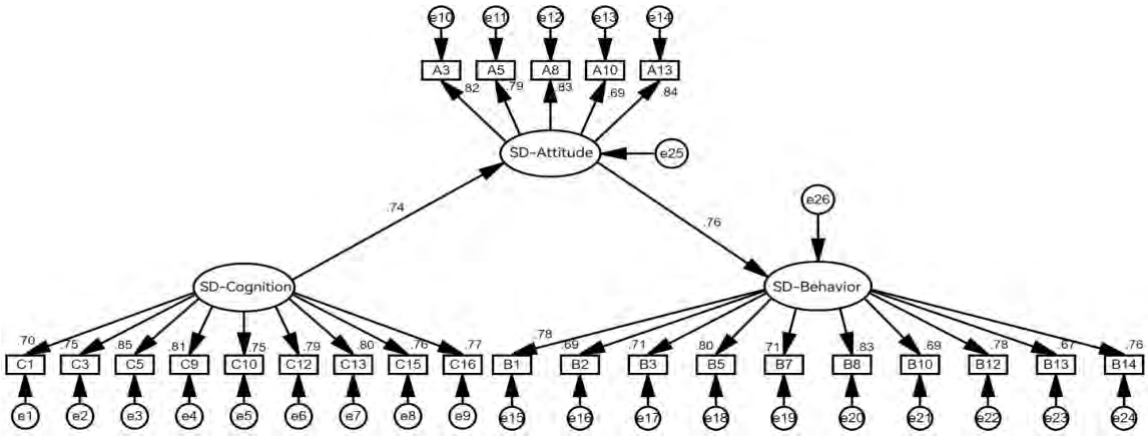


Table 4
Significance Verification of Mediating Effect

Path	Estimate	S.E.	Bootstrap 2000 times **95% bias-corrected CI**
Cognition → Attitude → Behavior	0.556***	0.044	0.490 ~ 0.616

Note. ***$p < .001$

Verification of the Multi-group Comparison

Finally, a multi-group analysis was conducted to verify the moderation effect of gender, formal education (sustainable development learning experience in college), and informal online learning (using ICT for sustainable development). A measurement equality test was conducted to check whether the variables were equally recognized according to gender, formal education, and informal online learning. It was confirmed that the goodness-of-fit indices of all models were acceptable, as shown in Table 5.

The model fit according to gender confirmed that $\chi^2/df = 2.640$ (< 3), CFI = 0.901 (> 0.9), and RMSEA = 0.054 (< 0.08), indicating an acceptable fit. The model fit according to educational experience showed that $\chi^2/df = 2.648$ (< 3), CFI = 0.890, and RMSEA = 0.054 (< 0.08). The model fit according to informal online learning revealed that $\chi^2/df = 2.875$ (< 3), CFI = .871, and RMSEA = 0.058 (< 0.08). Although the CFI value is slightly lower than 0.9, considering the other goodness-of-fit indices, the model was deemed acceptable.

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 5
Nested Multi-group Model Fits

Structural residuals	χ^2/df	CFI	RMSEA
Gender	2.640***	0.901	0.054
Formal education experience	2.648***	0.890	0.054
Informal online learning	2.875***	0.871	0.058

Note. $df = 573$, ***$p < .001$

The findings showed that the sustainable development cognition of the two groups by gender had a positive (+) significant effect on attitude ($p < .001$), and attitude had a positive (+) significant effect on behavior. ($p < .001$). Since the difference between 'cognition → attitude path' between male and female groups is .794, and the difference between 'attitude → behavior path' 1.616 is smaller than |1.96|, the difference in path is not statistically significant. As a result, the findings indicate no difference in the effect of attitudes toward sustainable development on practice according to gender. That is, the moderation effect of gender was not significant.

The findings showed that the cognition of sustainable development of the two groups had a positive (+) significant effect on their attitude ($p < .001$), and attitude had a positive (+) effect on behavior. It was found to have a statistically significant effect ($p < .001$). Since the difference in 'cognition → attitude path' between groups with or without class experience is 0.659, and the difference in 'attitude → behavior path' -1.477 is smaller than |1.96|, the difference in path is not statistically significant. Accordingly, the moderation effect of class experience at university was not significant.

The findings also reveal that the cognition of sustainable development of the two groups according to informal online learning has a positive (+) significant effect on attitude ($p < 0.001$), and attitude had a positive (+) significant effect on behavior ($p < .001$). The difference in the 'cognition → attitude path' between the below and above-average groups in informal online learning was 1.963, and the difference in the 'attitude → behavior path', 2.365, was greater than |1.96|, so the difference in the path was statistically significant. Accordingly, it was found that there was a difference in the effect of attitudes toward sustainable development on behavior according to informal online learning. In other words, the moderation effect of informal online learning was significant in the structural relationship of sustainable development (shown in Table 6).

Table 6
Significance Verification of Multi-group Path Analysis

Path toward gender	Male		Female		Between groups
	β	*SE*	β	*SE*	
Cognition → Attitude	0.712***	0.084	0.737***	0.100	0.794
Attitude → Behavior	0.699***	0.044	0.819***	0.051	1.616
Path toward formal education	**Yes**		**No**		**Between groups**
	β	*SE*	β	*SE*	
Cognition → Attitude	0.655***	0.113	0.739***	0.086	0.659
Attitude → Behavior	0.756***	0.059	0.726***	0.040	-1.477
Path toward informal online learning	**High level**		**Low level**		**Between groups**
	β	*SE*	β	*SE*	
Cognition → Attitude	0.709***	0.116	0.673***	0.094	1.963
Attitude → Behavior	0.759***	0.052	0.675***	0.046	2.365

Note. ***$p < .001$

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Discussion

Sustainable Development Level and Differences

As the world grapples with climate change, resource depletion, and social inequality, sustainable development has become imperative for college students expected to uphold social responsibility. However, despite the growing cognition and acceptance of sustainable development among students, the current study showed that their actual behaviors need to catch up with their level of cognition and attitude toward it. This is in line with the results reported by Andersen et al. (2018), Ávila et al. (2019), and Hesselink (2000), which also emphasized that students' behavior of sustainable development is not sufficient in their daily life. Moreover, Ávila et al. (2019) confirmed the lack of applicability and continuity of actions as a major barrier to practicing sustainable development. If the university's policy efforts to foster sustainable development remain one-off, it becomes difficult to expect sustainable development's ultimate change and growth.

In sequence, this study compared the level of sustainable development by gender and educational experiences and found their significant differences. This aligns with the findings conducted by Atik et al. (2022), Torbjörnssona (2011), Yoo and Oh (2016) and Zhou (2017). Yoo and Oh (2016) insisted that the difference between males and females may be somewhat limited, but gender with high sensitivity to sustainable development can be linked to behavior. In particular, this study found that female students had significantly higher levels of sustainable development cognition and attitude, which suggests that females are more aware and concerned about environmental issues than males. In this regard, Atik et al. (2022) confirmed that females preferred sustainable lifestyles, such as purchasing eco-friendly products, and in this study, females' sustainable development cognition was the highest at 3.93(shown in Table 2) compared to other areas of sustainable development.

The current research found differences in sustainable development according to school or personal learning experiences, corroborating the findings of prior studies (Gu, 2022; Hori & Fujii, 2021; Lee, 2019; Mahtab & Asghar, 2022). Schools can help college students understand the concepts and principles of sustainable development, and they can raise their cognition of sustainable development by understanding the meaning and background of sustainable development through classes (Mahtab & Asghar, 2022). Gu (2022) also argued that personal online learning opportunities linked to school classes contribute to further strengthening learning outcomes. In the process of actively collecting related digital information, sustainable development behavior can be further increased by positively affecting the values of college students.

The Association of Cognition and Attitude toward Sustainable Development Behavior

The current study revealed that both sustainable development cognition and attitude significantly impact behavior. Specifically, cognition acted as an influencing factor, and attitude acted as a mediating factor. These findings are consistent with previous studies conducted by Yoo and Lee (2014), Michalos et al. (2011), and Min (2019), which also found a significant correlation between cognition-attitude behavior and attitude-behavior of sustainable development. Yoo and Lee (2014) revealed that attitudinal factors mediate the association between environmental cognition and behavior, suggesting that attitude plays a crucial role in translating environmental knowledge into sustainable behavior.

This study adds to the body of literature by providing empirical evidence for the structural causal association between cognition, attitude, and behavior toward sustainable development. In this regard, as Blake (2001), and Ma and Zhao (2008), sustainable development behavior affects complex factors by operating comprehensively. This study particularly revealed the full mediating effect of sustainable development attitudes. Moreover, it expands on previous research by providing empirical evidence of the mediating effect of attitude on the association between cognition and behavior. Applying these findings to the cognitive behavior model (Ellis, 1978; Frijda, 1993), when students encounter sustainable development knowledge as an event, they perceive it through their own system or evaluate the knowledge in light of their attitudes. As a result, emotional or behavioral consequences are expressed. At this time, college students' original attitude and values may cause an additional outcome that further strengthens the related sustainable development attitude. This finding has significant implications for sustainable development interventions, as it suggests that phased interventions targeting cognition and attitude may be more effective in promoting sustainable behavior.

https://doi.org/10.33225/jbse/23.22.900

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

In this study, only the moderation effect of informal online learning was significant among the assumed personal characteristics within the relationship between sustainable development cognition-attitude-behavior. On the other hand, the study found no significant difference between groups according to the educational experience at the college. These findings are in line with prior study findings by Huang (2014), Yang et al. (2017), and Yi and Lu (2022). Huang (2014) and Yang et al. (2017) criticized the limitations of the current status of superficial sustainable development education in Chinese colleges, and this study is related to the assumption of sustainable development behavior as a dependent variable. In other words, the current college education is insufficient to induce changes in students' sustainable development behavior. In addition, as Yi and Lu (2022) argued, related implementation strategies and preparation of alternatives are required due to the lack of research dealing with college students' sustainable development behavior.

In the difference test, female students' attitudes and behavior toward sustainable development were higher than male counterparts. However, the causal relationship between these three factors showed that the difference according to gender was insignificant. These comparative research results are related to the studies of Huang (2014) and Min (2019). Rather than a tendency for female students' high-level sustainable development attitudes to be consistently linked to behavior, personal characteristics by gender, such as 'males are more actively interested in eco-technologies and sustainable energy (Huang, 2014)'. It can be interpreted that tastes are expressed more preferentially. In particular, since this study focused on students in major science, as Yu and Yang (2019) argued, the characteristics of each major, in addition to gender, may have an impact.

In sum, these findings suggest the prospect of using informal online learning to foster sustainable development behavior and provide support for using informal online learning. Hori and Fujii (2021) and Kim and Yi (2012) confirmed the increase in personal learning using ICT among young people in the 21st century and identified information sharing and communication in the online space as the best tools for learning. Considering the preferences and characteristics of college students in the MZ generation, we should recognize the significance of utilizing the digital space and ICT in education. Therefore, it is necessary to reflect on whether the national and policy attempts to foster sustainable development are being promoted in practice and whether the characteristics of university students as learners are actively reflected (Zhang, 2020).

Conclusions and Implications

This study aimed to examine the level of cognition, attitude, and behavior towards sustainable development and to verify the association among them through the moderation effect of informal online learning to enhance sustainable development behavior. In addition, various statistical processes were calculated to predict the final influencing factors for the accuracy of the research results. Therefore, the significant mediating role of sustainable development attitude and the moderation effect of informal online learning was confirmed. The study is expected to contribute to the sustainable development agenda by highlighting the need for targeted educational strategies to promote sustainable practices among young people. The above conclusions provide important messages for universities seeking to promote sustainable development education among college students.

The study emphasizes the importance of prioritizing attitude improvement as a prerequisite for effective sustainable development practice. It is not enough to provide information and knowledge about the seriousness of environmental issues. Sustainable development education must also aim to increase students' sense of need and empathetic attitude towards sustainable development. Moreover, the study highlights the need for college students to take an active and positive approach to sustainable development education. Equipping students with the knowledge, skills, and attitudes needed to address the complex challenges facing the world today is crucial for promoting a sustainable future. To that end, universities should play a critical role in promoting sustainable development education among college students and prioritize this important agenda in their curricula and pedagogical practices.

Universities also should develop and support a sustainable development education program that considers students' evolving needs and growth. In particular, universities should explore approaches that promote

https://doi.org/10.33225/jbse/23.22.900

behavioral change through personal life-oriented learning courses. This study proposes an experienced approach to sustainable development education, which interconnects non-formal education and informal learning in addition to university education. This holistic approach recognizes the interconnectedness of various personal experiences and suggests that sustainable development education should address these challenges in a comprehensive and integrated way.

Limitations

Nevertheless, this study has several limitations. First, since only college student participants were surveyed, the results may not be directly used by other students or groups with different cultural backgrounds. Second, the effects of cognition and attitude on sustainable development behavior have been considered, but the impacts of other potential variables may still exist. Therefore, to more comprehensively and practically understand sustainable development behavior in future studies, it may be considered to introduce factors such as family and social factors.

Declaration of Interest

The authors declare no competing interest.

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Received: *March 15, 2023* Revised: *July 10, 2023* Accepted: *September 12, 2023*

Cite as: Liu, Q., Tian, X., Bang, Y., & Park, K. H. (2023). Cognition and attitude toward sustainable development behavior: College students' informal online learning as a moderation effect. *Journal of Baltic Science Education*, *22*(5), 900-913. https://doi.org/10.33225/jbse/23.22.900

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