

Article

Green Minds, Smart Tools: Exploring the Mediating Role of Digital Citizenship in the Relationship Between Environmental Education Awareness and Self-Efficacy

Mohamed Ali Nemt-allah ^{1,*} , Mamdouh Mahmoud Mostafa ², Mamdouh Mosaad Helali ^{3,*} ,
Hussam Khalifah Aldawsari ⁴ , Yusra Zaki Aboud ³  and Ashraf Ragab Ibrahim ¹

¹ Educational Psychology and Statistics Department, Faculty of Education, Al-Azhar University, Tafhna Al-Ashraf 35822, Egypt; ashrafibrahem.26@azhar.edu.eg

² Mental Health Department, Faculty of Education, Al-Azhar University, Cairo 11765, Egypt; mamdouhbadawy.197@azhar.edu.eg

³ The National Research Center for Giftedness and Creativity, King Faisal University, Al-Ahsa 31982, Saudi Arabia; yozaki@kfu.edu.sa

⁴ Psychology and Education Department, College of Education, King Faisal University, Al-Ahsa 31982, Saudi Arabia; haldawsari@kfu.edu.sa

* Correspondence: mohamednamatallah.2026@azhar.edu.eg (M.A.N.-a.); mhelali@kfu.edu.sa (M.M.H.)

Abstract

Environmental education awareness (EEA) often fails to translate into confident environmental action, representing a critical knowledge–action gap in sustainability education. This study investigated whether digital citizenship mediates the relationship between EEA and self-efficacy among university students. A cross-sectional design was employed with 879 Egyptian university students from Al-Azhar University. Participants completed validated instruments measuring EEA, digital citizenship competencies (including internet political activism, technical skills, critical perspectives, and networking agency), and general self-efficacy. Mediation analysis using Hayes’ PROCESS macro revealed that digital citizenship significantly partially mediated the relationship between environmental awareness and self-efficacy, accounting for 21.9% of the total effect. Environmental awareness directly predicted self-efficacy ($\beta = 0.590$) and indirectly through digital citizenship ($\beta = 0.166$). These findings demonstrate that digital competencies serve as “smart tools” enabling students to transform ecological knowledge into confident environmental agency. The results underscore the necessity of integrating digital citizenship training within environmental curricula to cultivate climate-literate, digitally empowered citizens capable of meaningful contributions to global sustainability and climate action initiatives.

Keywords: environmental education awareness; digital citizenship; self-efficacy; mediation analysis; sustainability education



Received: 23 January 2026

Revised: 19 February 2026

Accepted: 20 February 2026

Published: 23 February 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

Environmental Education Awareness (EEA) is a multidimensional construct encompassing environmental knowledge, attitudes, and concern for the natural environment, reflecting the core objectives of international environmental education frameworks that emphasize awareness, sensitivity, and motivation to act [1,2]. Since the landmark 1977 Tbilisi conference, there has been a sustained global policy push to build environmental literacy as a critical response to escalating climate crises [3]. In the context of planetary boundaries and climate urgency, science and environmental literacies have emerged as central enablers

of transformative environmental action [4]. Educational institutions worldwide are increasingly integrating sustainability and climate change into curricula, positioning education as a fundamental social intervention for climate stabilization and sustainable development [5]. This global momentum underscores the imperative to understand how EEA develops and translates into effective pro-environmental behavior across diverse populations.

Digital citizenship has emerged as a critical 21st-century competency, transcending traditional notions of online safety to encompass responsible, ethical, and active participation in digitally mediated society [6,7]. As contemporary societies transition toward “digital-first” infrastructures, citizenship itself is increasingly enacted through datafied, networked systems that underpin social, political, economic, and cultural life [8,9]. This transformation necessitates competencies extending beyond technical proficiency to include critical evaluation of information, ethical engagement with digital platforms, and participation in struggles for equality and social justice within digital environments [10,11]. The ubiquity of digital technologies in education, governance, and civic engagement has rendered digital citizenship foundational for navigating misinformation, protecting digital rights, and fostering democratic participation [12,13], making it essential for preparing citizens to function effectively in increasingly datafied democracies.

Although the broader literature distinguishes environmental self-efficacy—defined as an individual’s belief in their capability to perform actions producing desired ecological outcomes—from general self-efficacy, the present study adopts a general self-efficacy framework consistent with Bandura’s foundational theory, examining whether digitally mediated competencies strengthen individuals’ overall confidence in their capability to act across achievement contexts, including environmental ones [14]. This construct encompasses three core elements: a capable agent (“I can do this”), concrete action repertoires (such as waste reduction or advocacy), and specific environmental aims (climate mitigation or ecosystem protection) [15]. Contemporary research positions ESE as the critical psychological bridge transforming environmental knowledge and concern into actual pro-environmental behavior [16,17]. Cultivating belief in oneself represents the ultimate goal of environmental education because information alone proves insufficient; individuals must perceive themselves as capable environmental actors who can meaningfully contribute to solutions [18,19]. This self-trusting agency sustains motivation, fosters resilience against climate anxiety, and enables persistent engagement with complex environmental challenges [20].

The knowledge–action gap illuminates a critical disconnect in which environmental knowledge fails to automatically translate into pro-environmental behavior or self-efficacy [21,22]. Research demonstrates that environmental awareness, while necessary, remains a weak and inconsistent predictor of action without accompanying beliefs in personal capability [23,24]. This phenomenon occurs because system knowledge about environmental problems can produce cognitive dissonance or feelings of helplessness rather than empowerment, particularly when education emphasizes crisis magnitude without cultivating concrete action skills [25,26]. Studies reveal that environmental awareness alone constitutes an insufficient predictor of self-efficacy, with confidence beliefs functioning as a significant intervening mechanism transmitting the effect of ecological knowledge onto pro-environmental outcomes, underscoring the necessity of identifying such mediating pathways—particularly digital citizenship competencies—through which awareness may be effectively converted into confident environmental agency [27]. Without systematic cultivation of action knowledge, mastery experiences, and supportive contexts, elevated awareness frequently stalls at concern rather than evolving into capable, sustained environmental action.

Digital citizenship functions as a critical mediator transforming environmental awareness into self-efficacy by providing “smart tools” that enable students to externalize and enact their knowledge [7,28]. Through information literacy and critical evaluation skills, digital citizenship converts abstract awareness into concrete strategies for navigating digital environments [29,30]. Digital competencies facilitate mastery experiences—the strongest source of self-efficacy—by empowering students to create meaningful outputs such as advocacy campaigns, digital stories, or collaborative projects that express their environmental understanding [31,32]. Research demonstrates that digital skills reduce cognitive strain and enhance domain-specific self-efficacy across disciplines, as tool proficiency strengthens belief in one’s capacity to accomplish tasks [33–35]. Digital informal learning and productive tool use partially mediate the relationship between literacy and performance [36], suggesting digital citizenship operationalizes awareness into robust self-belief through cognitive, behavioral, and affective pathways.

The integration of “Green Minds”—defined as environmentally literate, critically conscious individuals possessing the knowledge, attitudes, and motivation necessary to engage with ecological challenges—and “Smart Tools,” referring to the digital citizenship competencies that operationalize such awareness into confident civic action, proves essential for advancing global Sustainable Development Goals, particularly SDG 4 (Quality Education) and SDG 13 (Climate Action). EEA builds climate-literate citizens capable of informed mitigation and adaptation behaviors, directly supporting SDG 4.7’s emphasis on education for sustainable development [37,38]. Digital citizenship enables online activism, social justice engagement, and political commitment to sustainable development through technology-enhanced learning platforms [39,40]. Self-efficacy serves as a psychological foundation for sustained climate action, as educators’ environmental confidence significantly influences how effectively sustainability becomes embedded in teaching practice [41]. Research demonstrates that integrating SDG content through digital tools substantially enhances environmental learning gains and planetary concern [42,43], operationalizing SDG 4.7’s vision of global citizenship education while enabling agentic climate action under SDG 13 [44].

Despite robust independent documentation of digital tools enhancing environmental awareness [45,46] and self-efficacy mediating relationships between digital literacy and various outcomes [33,47,48], international literature lacks integration of these constructs within environmental contexts. Existing research treats digital technologies primarily as neutral delivery mechanisms rather than civic competencies that may bridge the awareness–self-efficacy gap [24,49]. Studies examining environmental self-efficacy as a mediator between attitudes and pro-environmental behavior typically omit digital citizenship pathways [16], while investigations of digital skills mediating performance outcomes focus on non-environmental domains such as entrepreneurship, health self-management, or academic achievement [50–52]. No study explicitly conceptualizes digital citizenship as the mediating mechanism through which EEA translates into environmental self-efficacy, representing a critical gap in understanding how participatory digital competencies convert ecological knowledge into confident environmental action.

The present study proposes a conceptual model in which EEA serves as the independent variable that initiates the pathway toward confident environmental action. However, environmental awareness alone does not automatically produce self-efficacy; rather, it must be operationalized through practical competencies that enable individuals to act on their knowledge. Digital citizenship is therefore positioned as the mediating variable, functioning as the functional bridge between knowing and doing—converting ecological knowledge into concrete digital repertoires such as online advocacy, critical information evaluation, and civic networking. These competencies, in turn, generate mastery experiences and agentic

behaviors that strengthen individuals' general self-efficacy beliefs, positioning self-efficacy as the outcome variable reflecting the ultimate translation of environmental awareness into confident, sustained action. This conceptual sequence—from awareness (EEA) → digital empowerment (digital citizenship) → confident agency (self-efficacy)—provides the theoretical backbone of the present investigation.

Given the critical gap in understanding how digital competencies facilitate the translation of environmental knowledge into confident environmental action, the present study aimed to investigate whether digital citizenship mediates the relationship between EEA and self-efficacy among university students. Specifically, this research sought to examine the bivariate relationships among EEA, digital citizenship dimensions, and self-efficacy, and to test the indirect effect of environmental awareness on self-efficacy operating through digital citizenship as a mediating mechanism. By empirically testing this mediation model, this study addresses the identified research gap regarding how participatory digital competencies may serve as “smart tools” that convert ecological knowledge (“green minds”) into confident environmental agency. Understanding this mediating pathway has important theoretical implications for bridging the knowledge–action gap in environmental education and practical implications for designing integrated curricula that combine sustainability content with digital citizenship training to cultivate climate-literate, digitally empowered citizens capable of meaningful contributions to global climate action and sustainable development initiatives.

2. Materials and Methods

2.1. Study Design and Sampling

This study employed a cross-sectional correlational design to examine the mediating role of digital citizenship in the relationship between EEA and self-efficacy. A convenience sampling method was used to recruit university students from Egypt. Two distinct samples were collected: a psychometric sample ($N = 614$) to validate the measurement instruments and a main sample ($N = 879$) to test the hypothesized mediation model. Participation was voluntary, and informed consent was obtained from all participants prior to data collection.

2.2. Participants

Participants were students enrolled at Al-Azhar University in Egypt, specifically from the Faculty of Education for Boys in Cairo, the Faculty of Education for Girls in Cairo, and the Faculty of Education for Boys in Tafhna Al-Ashraf. The demographic characteristics of both samples are presented in Table 1. The psychometric sample consisted of 614 university students aged 18 to 24 years ($M = 21.08$, $SD = 1.97$), while the main sample included 879 students aged 18 to 23 years ($M = 20.50$, $SD = 1.72$). Both samples showed relatively balanced distributions across gender, residence location, and grade levels.

2.3. Measures

The *Environmental Education Awareness Scale* (EEAS) was employed to assess participants' environmental awareness [53]. The scale comprises 13 items measured on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), with higher scores indicating greater EEA. The unidimensional structure of the scale was confirmed through confirmatory factor analysis (CFA) in the psychometric sample, demonstrating acceptable model fit indices: $\chi^2/df = 3.846$, goodness of fit index (GFI) = 0.933, adjusted goodness of fit index (AGFI) = 0.899, comparative fit index (CFI) = 0.918, Tucker–Lewis index (TLI) = 0.910, and root mean square error of approximation (RMSEA) = 0.077. Internal consistency reliability was excellent, with Cronbach's alpha (α) of 0.871 and McDonald's omega (ω) of 0.870 based on 614 valid cases.

Table 1. Demographic Characteristics of Study Participants. Note: N = frequency; % = valid percentage of total sample.

Variable	Category	Psychometric Sample (N = 614)		Main Sample (N = 879)	
		N	%	N	%
Gender	Male	324	52.8	473	53.8
	Female	290	47.2	406	46.2
Residence	Rural	235	38.3	333	37.9
	Urban	379	61.7	546	62.1
Grade Level	First	144	23.5	237	27.0
	Second	167	27.2	219	24.9
	Third	147	23.9	212	24.1
	Fourth	156	25.4	211	24.0

The Revised Digital Citizenship Scale (DCS-R) was employed to assess participants' digital citizenship competencies [54]. This instrument consists of 19 items distributed across four dimensions: Internet Political Activism (6 items), Technical Skills (3 items), Critical Perspectives (7 items), and Networking Agency (3 items). Responses were recorded on a 7-point Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). CFA demonstrated excellent model fit: $\chi^2/df = 1.302$, GFI = 0.969, AGFI = 0.960, CFI = 0.992, TLI = 0.991, and RMSEA = 0.022. Reliability coefficients for the subscales were strong: Internet Political Activism ($\alpha = 0.883$, $\omega = 0.883$), Technical Skills ($\alpha = 0.858$, $\omega = 0.859$), Critical Perspectives ($\alpha = 0.884$, $\omega = 0.881$), and Networking Agency ($\alpha = 0.871$, $\omega = 0.871$). The total scale demonstrated excellent internal consistency with $\alpha = 0.899$ and $\omega = 0.889$.

New General Self-Efficacy Scale (NGSE) was selected to assess participants' generalized confidence in their capability to perform across achievement situations. While domain-specific environmental self-efficacy measures may yield stronger construct-specific associations, general self-efficacy was employed to capture broad confidence beliefs applicable across behavioral domains, including environmental action, consistent with the study's exploratory mediation framework [55]. The scale consists of 8 items measured on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), with higher scores indicating greater general self-efficacy beliefs. Sample items include "I will be able to achieve most of the goals that I have set for myself" and "I believe I can succeed at most any endeavor to which I set my mind." CFA supported the unidimensional structure of the scale with acceptable model fit indices: $\chi^2/df = 4.450$, GFI = 0.970, AGFI = 0.936, CFI = 0.950, TLI = 0.918, and RMSEA = 0.075. The scale demonstrated adequate internal consistency reliability with $\alpha = 0.790$ and $\omega = 0.780$, which are considered acceptable for an 8-item scale and consistent with values reported in previous validation studies.

2.4. Procedure

Data collection was conducted between 15 October 2025 and 29 October 2025, using a Google Forms questionnaire distributed electronically to participants. The questionnaire included demographic questions and three validated psychometric instruments measuring the study variables. Participants completed the survey at their convenience, with an average completion time of approximately 20 min. All responses were anonymous and confidential. Data screening procedures identified incomplete or invalid responses, resulting in the exclusion of 10 cases (1.6%) from the psychometric sample due to missing data.

2.5. Data Analysis

Data were analyzed using SPSS version 27 and AMOS version 26. Preliminary analyses included descriptive statistics, correlation analyses, and assessment of normality assumptions. To assess potential common method bias, Harman's single-factor test was conducted, revealing that the first unrotated factor accounted for 30.676% of the total variance, well below the critical threshold of 50%. Pearson correlation coefficients were calculated to examine bivariate relationships among study variables. Mediation analysis was conducted using Hayes' PROCESS macro (Model 4) with 5000 bootstrap samples to test the indirect effect of EEA on self-efficacy through digital citizenship. Bootstrap confidence intervals at the 95% level were computed to assess the significance of direct, indirect, and total effects. All statistical tests were two-tailed with significance at $p < 0.05$.

3. Results

Prior to testing the main hypotheses, preliminary analyses were conducted to examine the distributional properties of the study variables and assess the assumptions underlying the planned statistical analyses. All variables demonstrated acceptable ranges of skewness and kurtosis, indicating approximate normality of distributions. Descriptive statistics for the main sample ($N = 879$) are presented in Table 2, including means, standard deviations, and ranges for all study variables.

The means for all variables indicated generally positive responses across the sample. EEA demonstrated a mean of 44.57 ($SD = 5.042$), ranging from 36.00 to 60.00, suggesting moderately high awareness levels with adequate variability to support further analyses. Among the digital citizenship dimensions, Critical Perspectives showed the highest mean ($M = 29.59$, $SD = 3.814$), followed by Technical Skills ($M = 17.31$, $SD = 1.296$), Internet Political Activism ($M = 17.24$, $SD = 3.929$), and Networking Agency ($M = 14.17$, $SD = 1.702$). The total Digital Citizenship score averaged 78.33 ($SD = 8.113$), with observed scores ranging from 60.00 to 133.00, indicating substantial variability that supports correlational and mediational analyses. Self-efficacy scores demonstrated a mean of 29.78 ($SD = 2.987$), ranging from 24.00 to 40.00, suggesting that participants generally possessed moderately high confidence in their capabilities. Missing data analysis revealed minimal missing values (1.6% in the psychometric sample), which were handled through listwise deletion.

Table 2. Descriptive Statistics for EEA, Digital Citizenship Dimensions, and Self-Efficacy.

Variable	M	SD	Minimum	Maximum
EEA	44.57	5.042	36.00	60.00
Internet Political Activism	17.24	3.929	12.00	42.00
Technical Skills	17.31	1.296	15.00	21.00
Critical Perspectives	29.59	3.814	21.00	49.00
Networking Agency	14.17	1.702	12.00	21.00
Digital Citizenship	78.33	8.113	60.00	133.00
Self-Efficacy	29.78	2.987	24.00	40.00

Pearson correlation coefficients were computed to examine the bivariate relationships among environmental education awareness, the four dimensions of digital citizenship, total digital citizenship, and self-efficacy. The correlation matrix is presented in Table 3. All correlations were statistically significant at $p < 0.01$, supporting the appropriateness of conducting mediation analyses.

Table 3. Pearson Correlation Coefficients Among EEA, Digital Citizenship Dimensions, and Self-Efficacy. Note: ** = $p < 0.01$ (2-tailed).

Variable	1	2	3	4	5	6	7
1. EEA	1						
2. Internet Political Activism	0.300 **	1					
3. Technical Skills	0.143 **	0.317 **	1				
4. Critical Perspectives	0.621 **	0.498 **	0.208 **	1			
5. Networking Agency	0.193 **	0.415 **	0.183 **	0.360 **	1		
6. Digital Citizenship	0.501 **	0.856 **	0.449 **	0.820 **	0.609 **	1	
7. Self-Efficacy	0.756 **	0.457 **	0.242 **	0.641 **	0.311 **	0.627 **	1

EEA demonstrated strong positive correlations with self-efficacy ($r = 0.756$, $p < 0.01$) and total digital citizenship ($r = 0.501$, $p < 0.01$), indicating that students with higher environmental awareness tended to report greater self-efficacy beliefs and stronger digital citizenship competencies. Among the digital citizenship dimensions, Critical Perspectives showed the strongest correlation with EEA ($r = 0.621$, $p < 0.01$), followed by Internet Political Activism ($r = 0.300$, $p < 0.01$), Networking Agency ($r = 0.193$, $p < 0.01$), and Technical Skills ($r = 0.143$, $p < 0.01$). Digital citizenship (total) was also significantly correlated with self-efficacy ($r = 0.627$, $p < 0.01$), suggesting that digital competencies are associated with confidence in one's capabilities. These patterns of relationships provided preliminary support for the hypothesized mediation model.

To test the mediating role of digital citizenship in the relationship between EEA and self-efficacy, Hayes' PROCESS macro (Model 4) was employed with 5000 bootstrap samples. The analysis examined whether digital citizenship (M) mediated the effect of EEA (X) on self-efficacy (Y). The unstandardized and standardized regression coefficients, along with bootstrap confidence intervals, are presented in Table 4.

Table 4. Unstandardized and Standardized Path Coefficients for the Mediation Model Testing Digital Citizenship as Mediator Between Environmental Awareness and Self-Efficacy. Note: B = unstandardized coefficient; SE = standard error; β = standardized coefficient; CI = confidence interval; --- = not applicable.

Pathway	B	SE	β	t	p	95% CI
Predicting Digital Citizenship (M)						
Constant	42.411	2.109	---	20.108	0.001	[38.271, 46.551]
Environmental Awareness → Digital Citizenship	0.806	0.047	0.501	17.140	0.001	[0.714, 0.898]
Predicting Self-Efficacy (Y)						
Constant	4.640	0.638	---	7.272	0.001	[3.388, 5.892]
Environmental Awareness → Self-Efficacy	0.350	0.014	0.590	25.720	0.001	[0.323, 0.376]
Digital Citizenship → Self-Efficacy	0.122	0.008	0.331	14.432	0.001	[0.105, 0.139]
Total Effect Model						
Environmental Awareness → Self-Efficacy	0.448	0.013	0.756	34.239	0.001	[0.422, 0.474]

The results revealed that EEA significantly predicted digital citizenship ($B = 0.806$, $SE = 0.047$, $\beta = 0.501$, $p < 0.001$), indicating that a one-unit increase in environmental awareness was associated with a 0.806-unit increase in digital citizenship. The model predicting digital citizenship from environmental awareness accounted for 25.09% of the variance ($R^2 = 0.251$, $F(1, 877) = 293.778$, $p < 0.001$). In the full mediation model predicting self-efficacy, both EEA ($B = 0.350$, $SE = 0.014$, $\beta = 0.590$, $p < 0.001$) and digital citizenship ($B = 0.122$, $SE = 0.008$, $\beta = 0.331$, $p < 0.001$) emerged as significant predictors. Together, these predictors explained 65.43% of the variance in self-efficacy ($R^2 = 0.654$, $F(2, 876) = 828.814$, $p < 0.001$), indicating a substantial proportion of variance accounted for by the model. The decomposition of effects is presented in Table 5, which summarizes the total, direct, and indirect effects of EEA on self-efficacy through digital citizenship.

Table 5. Decomposition of Total, Direct, and Indirect Effects of EEA on Self-Efficacy Through Digital Citizenship. Note: B = unstandardized coefficient; SE = standard error; β = standardized coefficient; CI = confidence interval.

Effect Type	B	SE	β	95% Bootstrap CI	% of Total Effect
Total Effect	0.448	0.013	0.756	[0.422, 0.474]	100.0%
Direct Effect	0.350	0.014	0.590	[0.323, 0.376]	78.1%
Indirect Effect (through Digital Citizenship)	0.098	0.010	0.166	[0.079, 0.117]	21.9%

The total effect of EEA on self-efficacy was significant ($B = 0.448$, $SE = 0.013$, $\beta = 0.756$, $p < 0.001$, 95% CI [0.422, 0.474]), indicating that environmental awareness positively predicted self-efficacy when digital citizenship was not included in the model ($R^2 = 0.572$, $F(1, 877) = 1172.272$, $p < 0.001$). The direct effect of EEA on self-efficacy remained significant after controlling for digital citizenship ($B = 0.350$, $SE = 0.014$, $\beta = 0.590$, $p < 0.001$, 95% CI [0.323, 0.376]), accounting for 78.1% of the total effect. Critically, the indirect effect through digital citizenship was statistically significant ($B = 0.098$, $SE = 0.010$, $\beta = 0.166$, 95% CI [0.079, 0.117]), as evidenced by the bootstrap confidence interval that did not include zero. This indirect effect accounted for 21.9% of the total effect, indicating that approximately one-fifth of the relationship between EEA and self-efficacy was mediated through digital citizenship competencies.

The conceptual model depicting the standardized path coefficients is illustrated in Figure 1. The figure shows the significant pathways from EEA to digital citizenship ($\beta = 0.501$, $p < 0.001$), from EEA to self-efficacy ($\beta = 0.590$, $p < 0.001$), and from digital citizenship to self-efficacy ($\beta = 0.331$, $p < 0.001$). The indirect pathway ($\beta = 0.166$) demonstrates the mediating mechanism through which environmental awareness influences self-efficacy via enhanced digital citizenship competencies.

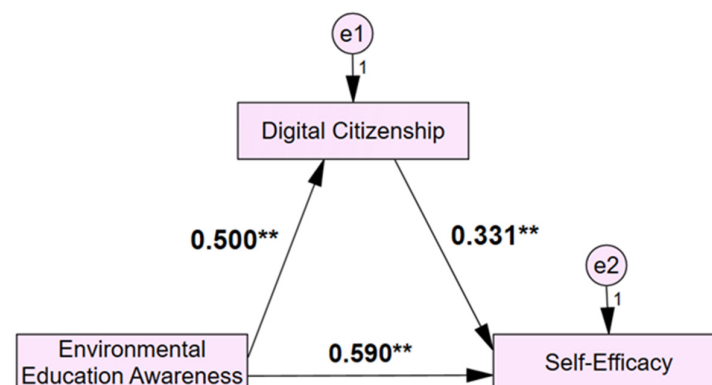


Figure 1. Standardized Path Coefficients for the Partial Mediation Model: Digital Citizenship Mediating the Relationship Between EEA and Self-Efficacy. Note: ** = $p < 0.01$; ¹ = Fixed loading set to 1 for scaling purposes.

These findings provide strong empirical support for the hypothesis that digital citizenship partially mediates the relationship between EEA and self-efficacy. While environmental awareness directly enhances self-efficacy beliefs, a significant portion of this relationship operates indirectly through the development of digital citizenship competencies, particularly through critical perspectives, technical skills, online political activism, and networking agency.

4. Discussion

The present study demonstrates that digital citizenship serves as a significant partial mediator in the relationship between EEA and self-efficacy, accounting for 21.9% of the total

effect. This finding reveals that while environmental awareness directly strengthens individuals' confidence in their capabilities (78.1% direct effect), digital competencies provide an additional pathway through which ecological knowledge translates into self-belief. Digital citizenship functions as a functional bridge, translating environmental knowledge into actionable confidence by equipping students with the practical digital repertoires necessary to move from awareness to agency. The strong correlation between Critical Perspectives and environmental awareness ($r = 0.621$) suggests that developing critical evaluation skills represents the primary mechanism linking environmental knowledge to digital citizenship. The mediating role of digital citizenship indicates that students who possess environmental awareness can leverage digital tools, online activism platforms, and networking capabilities to transform abstract knowledge into concrete action repertoires, thereby enhancing their perceived capacity as environmental agents capable of meaningful contributions.

The findings can be further understood in light of the theoretical nature of each model construct. EEA operates across three interrelated levels: cognitive (knowledge of environmental issues), affective (emotional concern toward the environment), and behavioral intention (motivation to engage in pro-environmental action), with the translation across these levels being neither automatic nor guaranteed—a gap this study empirically confirms. Digital citizenship, operationalized across Internet Political Activism, Technical Skills, Critical Perspectives, and Networking Agency, extends beyond passive technology use toward active, critically informed civic participation, providing the practical repertoires necessary to bridge this gap. General self-efficacy, shaped by mastery experiences, vicarious learning, verbal persuasion, and physiological states, represents the ultimate psychological outcome through which EEA and digital citizenship collectively manifest as confident environmental agency.

These findings align with established literature demonstrating that environmental self-efficacy mediates the knowledge–action gap, converting awareness into behavior [16,23,24]. However, this study extends existing research by identifying digital citizenship as a novel mediating mechanism not previously examined in environmental contexts. The results support assertions that digital competencies facilitate mastery experiences—the strongest source of self-efficacy—by enabling students to create advocacy campaigns and collaborative projects [31,32]. Consistent with findings that digital skills reduce cognitive strain and enhance domain-specific self-efficacy [33–35], our results suggest digital citizenship operationalizes environmental awareness into self-belief. This integration addresses the critical gap where digital technologies were treated as neutral delivery mechanisms rather than civic competencies bridging awareness and efficacy [24,49].

The findings carry significant implications for advancing Sustainable Development Goals, particularly SDG 4.7 (education for sustainable development) and SDG 13 (climate action). Educational institutions should intentionally integrate digital citizenship training within environmental curricula, recognizing that technical skills, critical perspectives, and online activism competencies serve as “smart tools” enabling students to externalize ecological knowledge [28]. The strong mediating role of Critical Perspectives suggests that teaching students to critically evaluate digital information about environmental issues represents a high-leverage intervention point. Educators should design learning experiences that combine environmental content with opportunities for digital advocacy, online collaboration, and technology-enhanced storytelling, thereby building both green minds and the digital capabilities necessary to translate awareness into confident environmental action. This integrated approach directly supports climate-literate citizenship capable of informed mitigation behaviors [37,38].

Several limitations warrant consideration when interpreting these findings. The cross-sectional design precludes causal inference, as reciprocal relationships may exist

whereby self-efficacy enhances environmental awareness or digital citizenship. As data were collected at a single timepoint, observed relationships reflect associations rather than directional causality; longitudinal and experimental designs are required to establish temporal precedence among study variables. The convenience sample drawn exclusively from Egyptian university students limits generalizability across cultural contexts, educational levels, and age groups. Restriction to a single national and institutional context constrains transferability to populations differing in digital infrastructure, environmental policy landscape, or educational tradition, necessitating cross-cultural replication before broader conclusions are warranted.

The reliance on self-report measures introduces potential common method bias, though Harman's test suggested this was not problematic. Self-reported data remain susceptible to social desirability bias; future research should incorporate behavioral measures or multi-informant designs to enhance construct validity and response accuracy. The study employed general self-efficacy rather than domain-specific environmental self-efficacy, which may have underestimated the strength of relationships given that specialized measures typically demonstrate stronger associations with related constructs. Employing a domain-specific environmental self-efficacy instrument would yield more precise effect estimates and stronger ecological validity in future investigations. Future research should address these limitations through longitudinal designs, diverse samples, multi-method assessments, and environmental-specific efficacy measures to strengthen causal claims and ecological validity.

Although digital citizenship was operationalized as a composite variable, disaggregating its four dimensions as independent mediators in future analyses would identify which specific competencies most efficiently facilitate the awareness-to-efficacy translation, enabling more targeted pedagogical interventions. Future investigations should employ longitudinal and experimental designs to establish temporal precedence and causal relationships among environmental awareness, digital citizenship, and self-efficacy. Researchers should examine whether domain-specific environmental self-efficacy demonstrates stronger mediation patterns than general self-efficacy, potentially revealing distinct pathways for different environmental behaviors (climate advocacy versus conservation actions). Cross-cultural studies comparing digital citizenship's mediating role across Global North and South contexts would illuminate how technological access and digital infrastructure moderate these relationships. Intervention studies testing integrated environmental-digital curricula could provide practical evidence for optimal pedagogical approaches. Finally, researchers should investigate which specific digital citizenship dimensions (critical perspectives, technical skills, activism, networking) exert the strongest mediating effects, enabling targeted educational interventions that maximize the transformation of environmental awareness into confident, sustained climate action across diverse populations and educational contexts.

5. Conclusions

This study provides empirical evidence that digital citizenship serves as a critical mediating mechanism through which EEA translates into self-efficacy, thereby integrating "green minds" with "smart tools." The findings reveal that approximately one-fifth of environmental awareness's effect on self-efficacy operates through digital competencies, suggesting that ecological knowledge alone is insufficient without accompanying digital literacy, critical evaluation skills, and online civic participation. By identifying digital citizenship as the bridge spanning the knowledge-action gap, this research advances theoretical understanding of how 21st-century competencies enable confident environmental action. The results underscore the necessity of integrated educational approaches that combine environmental

content with digital skill development to cultivate climate-literate, digitally empowered citizens capable of meaningful contributions to global sustainability challenges and climate stabilization efforts. Critically, the findings affirm that environmental education curricula must be redesigned to incorporate digital citizenship training, ensuring students develop not only green minds but also the digital empowerment necessary to act meaningfully on that knowledge in real-world contexts.

Author Contributions: Conceptualization, M.M.M. and M.M.H.; methodology, A.R.I.; software, A.R.I.; validation, M.M.M., M.M.H. and A.R.I.; formal analysis, A.R.I.; investigation, M.A.N.-a., H.K.A. and Y.Z.A.; resources, H.K.A. and Y.Z.A.; data curation, M.A.N.-a.; writing—original draft preparation, M.A.N.-a.; writing—review and editing, M.A.N.-a.; visualization, A.R.I.; supervision, M.M.M. and M.M.H.; project administration, M.M.H.; funding acquisition, M.M.H. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [Grant No. KFU260439].

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of the Faculty of Education at Al-Azhar University, Dakahlia, Egypt (protocol code: Ref. No. EDU-REC-2025-072, approval date: 22 October 2025).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Acknowledgments: The researchers would like to thank the Deanship of Scientific Research at King Faisal University, Al-Ahsa 31982, for providing the research fund for publishing Research Grant No. [KFU260439]. The authors thank all participants for their valuable contributions to this study.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

EEA	Environmental Education Awareness
SDG	Sustainable Development Goal
EEAS	Environmental Education Awareness Scale
DCS-R	Revised Digital Citizenship Scale
NGSE	New General Self-Efficacy Scale
CFA	Confirmatory Factor Analysis
GFI	Goodness of Fit Index
AGFI	Adjusted Goodness of Fit Index
CFI	Comparative Fit Index
TLI	Tucker–Lewis Index
RMSEA	Root Mean Square Error of Approximation

References

1. Ardoin, N.M.; Bowers, A.W.; Gaillard, E. Environmental education outcomes for conservation: A systematic review. *Biol. Conserv.* **2019**, *241*, 108224. [[CrossRef](#)]
2. Omoogun, A.C.; Egbonyi, E.E.; Onnoghen, U.N. From environmental awareness to environmental responsibility: Towards a stewardship curriculum. *J. Educ. Issues* **2016**, *2*, 60–72. [[CrossRef](#)]
3. Kranz, J.; Schwichow, M.; Breitenmoser, P.; Niebert, K. The (Un)political Perspective on Climate Change in Education—A Systematic Review. *Sustainability* **2022**, *14*, 4194. [[CrossRef](#)]
4. Guerrero, G.; Sjöström, J. Critical scientific and environmental literacies: A systematic and critical review. *Stud. Sci. Educ.* **2024**, *61*, 41–87. [[CrossRef](#)]

5. Abo-Khalil, A.G. Integrating sustainability into higher education challenges and opportunities for universities worldwide. *Heliyon* **2024**, *10*, e29946. [\[CrossRef\]](#)
6. Buchholz, B.A.; DeHart, J.; Moorman, G. Digital Citizenship During a Global Pandemic: Moving beyond digital literacy. *J. Adolesc. Adult Lit.* **2020**, *64*, 11–17. [\[CrossRef\]](#)
7. Pangrazio, L.; Sefton-Green, J. Digital Rights, Digital Citizenship and Digital Literacy: What's the Difference? *J. New Approaches Educ. Res.* **2021**, *10*, 15–27. [\[CrossRef\]](#)
8. Örtengren, A. Philosophical underpinnings of digital citizenship through a postdigital lens: Implications for teacher educators' professional digital competence. *Educ. Inf. Technol.* **2023**, *29*, 4253–4285. [\[CrossRef\]](#)
9. Tomasello, F. From industrial to digital citizenship: Rethinking social rights in cyberspace. *Theory Soc.* **2022**, *52*, 463–486. [\[CrossRef\]](#)
10. Emejulu, A.; McGregor, C. Towards a radical digital citizenship in digital education. *Crit. Stud. Educ.* **2016**, *60*, 131–147. [\[CrossRef\]](#)
11. Carmi, E.; Yates, S.J.; Lockley, E.; Pawluczuk, A. Data citizenship: Rethinking data literacy in the age of disinformation, misinformation, and malinformation. *Internet Policy Rev.* **2020**, *9*, 1–22. [\[CrossRef\]](#)
12. Saputra, M.; Siddiq, I.H.A. Social Media and Digital citizenship: The urgency of digital literacy in the middle of a disrupted society era. *Int. J. Emerg. Technol. Learn.* **2020**, *15*, 156–161. [\[CrossRef\]](#)
13. Sharma, S.; Kar, A.K.; Gupta, M.P.; Dwivedi, Y.K.; Janssen, M. Digital citizen empowerment: A systematic literature review of theories and development models. *Inf. Technol. Dev.* **2022**, *28*, 660–687. [\[CrossRef\]](#)
14. Hamann, K.R.S.; Wullenkord, M.C.; Reese, G.; Van Zomeren, M. Believing that we can change our world for the better: A Triple-A (Agent-Action-Aim) framework of Self-Efficacy beliefs in the context of collective social and ecological aims. *Personal. Soc. Psychol. Rev.* **2023**, *28*, 11–53. [\[CrossRef\]](#)
15. Hamann, K.R.S.; Reese, G. My influence on the world (of others): Goal efficacy beliefs and efficacy affect predict private, public, and activist pro-environmental behavior. *J. Soc. Issues* **2020**, *76*, 35–53. [\[CrossRef\]](#)
16. Qin, Z.; Wu, Q.; Bi, C.; Deng, Y.; Hu, Q. The relationship between climate change anxiety and pro-environmental behavior in adolescents: The mediating role of future self-continuity and the moderating role of green self-efficacy. *BMC Psychol.* **2024**, *12*, 241. [\[CrossRef\]](#)
17. Reese, G.; Junge, E. Keep on rockin' In a (Plastic-)Free world: Collective efficacy and Pro-Environmental Intentions as a function of task difficulty. *Sustainability* **2017**, *9*, 200. [\[CrossRef\]](#)
18. Saribas, D.; Kucuk, Z.D.; Ertepinar, H. Implementation of an environmental education course to improve pre-service elementary teachers' environmental literacy and self-efficacy beliefs. *Int. Res. Geogr. Environ. Educ.* **2016**, *26*, 311–326. [\[CrossRef\]](#)
19. Vrselja, I.; Batinić, L.; Pandžić, M. Relationship between Socioeconomic Status and Pro-Environmental Behavior: The Role of Efficacy Beliefs. *Soc. Sci.* **2024**, *13*, 273. [\[CrossRef\]](#)
20. Vandaele, M.; Stållhammar, S. "Hope dies, action begins?" The role of hope for proactive sustainability engagement among university students. *Int. J. Sustain. High. Educ.* **2022**, *23*, 272–289. [\[CrossRef\]](#)
21. Hoffmann, R.; Muttarak, R. Greening through schooling: Understanding the link between education and pro-environmental behavior in the Philippines. *Environ. Res. Lett.* **2020**, *15*, 014009. [\[CrossRef\]](#)
22. Shafiei, A.; Maleksaeidi, H. Pro-environmental behavior of university students: Application of protection motivation theory. *Glob. Ecol. Conserv.* **2020**, *22*, e00908. [\[CrossRef\]](#)
23. Chen, J.; He, M.; She, S. The impact of environmental serious game on pro-environmental behavior through environmental psychological ownership and environmental self-efficacy. *Sci. Rep.* **2025**, *15*, 27616. [\[CrossRef\]](#) [\[PubMed\]](#)
24. Atta, M.H.R.; AbdELhay, E.S.; AbdELhay, I.S.; Amin, S.M.; El-Monshed, A.H.; Abdelaliem, S.M.F.; Alabdullah, A.A.S.; Eweida, R.S. Effectiveness of a web-based educational program on climate change awareness, climate activism, and pro-environmental behavior among primary health care in rural areas: A randomized controlled trial. *BMC Nurs.* **2025**, *24*, 449. [\[CrossRef\]](#)
25. Deisenrieder, V.; Kubisch, S.; Keller, L.; Stötter, J. Bridging the action gap by democratizing climate change Education—The case of K.I.D.Z.21 in the context of Fridays for Future. *Sustainability* **2020**, *12*, 1748. [\[CrossRef\]](#)
26. Gepp, S.; Jung, L.; Wabnitz, K.; Schneider, F.; Gierke, F.V.; Otto, H.; Hartmann, S.; Gemke, T.; Schulz, C.; Gabrysch, S.; et al. The Planetary Health Academy—A virtual lecture series for transformative education in Germany. *Lancet Planet. Health* **2023**, *7*, e68–e76. [\[CrossRef\]](#)
27. Li, Y.; Yang, D.; Liu, S. The impact of environmental education at Chinese Universities on college students' environmental attitudes. *PLoS ONE* **2024**, *19*, e0299231. [\[CrossRef\]](#)
28. Martzoukou, K.; Kostagiolas, P.; Lavranos, C.; Lauterbach, T.; Fulton, C. A study of university law students' self-perceived digital competences. *J. Librariansh. Inf. Sci.* **2021**, *54*, 751–769. [\[CrossRef\]](#)
29. Yue, A.; Nekmat, E.; Beta, A.R. Digital Literacy through Digital Citizenship: Online civic participation and public opinion evaluation of youth minorities in Southeast Asia. *Media Commun.* **2019**, *7*, 100–114. [\[CrossRef\]](#)
30. Swart, J.; Broersma, M. The trust Gap: Young people's tactics for assessing the reliability of political news. *Int. J. Press/Politics* **2021**, *27*, 396–416. [\[CrossRef\]](#)

31. Barreda-Coaquira, A.; Chata-Condori, S.; Malaga-Pinto, G.L.; Flores, M.M.; Sanga, G.L.L. Integration of digital applications and their effect on creative expression in visual arts students. *Minerva* **2025**, *6*, 82–92. [[CrossRef](#)]
32. Niemi, H.; Niu, S.J. Digital Storytelling Enhancing Chinese Primary School Students' Self-Efficacy in Mathematics Learning. *J. Pac. Rim Psychol.* **2021**, *15*, 1–17. [[CrossRef](#)]
33. Ibrahim, R.K.; Aldawsari, A.N. Relationship between digital capabilities and academic performance: The mediating effect of self-efficacy. *BMC Nurs.* **2023**, *22*, 434. [[CrossRef](#)] [[PubMed](#)]
34. Yuan, X.; Rehman, S.; Altalbe, A.; Rehman, E.; Shahiman, M.A. Digital literacy as a catalyst for academic confidence: Exploring the interplay between academic self-efficacy and academic procrastination among medical students. *BMC Med. Educ.* **2024**, *24*, 1317. [[CrossRef](#)] [[PubMed](#)]
35. Rehman, S.; Addas, A.; Rehman, E.; Khan, M.N.; Shahiman, M.A.; Rahman, M.A.; Wang, M. Leveraging digital skills to reduce cognitive strain: Implications for academic self-efficacy in medical education. *Acta Psychol.* **2024**, *251*, 104602. [[CrossRef](#)]
36. Zakir, S.; Hoque, M.E.; Susanto, P.; Nisaa, V.; Alam, M.K.; Khatimah, H.; Mulyani, E. Digital literacy and academic performance: The mediating roles of digital informal learning, self-efficacy, and students' digital competence. *Front. Educ.* **2025**, *10*, 1590274. [[CrossRef](#)]
37. Kioupi, V.; Voulvoulis, N. Education for Sustainable Development: A systemic framework for connecting the SDGs to educational outcomes. *Sustainability* **2019**, *11*, 6104. [[CrossRef](#)]
38. Monroe, M.C.; Plate, R.R.; Oxarart, A.; Bowers, A.; Chaves, W.A. Identifying effective climate change education strategies: A systematic review of the research. *Environ. Educ. Res.* **2017**, *25*, 791–812. [[CrossRef](#)]
39. Mondejar, M.E.; Avtar, R.; Diaz, H.L.B.; Dubey, R.K.; Esteban, J.; Gómez-Morales, A.; Hallam, B.; Mbungu, N.T.; Okolo, C.C.; Prasad, K.A.; et al. Digitalization to achieve sustainable development goals: Steps towards a Smart Green Planet. *Sci. Total Environ.* **2021**, *794*, 148539. [[CrossRef](#)]
40. Angelaki, M.E.; Bersimis, F.; Karvounidis, T.; Douligeris, C. Towards more sustainable higher education institutions: Implementing the sustainable development goals and embedding sustainability into the information and computer technology curricula. *Educ. Inf. Technol.* **2023**, *29*, 5079–5113. [[CrossRef](#)]
41. Trott, C.D. Reshaping our world: Collaborating with children for community-based climate change action. *Action Res.* **2019**, *17*, 42–62. [[CrossRef](#)]
42. Saini, M.; Sengupta, E.; Singh, M.; Singh, H.; Singh, J. Sustainable Development Goal for Quality Education (SDG 4): A study on SDG 4 to extract the pattern of association among the indicators of SDG 4 employing a genetic algorithm. *Educ. Inf. Technol.* **2022**, *28*, 2031–2069. [[CrossRef](#)] [[PubMed](#)]
43. Ferrer-Estévez, M.; Chalmeta, R. Integrating Sustainable Development Goals in educational institutions. *Int. J. Manag. Educ.* **2021**, *19*, 100494. [[CrossRef](#)]
44. Boeren, E. Understanding Sustainable Development Goal (SDG) 4 on "quality education" from micro, meso and macro perspectives. *Int. Rev. Educ.* **2019**, *65*, 277–294. [[CrossRef](#)]
45. Hajj-Hassan, M.; Chaker, R.; Cederqvist, A. Environmental Education: A Systematic review on the use of digital tools for fostering sustainability awareness. *Sustainability* **2024**, *16*, 3733. [[CrossRef](#)]
46. Chen, S. To explore the impact of augmented reality digital picture books in environmental education courses on environmental attitudes and environmental behaviors of children from different cultures. *Front. Psychol.* **2022**, *13*, 1063659. [[CrossRef](#)]
47. Wu, J.; Zhang, Q.; Gan, X.; Liu, X.; Hu, J.; Wang, Y. The relationship between digital literacy and innovative behavior among Chinese medical students: The chain mediating roles of diversity experience and creative self-efficacy. *BMC Med. Educ.* **2025**, *25*, 1194. [[CrossRef](#)]
48. Zhou, Y.; Xu, J.; Wang, R.; Guan, X. Understanding how digital health literacy affects health self-management behaviors: The mediating role of self-efficacy in college students. *Sci. Rep.* **2025**, *15*, 27230. [[CrossRef](#)]
49. Eweida, R.S.; O'Connell, M.A.; Zoromba, M.; Mahmoud, M.F.; Altheeb, M.K.; Selim, A.; Atta, M.H.R. Video-Based climate change program Boosts Eco-Cognizance, emotional Response and Self-Efficacy in rural nursing Students: Randomised controlled trial. *J. Adv. Nurs.* **2025**, *81*, 8371–8383. [[CrossRef](#)]
50. Liang, J.; Wang, L.; Luo, J.; Yan, Y.; Fan, C. The relationship between student interaction with generative artificial intelligence and learning achievement: Serial mediating roles of self-efficacy and cognitive engagement. *Front. Psychol.* **2023**, *14*, 1285392. [[CrossRef](#)]
51. Herlina, M.G.; Ozgen, E.; Handranata, Y.W.; Rinaldi, B. Exploring Digital Source of Information on Opportunity Recognition for Future entrepreneurs: Self-Efficacy as the Mediator. *J. Educ. Cult. Soc.* **2025**, *16*, 277–296. [[CrossRef](#)]
52. Xu, S.; Khan, K.I.; Shahzad, M.F. Examining the influence of technological self-efficacy, perceived trust, security, and electronic word of mouth on ICT usage in the education sector. *Sci. Rep.* **2024**, *14*, 16196. [[CrossRef](#)]
53. Aldawsari, N.D.; Nemt-allah, M.A.; Abdellatif, M.S. Environmental Education Awareness in Light of Sustainable Development Goals and Its Relationship with Environmental Responsibility Among University Students. *Sustainability* **2025**, *17*, 9393. [[CrossRef](#)]

54. Connolly, R.; Miller, J. Evaluating and revising the Digital Citizenship Scale. *Informatics* **2022**, *9*, 61. [[CrossRef](#)]
55. Chen, G.; Gully, S.M.; Eden, D. Validation of a new general self-efficacy scale. *Organ. Res. Methods* **2001**, *4*, 62–83. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.