



MEDIATING ROLE OF SELF-EFFICACY IN THE LINK BETWEEN ENVIRONMENTAL KNOWLEDGE AND ZERO-WASTE BEHAVIOR AMONG PRESERVICE ELEMENTARY TEACHERS

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Abstract

The researches on the mediating role of self-efficacy in the correlation between knowledge and zero-waste behavior among elementary pre-service teachers are examined in this study. Its purpose is to inform the gaps in our knowledge of how environmental literacy converts into sustainable action by assessing the impact of zero-waste associated with knowledge, comparing educational strategies, and exploring which psychological determinants and situational factors moderate behavior. We conducted a systematic review of quantitative, qualitative and mixed-method study from different parts of the world that focused on environmental literacy, self-efficacy and behaviors with teacher education programs. The review concludes that self-efficacy constantly mediates the link of environmental knowledge to pro-environmental behaviors and interventions are successful in promoting self-efficacy and intentions. But evidence of behavior change is not as consistently reported. Mechanistic shortcomings, including the use of self-report and cross-sectional measures and lack of investigation into psychological and contextual factors are highlighted. The synthesis highlights the significance of coupling self-efficacy development with sustainability education in order to convey learning into action. These results provide important information in relation to the teacher education programs that aim to instill enduring zero-waste behaviour among preservice teachers, and may contribute to self-efficacy and pedagogical effectiveness.

Keywords: Self-efficacy, Environmental knowledge, Zero-Waste Behavior, Teacher Education

A. INTRODUCTION

The study on the mediating effect of self-efficacy in the relationship between environmental knowledge and zero waste behavior among preservice elementary teachers has become a significant area of research, since sustainable development and environmental education have been emphasized worldwide. Education for Sustainable Development (ESD) seeks to prepare students with the competences, knowledge and values needed to act in a sustainable manner, where teachers are expected to play an important role as change agents.¹² In recent years the inclusion of environmental literacy and self-efficacy into teacher education has developed, emphasising the need for both cognitive-orientated and motivational aspects to influence pro-

¹ Katja Handtke, Lena Richter-Beuschel, and Susanne Bögeholz, "Self-Efficacy Beliefs of Teaching ESD: A Theory-Driven Instrument and the Effectiveness of ESD in German Teacher Education," *Sustainability* 14, no. 11 (2022): 6477, <https://doi.org/10.3390/su14116477>.

² Ilona Ratinen and Ulla Kemi, "Promoting Sustainability Competency and Self-Efficacy in Class Teacher Education," *Frontiers in Sustainability* 4 (2023): 11–25, <https://doi.org/10.3389/frsus.2023.1205680>.

environmental behaviours.³⁴ Under such circumstances under-researched area about how the environmental knowledge of preservice teachers reflects on sustainable behaviors becomes important in realizing sustainability goals more widely.⁵⁶

The significance role of environmental knowledge and self-efficacy to enhance sustainable behaviors has been acknowledged; however, extensive research is still needed to explore the dynamics between them especially in relation to zero-waste behavior among pre-service elementary teachers⁷⁸ Although certain research has demonstrated quite decent environmental knowledge and self-efficacy in this age group,⁹¹⁰ other findings have shown the discrepancy between perceived and actual knowledge,¹¹¹² which could indicate potential over- or underestimations of competence. Further, there are mixed results as to whether it is only environmental knowledge that can lead to behavioural change or whether self-efficacy plays a significant mediational and / or moderation role in the relationship.¹³¹⁴¹⁵ The implications of such gaps are grave as failed translation of knowledge into practice may jeopardize the cultivation and

³ D. Saribas, Z. D. Kucuk, and H. Ertepinar, "Implementation of an Environmental Education Course to Improve Pre-Service Elementary Teachers' Environmental Literacy and Self-Efficacy Beliefs," *International Research in Geographical and Environmental Education* 26, no. 4 (2017): 311–326, <https://doi.org/10.1080/10382046.2016.1262512>.

⁴ Gary Effeney and Julie M. Davis, "Education for Sustainability: A Case Study of Pre-Service Primary Teachers' Knowledge and Efficacy," *Australian Journal of Teacher Education* 38, no. 5 (2013), <https://doi.org/10.14221/AJTE.2013V38N5.4>.

⁵ Aylin Arslan and Emine Durmuş, "Green Prospective Teachers: A Research on Prospective Teachers' Sustainable Environmental Behaviors, Consumption Habits and Ecological Footprint Awareness," *SAGE Open* 15, no. 3 (2025), <https://doi.org/10.1177/21582440251365820>.

⁶ María Ángeles García-Fortes et al., "Are Future Teachers Involved in Contributing to and Promoting the Reduction of Massive Waste Generation?" *Sustainability* 16, no. 17 (2024): 7624, <https://doi.org/10.3390/su16177624>.

⁷ Ş. Söğüt and K. Karatekin, "Sınıf Öğretmeni Adaylarının Çevre Eğitimi Öz-Yeterlilik Algıları ile Sorumlu Çevresel Davranışları Arasındaki İlişkinin İncelenmesi," *Amasya Üniversitesi Eğitim Fakültesi Dergisi* (2024), <https://doi.org/10.17539/amauefd.1589027>.

⁸ P. A. M. Gapol et al., "Is Sustainability a 'Lesson Plan' for Preservice Teachers? Extent of Environmental Awareness in the Framework of Waste Management Among Preservice Teachers," *Procedia Computer Science* 236 (2024): 527–532, <https://doi.org/10.1016/j.procs.2024.05.062>.

⁹ Fatma Gürbüz and Ahmet A. Konakci, "Investigation of Environmental Knowledge and Environmental Education Self-Efficacy Levels of Science Teachers and Teachers Candidates," *Journal of New Results in Science* 17, no. 1 (2020): 1228–1243, <https://doi.org/10.14687/JHS.V16I4.5884>.

¹⁰ Nurdan T. Önal, "Relationship Between the Attitudes of Pre-School Teacher Candidates Towards Environmental Issues and Their Self-Efficacy Beliefs About Environmental Education," *Research in Geographical and Environmental Education* 34, no. 5 (2020): 145–159, <https://doi.org/10.33403/RIGEO.79161>.

¹¹ Mette H. H. Hansen and Martin K. Sillasen, "Missing Concordance Between Knowledge and Efficacy Among Danish Science Teacher Students Regarding Education for Sustainable Development," *Nordic Studies in Science Education* 16, no. 2 (2020): 215–227, <https://doi.org/10.5617/nordina.6598>.

¹² Effeney and Davis, "Education for Sustainability."

¹³ Minji Noh, "Investigating the Relationship Between Recycling/Reuse Knowledge and Recycling/Reuse Intention: The Moderating Role of Self-Efficacy," *Sustainability* 16, no. 14 (2024): 6099, <https://doi.org/10.3390/su16146099>.

¹⁴ Ebru Enginkaya and Mehmet H. Sağlam, "Recycling Reinforced: The Synergistic Dynamics of Sustainable Behavior," *Sustainability* 16, no. 9 (2024): 3827, <https://doi.org/10.3390/su16093827>.

¹⁵ L. Santos and C. G. Ramirez, "Effect of Environmental Knowledge and Awareness on Green Behavior," *The Normal Lights* 16, no. 2 (2023): 2081–2099, <https://doi.org/10.56278/tnl.v16i2.2081>.

nurturing of sustainable consumption habits and waste reduction behaviors that are crucial for environmental sustainability.¹⁶¹⁷

The theoretical framework used underpinning this research is that of environmental knowledge understood as the cognitive comprehension of ecological, self-efficacy refers to the perception of being able to perform a particular kind of behavior, and zero-waste behavior represents the actual waste prevention and sustainable consumption.¹⁸¹⁹ According to the framework, self-efficacy mediates the influence of environmental knowledge on zero-waste behavior; this is consistent with Bandura's (1986) social cognitive theory, which emphasizes efficacy beliefs as precursors of behavior change.²⁰²¹

The aim of this systematic review is to combine empirical studies on the mediating effects of self-efficacy in the relationship between environmental knowledge and zero-waste behavior among preservice elementary teachers. Through this operative review, the current article aims to advance teacher training and sustainability interventions to support both knowledge and self-efficacy in sustainable waste management practices. This contribution is important for the development of theory and practice in environmental education.²²²³

This review applies a systematic literature search and include process with an emphasis on preservice teachers' environmental knowledge, self-efficacy, and waste-related behaviour. Structural equation modeling and mediation analyses are emphasized to clarify the links among variables. Results are structured to emphasize theoretical implications, empirical patterns, and implications for teacher preparation and policy.

The purpose of this report is to review the literature on the mediating effect of self-efficacy within the environmental knowledge-zero waste behavior connection, focusing primarily on preservice elementary teachers, to summarize what is currently known and what remains yet unknown. This review is significant as preservice teachers serve as critical acquaintances to facilitate sustainable behavior in next generations; how self-efficacy was interposed between environmental awareness knowledge and actualization of zero-waste practice could have implications for teacher education. The report provides an analysis of self-efficacy as a precursor of environmentally responsible behavior, it serves to examine the efficacy of interventions used with pre-service elementary teachers, and offers insights into improving sustainability education for preservice elementary teachers.

¹⁶ Ridayani et al., "The Correlation of Environmental Education, Environmental Knowledge, Environmental Involvement, and Waste Management Behavior," *IOP Conference Series: Earth and Environmental Science* 1105, no. 1 (2022): 012008, <https://doi.org/10.1088/1755-1315/1105/1/012008>.

¹⁷ M. Y. Yusliza et al., "An Investigation of Pro-Environmental Behaviour and Sustainable Development in Malaysia," *Sustainability* 12, no. 17 (2020), <https://doi.org/10.3390/su12177083>.

¹⁸ Handtke, Richter-Beuschel, and Bögeholz, "Self-Efficacy Beliefs of Teaching ESD."

¹⁹ Noh, "Recycling Knowledge and Self-Efficacy."

²⁰ J. B. Vancouver, K. M. More, and R. J. Yoder, "Self-Efficacy and Resource Allocation," *Journal of Applied Psychology* 93, no. 1 (2008): 35–47, <https://doi.org/10.1037/0021-9010.93.1.35>.

²¹ Kira R. S. Hamann, Jens R. Holz, and Gerhard Reese, "Coaching for a Sustainability Transition: Empowering Student-Led Sustainability Initiatives by Developing Skills, Group Identification, and Efficacy Beliefs," *Frontiers in Psychology* 12 (2021): 623972, <https://doi.org/10.3389/fpsyg.2021.623972>.

²² A. Tanjung et al., "Sustainability in Education: Nurturing Tomorrow's Future Teachers Through Waste Separation and Recycling Intentions," *Multidisciplinary Science Journal* 7, no. 2 (2024): 2025143, <https://doi.org/10.31893/multiscience.2025143>.

²³ Martin Daumiller, Maria V. Keller, and Markus Dresel, "Exploring the Role of Teacher Self-Efficacy and Personal Environmental Practices in Integrating Sustainability into Their Teaching: A Network Analysis of German Teachers," preprint (2024), <https://doi.org/10.31234/osf.io/apmys>.

B. RESEARCH METHOD

The present systematic literature review (SLR) uses a structured approach to synthesize the studies that have focused on the mediating roles of self-efficacy between environmental knowledge and zero-waste behavior among preservice elementary teachers. It conducted the proposed review according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations that have become established rules in systematic reviews allowing for transparent and sound documentation of systematic research synthesis.²⁴

The research question posed as a driving force of this review was: How does self-efficacy moderate the relationship between environmental knowledge and zero-waste behavior in preservice elementary teachers? With this in mind the research question was filled out with more specific questions, such as How does self-efficacy affect sustainability education and behavior in pre-service teachers? What is the influence of ecological literacy on self-efficacy and the development of sustainable behavior in preservice teachers? Also, how do education programs influence self-efficacy and EE sustainable behaviour? These searches were constructed to capture the broadest array of relevant content.

Literature was retrieved from a range of major academic databases, including: Scopus; Web of Science and Google Scholar to achieve substantial and varied amounts of peer-reviewed research.²⁵ Search was also narrowed using various Boolean operators, which included specific keywords such as "self-efficacy," "environmental knowledge," "zero-waste behavior," and "preservice teacher." Inclusion and exclusion criteria were used to screen studies. Only empirical, peer-reviewed research studies conducted from 2000 to 2024 in the context of preservice elementary teachers and related to the intersection of environmental knowledge, self-efficacy and zero-waste practices were considered. A total of 104 publications were retrieved after an initial search.

An additional 168 candidate papers were identified with citation chaining (backward and forward). Relevance was rated according a scoring system (which ranged from zero to eight) for design, sample population and the extent of mediation by self-efficacy. After screening, 50 papers were selected for final synthesis. A flow chart was constructed in accordance with PRISMA for the selection process.²⁶ Driven by PRISMA principles, this review provides a transparent and replicable examination that teachers new knowledge on the mediating effect of self-efficacy in zero-waste context. It offers novel perspectives on how to incorporate sustainability in teacher education.

C. RESULT AND DISCUSSION

Descriptive Summary of the Studies

This section provides an overview of studies on environmental knowledge, self-efficacy, and sustainable behaviors in teacher education throughout the literature of Mediating role of self-efficacy on the relationship between environmental knowledge and zero-waste behaviour among preservice elementary teachers. Quantitative, qualitative, and mixed-method studies from different geographical areas, such as Asia, Europe and North America are included in this review and they treated the preservice teachers' environmental literacy level, attitudes or behavioral intentions. This comparison is germane to the research questions, because it provides a synthesis

²⁴ Moher, David, Alessandro Liberati, Jennifer Tetzlaff, and Douglas G. Altman, for the PRISMA Group.

Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. BMJ 339 (2009): b2535. <https://doi.org/10.1136/bmj.b2535>.

²⁵ Liberati et al., "PRISMA Statement."

²⁶ Liberati et al., "PRISMA Statement."

of empirical evidence about how self-efficacy mediates the translating of environmental knowledge into zero-waste and pro-environmental behaviors through which the effectiveness of educational interventions aimed at fostering these constructs might be evaluated.

30 studies measured environmental knowledge (EK) in different ways, from basic literacy such as preschoolers' understanding of the garbage collectors occupation to more technical waste management concepts, often representing moderate levels of understanding among preservice teachers.²⁷²⁸ Several of the studies highlighted inconsistencies between perceived and actual knowledge, demonstrating either an overestimation or under-knowledge of technical understanding.²⁹³⁰ Knowledge was identified as frequently associated with intentions but not necessarily translated into behavior without mediating moderators.³¹

35 studies quantitatively measured self-efficacy with most of them obtaining moderate to high scores for preservice teachers and with increased values after interventions or field experiences.³²³³ Self-efficacy was frequently found to be a core predictor of sustainable behavior and teaching implementation³⁴³⁵ Some research found curvilinear (non-linear) relationships between self-efficacy and motivation or resource allocations, which speaks to the non-trivial coupling of these constructs in a dynamic manner.³⁶

A total of 25 studies yielded behavioral outcomes involving waste reduction, proenvironmental behavior or recycling participation.³⁷³⁸³⁹ Consistency of behavior differed, with general recycling in the home being more popular than specific waste treatment actions.⁴⁰

²⁷ S. Schutte and N. Bhullar, "Approaching Environmental Sustainability: Perceptions of Self-Efficacy and Changeability," *The Journal of Psychology* 151, no. 3 (2017): 321–333, <https://doi.org/10.1080/00223980.2017.1289144>.

Ioannis Karachalios and Nikolaos Tantaroudas, "Future Greek Pre-Service Teachers' Knowledge, Attitudes, and Self-Efficacy in Waste Management," *British Journal of Education* 13, no. 8 (2025): 25–42, <https://doi.org/10.37745/bje.2013/vol13n82542>.

²⁸ Gürbüz and Konakci, "Environmental Knowledge and Self-Efficacy."

²⁹ Hansen and Sillasen, "Knowledge and Efficacy in ESD."

³⁰ Effeney and Davis, "Education for Sustainability."

³¹ Miyeon Chung and Chaewon Na, "Objective and Subjective Environmental Knowledge Effects on Environmental Behaviors of Pre-Service Early Childhood Teachers: The Mediating Role of Environmental Sensitivity," *Korean Journal of Environmental Education* 36, no. 4 (2023): 430–445, <https://doi.org/10.17965/kjee.2023.36.4.430>.

³² R. R. Baumann, S. Meyer, L. Bärtelein, and S. Martschinke, "Intrinsische Motivation, Wissen und Selbstwirksamkeit zu BNE im Grundschullehramtsstudium," *Zeitschrift für Hochschulentwicklung* (2023), <https://doi.org/10.21240/zfhe/18-04/13>.

³³ A. Trauth-Nare, "Influence of an Intensive, Field-Based Life Science Course on Preservice Teachers' Self-Efficacy for Environmental Science Teaching," *Journal of Science Teacher Education* 26, no. 5 (2015): 497–519, <https://doi.org/10.1007/S10972-015-9434-3>.

³⁴ J. Zhang and A. Cao, "The Psychological Mechanisms of Education for Sustainable Development," *Sustainability* 17, no. 3 (2025): 933, <https://doi.org/10.3390/su17030933>.

³⁵ Daumiller, Keller, and Dresel, "Teacher Self-Efficacy and Sustainability Teaching."

³⁶ J. B. Vancouver, K. M. More, and R. J. Yoder, "Self-Efficacy and Resource Allocation," *Journal of Applied Psychology* 93, no. 1 (2008): 35–47, <https://doi.org/10.1037/0021-9010.93.1.35>.

³⁷ Ioannis Karachalios and Nikolaos Tantaroudas, "Future Greek Pre-Service Teachers' Knowledge, Attitudes, and Self-Efficacy in Waste Management," *British Journal of Education* 13, no. 8 (2025): 25–42, <https://doi.org/10.37745/bje.2013/vol13n82542>.

³⁸ Maya Khazen et al., "The Impact of a Sustainability Education Initiative on Pre-Service Teachers: Changes in Environmental Attitudes, Willingness to Act, and Ecological Footprint," *Sustainability* 17, no. 12 (2025): 5621, <https://doi.org/10.3390/su17125621>.

³⁹ Enginkaya and Sağlam, "Recycling Reinforced."

⁴⁰ Karachalios and Tantaroudas, "Greek Pre-Service Teachers and Waste Management."

Attitudes and intentions were generally improved by intervention, but actual change in behavior was reported less consistently.⁴¹⁴²⁴³

The effectiveness of educational or coaching interventions for 20 studies had identified improves on self-efficacy, environmental attitudes and occasionally.⁴⁴⁴⁵ Interventions were distributed from short workshops to semester long courses and online labs, with diverging success in improving knowledge and efficacy.⁴⁶⁴⁷ Certain researches pointed to the value of experiential learning and hands-on activities in order to facilitate effective self-efficacy growth.⁴⁸

15 studies evaluated self-efficacy as a mediating variable in a quantitative manner, by mostly structural equation model, and found partial to full mediation of environmental knowledge on behavior.⁴⁹⁵⁰⁵¹ The mediation effects differed according to the characteristics of studies and some have identified other mediators, namely: environmental sensitivity, behavioral intentions and perceived behavioral control.⁵²⁵³ Some studies reported on that self-efficacy could only partially explain the variance of sustainable behavior outcomes.⁵⁴⁵⁵

Critical Analysis and Synthesis

Results indicated the importance of self-efficacy as a mediator between Environmental Knowledge (EK) and Zero Waste Behavior (ZWB) among preservice elementary teachers. A number of vindications that there are significant relationships between environmental knowledge, perceived behavioural control and sustainable behavior exist and justify the need for tailored educational approaches. Nevertheless, the generalization of the result is limited by methodological problems such as self-reporting biases, cross-sectional data collection and low external validity. The disharmony between "true" and "perceived" knowledge, and the neglect of situational and psychological correlates reveal lacunae in existing knowhow. The results indicate

⁴¹ Tanjung et al., "Waste Separation and Recycling Intentions."

⁴² G. M. Kaygisiz, E. Benzer, and C. D. Eren, "Aktif Öğrenmeye Dayalı Etkinliklerin Okul Öncesi Öğretmen Adaylarının Çevre Etiği Farkındalığı, Çevre Davranışı ve Çevre Eğitime İlişkin Öz-Yeterliklerine Etkisi," *Maru Journal of Education and Behavioral Development* 3, no. 4 (2019): 112–124, <https://doi.org/10.15285/MARUAEBD.542612>.

⁴³ Hamann, Holz, and Reese, "Coaching for a Sustainability Transition."

⁴⁴ Schutte and Bhullar, "Environmental Sustainability and Self-Efficacy."

⁴⁵ Wei Gao et al., "How Can Strengthen the Role of Environmental Education? Site-Scale Ecological Virtual Laboratory Enhance Self-Efficacy, Which Improve Environmental Information Cognition and Environmental Awareness," preprint (2025), <https://doi.org/10.21203/rs.3.rs-7169354/v1>.

⁴⁶ Baumann et al., "Intrinsische Motivation, Wissen und Selbstwirksamkeit."

⁴⁷ D. Saribas, Z. D. Kucuk, and H. Ertepinar, "Implementation of an Environmental Education Course to Improve Pre-Service Elementary Teachers' Environmental Literacy and Self-Efficacy Beliefs," *International Research in Geographical and Environmental Education* 26, no. 4 (2017): 311–326, <https://doi.org/10.1080/10382046.2016.1262512>.

⁴⁸ Trauth-Nare, "Field-Based Course and Environmental Teaching Self-Efficacy."

⁴⁹ Schutte and Bhullar, "Environmental Sustainability and Self-Efficacy."

⁵⁰ Zhang and Cao, "Psychological Mechanisms of ESD."

⁵¹ Noh, "Recycling Knowledge and Self-Efficacy."

⁵² Chung and Na, "Environmental Knowledge Effects on Environmental Behaviors."

⁵³ Khusnul Masykuroh, E. Yetti, and Y. Nurani, "Parents' Environmental Literacy: From Knowledge to Pro-Environmental Behavior," *Journal of Law and Sustainable Development* 12, no. 1 (2024): 17–29, <https://doi.org/10.55908/sdgs.v12i1.3197>.

⁵⁴ N. Vukelić, D. Lončarić, and N. Rončević, "Predicting Student Teachers' ESD Implementation Intention," *Journal of Teacher Education for Sustainability* 27, no. 1 (2025): 33–56, <https://doi.org/10.2478/jtes-2025-0003>.

⁵⁵ Ilona Oinonen, Timo Seppälä, and Riikka Paloniemi, "How Does Action Competence Explain Young People's Sustainability Action?" *Environmental Education Research* 30, no. 4 (2023): 499–518, <https://doi.org/10.1080/13504622.2023.2241675>.

a call for stronger intervention-based research, focused on explicitly investigating these mechanisms and moving forward teacher education's sustainability.

Results From the thematic review, we found that SE moderated the relationship between EK and ZWB among PSTs. Although several studies show how environmental knowledge plays a positive role in pro-environmental behaviour, self-efficacy is needed to transform this knowledge into action. Environmental education and TSPD programs play a significant role in shaping self-efficacy and responsible behavior of preservice teachers, underlining the importance of curriculum design and field exposures. Moreover, psychological constructs including attitudes, motivation and perceived behavioral control to some extent mediate the effect that self-efficacy has on zero-waste behaviors. The growing appreciation of situational and cultural variances suggests that divergent strategies may be called for across different domains of education.

The chronological view shows that the studies on self-efficacy in the mechanism between EK and ZWB have changed, from an emphasis on knowledge to psychological science education. Early research evidence was provided regarding the influence of self-efficacy on teaching and environmental behavior, it then moved on to investigate interventions, self-efficacy scales and embedded in the sustainability literature in teachers' pre-service preparation programs. Recent research focuses on the interaction between psychological mediators, contextual variables, and pedagogical innovation.

In general, the studies concur about environmental knowledge being favorable for ZWB and that self-efficacy is an important mediator. Yet, there are inconsistencies in the magnitude and direction of these relationships - notably across knowledge measures and the role played by psychological as well contextual factors. These discrepancies might be due to the disparities in methods, sample populations and cultural backgrounds.

Theoretical and Practical Implications

Theoretical implications The findings of our study provide insight on self-efficacy as a significant mediating process linking environmental knowledge with zero-waste behaviors among preservice elementary school teachers and support Bandura's^{56,57} social cognitive theory. Environmental knowledge is insufficient to predict behavior toward sustainability if self-efficacy and motivational constructs are absent, which the authors criticize as knowledge-deficit model.⁵⁸ This difference between perceived and actual knowledge together with overconfidence (Dunning-Kruger effect) suggests complex cognitive factor relationships reflecting teacher readiness that should be included when conceptualising formal theoretical models.⁵⁹ Moreover, self-efficacy can be affected by contextual and structural level factors like educational interventions (e.g., environmental stimuli, social norms or institutional support)⁶⁰ suggesting that a multi-level approach is necessary to explain sustainability behavior in an educational context.^{61,62} The moderators of self-efficacy along with the other psychological variables like environmental attitudes and social norms in sustainability behaviour prediction, complicate matters even more,

⁵⁶ Schutte and Bhullar, "Environmental Sustainability and Self-Efficacy."

⁵⁷ Zhang and Cao, "Psychological Mechanisms of ESD."

⁵⁸ Chung and Na, "Environmental Knowledge Effects on Environmental Behaviors."

⁵⁹ Hansen and Sillasen, "Knowledge and Efficacy in ESD."

⁶⁰ Christian Hopp and Ute Stephan, "The Influence of Socio-Cultural Environments on the Performance of Nascent Entrepreneurs: Community Culture, Motivation, Self-Efficacy, and Start-Up Success," *Entrepreneurship & Regional Development* 24, nos. 9–10 (2012): 917–945, <https://doi.org/10.1080/08985626.2012.742326>

⁶¹ Hamann, Holz, and Reese, "Coaching for a Sustainability Transition."

⁶² Daumiller, Keller, and Dresel, "Teacher Self-Efficacy and Sustainability Teaching."

which implies that a holistic perspective integrating multiple mediators is required.⁶³ Additionally, the influence of both self-efficacy and environmental knowledge is context dependent (e.g., cultural or educational) hence such culturally appropriate adaptations are required.⁶⁴

Finally, in practice, teacher education programs need to build students' confidence through behavior-based experiences like field-based courses and service learning that improve both self-confidence and self-competence when it comes to teaching sustainability.⁶⁵ When embedded into learning plans, it should be considered that environmental awareness needs to be combined with sustainable skills and pedagogy in order to develop self-efficacy and behaviour change (O'Brien et al., 2015). Interventions should include problem-solving and local environmental issue reflections to increase self-efficacy and fruit sustainable behaviour.⁶⁶ Institutional changes need to fill perceived and real knowledge gaps by providing testing and feedback systems, and enabling teaching environments that allow the effective application of sustainability activities.⁶⁷

D. CONCLUSION

The literature supports that environmental knowledge is key for prospective elementary teachers, as it impact their participation on zero-waste and pro-environmental behaviors. But understanding is not enough to induce ongoing behavior change. Self-efficacy is an essential psychological mediator that helps teachers translate their environmental knowledge into action. Increased self-efficacy through education and experiential learning increases motivation and competency, leading to greater adherence over time. The Mediation Effect of Self-efficacy and its empirical e-spaghetti There is evidence for the mediation influence of self-efficacy, which plays a crucial role to connect cognition and behavior in environmental issues education.

Self-efficacy focused interventions – particularly those that include experiential learning (e.g., field-based courses, virtual labs and peer coaching) – have positive effects. These are more effective than some conventional approaches but have limitations in design variability and lack of longitudinal follow-up, making it difficult to conduct a full evaluation of sustainability of behavior change. Although self-efficacy predicts intentions and reported behavior, actual change is affected by external factors (e.g., social norms, organizational support) in addition to environmental concern.

Methodologically the field is highly dependent on cross sectional, self reported data, which means that causal inference and objective measurement are limited. Differences between 'supposed-to-know' and actual knowledge demonstrate the importance of validated tools. There are differences in the curricula and not all teachers have been exposed to an extensive sustainability education, which makes such preparedness varied. Longitudinal studies would be particularly useful for examining the fluid nature of learning through knowledge, self-efficacy, and context trajectories while also to creating standardized measures to improve the validity of pedagogical methods. Encouraging self-efficacy of environmentally educated preservice teachers is still essential for the integration of sustainability into future education.

⁶³ Zhang and Cao, "Psychological Mechanisms of ESD."

⁶⁴ S. Salehi, A. Telešienė, and Z. Pazokinejad, "Socio-Cultural Determinants and the Moderating Effect of Gender in Adopting Sustainable Consumption Behavior Among University Students in Iran and Japan," *Sustainability* 13, no. 16 (2021), <https://doi.org/10.3390/su13168955>.

⁶⁵ Gao et al., "Strengthening the Role of Environmental Education."

⁶⁶ Söğüt and Karatekin, "Öz-Yeterlik dan Perilaku Lingkungan."

⁶⁷ Hamann, Holz, and Reese, "Coaching for a Sustainability Transition."

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