

**THE INFLUENCE OF ACTION-ORIENTED ESD LEARNING TO
IMPROVE STUDENTS' SUSTAINABLE UNDERSTANDING AND
ACTION ON FOOD WASTE TOPIC**

RESEARCH PAPER

Submitted as Requirement to Obtain Degree of *Sarjana Pendidikan* in
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**SCIENCE EDUCATION STUDY PROGRAM
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THE INFLUENCE OF ACTION-ORIENTED ESD LEARNING TO IMPROVE STUDENTS' SUSTAINABLE UNDERSTANDING AND ACTION ON FOOD WASTE TOPIC

Oleh
Faza Alika Sari Maudina

Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Pendidikan pada Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam

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APPROVAL SHEET
THE INFLUENCE OF ACTION-ORIENTED ESD LEARNING TO
IMPROVE STUDENTS' SUSTAINABLE UNDERSTANDING AND
ACTION ON FOOD WASTE TOPIC

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Faza Alika Sari Maudina

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THE INFLUENCE OF ACTION-ORIENTED ESD LEARNING TO IMPROVE STUDENTS' SUSTAINABLE UNDERSTANDING AND ACTION ON FOOD WASTE TOPIC

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ABSTRACT

Food waste has become a global issue that impacts our planet's resources and contributes to global warming making students' sustainability understanding and action are crucial in addressing this environmental issue in Indonesia. This study aims to improve students' sustainability understanding and action towards food waste management to reduce environmental pollution through the Action-Oriented Education for Sustainable Development (ESD) learning approach. There were 36 students in 7th grade of junior high school, which was observed through convenience sampling in the research with a weak experimental method. The research design used was a single group pretest-posttest design. The instruments used were open-ended essay questions to assessed students' sustainability understanding and sustainable action questionnaire which has been adapted from the Environmental Citizenship Questionnaire (ECQ). Both instruments were valid and reliable for the research. The data analysis used was Paired Sample t-Test, students' average score calculation, and N-gain score. The result showed there was significant difference in both sustainability understanding and action with ($p \text{ value}_{(0.00)} < \alpha_{(0.05)}$) and ($p \text{ value}_{(0.04)} < \alpha_{(0.05)}$), respectively. This indicated that the implementation of Action-Oriented ESD learning approach had a significant effect on students' sustainability understanding and actions. However, the improvements of the students did not fully achieve its maximum potential. The study recommended to extending the duration of forming a students' action habit during the implementation, improving the teacher's guidance and the ability to monitor thoroughly on each student, providing deeper content discussion, and facilitate collaboration with community to effectively improve students' sustainability action.

Keywords: Action-Oriented ESD learning, Sustainable Action, Sustainable Understanding

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ABSTRAK

Sampah makanan telah menjadi masalah global yang berdampak pada sumber daya planet dan berkontribusi terhadap pemanasan global. Pemahaman dan tindakan keberlanjutan siswa penting untuk mengatasi masalah lingkungan ini di Indonesia. Penelitian ini bertujuan untuk meningkatkan pemahaman dan aksi keberlanjutan siswa terhadap pengelolaan sampah makanan untuk mengurangi pencemaran lingkungan melalui pendekatan pembelajaran *Action-Oriented ESD*. Sebanyak 36 siswa kelas 7 SMP, diamati melalui *convenience sampling* dalam penelitian ini dengan menggunakan metode *weak experimental*. Desain penelitian yang digunakan adalah *single group pretest-posttest design*. Instrumen yang digunakan adalah pertanyaan esai untuk menilai pemahaman keberlanjutan siswa dan kuesioner tindakan berkelanjutan yang diadaptasi dari *Environmental Citizenship Questionnaire (ECQ)*. Kedua instrument tersebut valid dan reliabel untuk penelitian ini. Analisis data yang digunakan adalah *Paired Sample t-Test*, perhitungan nilai rata-rata siswa, dan nilai *N-gain*. Hasil penelitian menunjukkan bahwa terdapat perbedaan yang signifikan pada pemahaman dan tindakan keberlanjutan dengan ($p \text{ value}_{(0.00)} < \alpha_{(0.05)}$) dan ($p \text{ value}_{(0.04)} < \alpha_{(0.05)}$). Hal ini menunjukkan bahwa implementasi pendekatan pembelajaran *Action-Oriented ESD* memiliki pengaruh yang signifikan terhadap pemahaman dan aksi keberlanjutan siswa. Namun, peningkatan yang dilakukan oleh para siswa tidak sepenuhnya mencapai potensi maksimal. Studi ini merekomendasikan untuk memperpanjang durasi pembentukan kebiasaan aksi siswa dalam pelaksanaannya, meningkatkan bimbingan guru dan kemampuan untuk memonitor secara menyeluruh pada setiap siswa, memberikan diskusi konten yang lebih dalam, dan memfasilitasi kolaborasi dengan masyarakat untuk meningkatkan aksi keberlanjutan siswa secara efektif.

Kata kunci: Aksi Keberlanjutan, Pembelajaran Orientasi Aksi dalam ESD, Pemahaman Keberlanjutan

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REFERENCES

- Al-Obadi, M., Ayad, H., Pokharel, S., & Ayari, M. A. (2022). Perspectives on Food Waste Management: Prevention and Social Innovations. *Sustainable Production and Consumption*, 31, 190–208. <https://doi.org/10.1016/j.spc.2022.02.012>
- Alsaati, T., El-Nakla, S., & El-Nakla, D. (2020). Level of Sustainability Awareness among University Students in the Eastern Province of Saudi Arabia. *Sustainability (Switzerland)*, 12(8). <https://doi.org/10.3390/SU12083159>
- Antón-Peset, A., Fernandez-Zamudio, M. A., & Pina, T. (2021). Promoting Food Waste Reduction at Primary Schools: A Case Study. *Sustainability (Switzerland)*, 13(2), 1–19. <https://doi.org/10.3390/su13020600>
- Ariza, M. R., Boeve De Pauw, J., Olsson, D., Van Petegem, P., Parra, G., & Gericke, N. (2021). Promoting Environmental Citizenship in Education: The Potential of the Sustainability Consciousness Questionnaire to Measure Impact of Interventions. *Sustainability (Switzerland)*, 13(20). <https://doi.org/10.3390/su132011420>
- Bappenas. (2021). *Pengelolaan Limbah Makanan yang Berkelanjutan Berkontribusi pada Pembangunan Rendah Karbon di Indonesia*. Retrieved May 20, 2025, from <https://www.antaranews.com/berita/2200710/bappenas-beberkan-strategi-pengelolaan-limbah-makanan-di-indonesia>
- Bathmanathan, V., Rajadurai, J., & Alahakone, R. (2023). What a Waste? An Experience in a Secondary School in Malaysia of a Food Waste Management System (FWMS). *Heliyon*, 9(10). <https://doi.org/10.1016/j.heliyon.2023.e20327>
- Behrendt, M., Franklin, T. (2014). A Review of Research on School Field Trips and Their Value in Education. *International Journal of Environmental and Science Education*, 9(3), 235–245. <https://doi.org/10.12973/ijese.2014.213a>
- Bezeljak, P., Scheuch, M., & Torkar, G. (2020). Understanding of Sustainability and Education for Sustainable Development among Pre-Service Biology Teachers. *Sustainability (Switzerland)*, 12(17). <https://doi.org/10.3390/SU12176892>
- Bhatia, L., Jha, H., Sarkar, T., & Sarangi, P. K. (2023). Food Waste Utilization for Reducing Carbon Footprints towards Sustainable and Cleaner Environment: A Review. *International Journal of Environmental Research and Public Health*, 20(3). <https://doi.org/10.3390/ijerph20032318>
- Bramwell-Lalor, S., Kelly, K., Ferguson, T., Hordatt Gentles, C., & Roofe, C. (2020). Project-based Learning for Environmental Sustainability Action. *Southern African Journal of Environmental Education*, 36. <https://doi.org/10.4314/sajee.v36i1.10>
- Braßler, M., Sprenger, S. (2021). Fostering Sustainability Knowledge, Attitudes, and Behaviours through a Tutor-Supported Interdisciplinary Course in Education for Sustainable Development. *Sustainability (Switzerland)*, 13(6). <https://doi.org/10.3390/su13063494>

- Butar, F. B., Sayekti, C. (2024). Sustainable Food Movement: Regulating Food Loss and Waste in Indonesia. *Journal of Interdisciplinary Law and Legal Issues*, 2(1), 1.
- Chang, B. (2019). Reflection in Learning. *Online Learning Journal*, 23(1), 95–110. <https://doi.org/10.24059/olj.v23i1.1447>
- Chaplin, G., Wyton, P. (2014). Student Engagement with Sustainability: Understanding the Value-Action Gap. *International Journal of Sustainability in Higher Education*, 15(4), 404–417. <https://doi.org/10.1108/IJSHE-04-2012-0029>
- Chen, P., Chang, Y. C. (2024). Incorporating Creative Problem-Solving Skills to Foster Sustainability among Graduate Students in Education Management. *Cleaner Production Letters*, 7. <https://doi.org/10.1016/j.clpl.2024.100082>
- Chen, S. Y., & Liu, S. Y. (2020). Developing Students' Action Competence for a Sustainable Future: A Review of Educational Research. *Sustainability (Switzerland)*, 12(4). <https://doi.org/10.3390/su12041374>
- Chew, K. R., Leong, H. Y., Khoo, K. S., Vo, D. V. N., Anjum, H., Chang, C. K., & Show, P. L. (2021). Effects of Anaerobic Digestion of Food Waste on Biogas Production and Environmental Impacts: A Review. *Environmental Chemistry Letters*, 19(4), 2921–2939. <https://doi.org/10.1007/s10311-021-01220-z>
- Clement, J., Alenčikienė, G., Riipi, I., Starkutė, U., Čepytė, K., Buraitytė, A., Zabulionė, A., & Šalaševičienė, A. (2023). Exploring Causes and Potential Solutions for Food Waste among Young Consumers. *Foods*, 12(13). <https://doi.org/10.3390/foods12132570>
- Demssie, Y. N., Biemans, H. J. A., Wesselink, R., & Mulder, M. (2023). Fostering Students' Systems Thinking Competence for Sustainability by Using Multiple Real-World Learning Approaches. *Environmental Education Research*, 29(2), 261–286. <https://doi.org/10.1080/13504622.2022.2141692>
- Derqui, B., Grimaldi, D., & Fernandez, V. (2020). Building and Managing Sustainable Schools: The Case of Food Waste. *Journal of Cleaner Production*, 243. <https://doi.org/10.1016/j.jclepro.2019.118533>
- Ding, Y., Zhao, M., Li, Z., Xia, B., Atutova, Z., & Kobylkin, D. (2022). Impact of Education for Sustainable Development on Cognition, Emotion, and Behavior in Protected Areas. *International Journal of Environmental Research and Public Health*, 19(15). <https://doi.org/10.3390/ijerph19159769>
- Djirong, A., Jayadi, K., Abduh, A., Mutolib, A., Mustofa, R. F., & Rahmat, A. (2024). Assessment of Student Awareness and Application of Eco-Friendly Curriculum and Technologies in Indonesian Higher Education for Supporting Sustainable Development Goals (SDGs): A Case Study on Environmental Challenges. *Indonesian Journal of Science and Technology*, 9(3), 657–678. <https://doi.org/10.17509/ijost.v9i3.74385>
- Eliyawati, Widodo, A., Kaniawati, I., & Fujii, H. (2024). *Penerapan ESD dalam Pembelajaran IPA*. UPI Press.

- Environmental Protection Agency. (2021). *From Farm to Kitchen: The Environmental Impacts of U.S. Food Waste*.
- Filho, W. L., Trevisan, L. V., Dinis, M. A. P., Ulmer, N., Paço, A., Borsari, B., Sierra, J., & Salvia, A. (2024). Fostering Students' Participation in the Implementation of the Sustainable Development Goals at Higher Education Institutions. *Discover Sustainability*, 5(1). <https://doi.org/10.1007/s43621-024-00204-7>
- Food and Agriculture Organization. (2015). *Global Food Losses and Food Waste*. FAO.
- Food and Agriculture Organization. (2024). Food Loss Prevention and Reduction Analysis in Indonesia. In *Food loss prevention and reduction analysis in Indonesia*. FAO. <https://doi.org/10.4060/cc8935en>
- Gelinder, L., Hjalmskog, K., & Lidar, M. (2020). Sustainable Food Choices? A Study of Students' Actions in a Home and Consumer Studies Classroom. *Environmental Education Research*, 26(1), 81–94. <https://doi.org/10.1080/13504622.2019.1698714>
- Giordano, C., Di Fiore, G., Alboni, F., Carloni, E., Rivaroli, S., & Falasconi, L. (2023). Household Food Waste Awareness in Relation to Motivations. *Sustainability (Switzerland)*, 15(15). <https://doi.org/10.3390/su151511582>
- Green, C., Molloy, O., & Duggan, J. (2022). An Empirical Study of the Impact of Systems Thinking and Simulation on Sustainability Education. *Sustainability (Switzerland)*, 14(1). <https://doi.org/10.3390/su14010394>
- Hadjichambis, A. C., & Paraskeva-Hadjichambi, D. (2020). Environmental Citizenship Questionnaire (ECQ): The Development and Validation of an Evaluation Instrument for Secondary School Students. *Sustainability (Switzerland)*, 12(3). <https://doi.org/10.3390/SU12030821>
- Hake, R. R. (1998). Interactive-Engagement versus Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses. *American Journal of Physics*, 66(1), 64–74. <https://doi.org/10.1119/1.18809>
- Handayati, Y., & Widyanata, C. (2024). Effective Food Waste Management Model for the Sustainable Agricultural Food Supply Chain. *Scientific Reports*, 14(1). <https://doi.org/10.1038/s41598-024-59482-w>
- Hodges, L. C. (2018). Contemporary Issues in Group Learning in Undergraduate Science Classrooms: A Perspective from Student Engagement. *CBE Life Sciences Education*, 17(2). <https://doi.org/10.1187/cbe.17-11-0239>
- Holt, G. (2025). *What is Education for Sustainable Development?*
- Höppner, C., & Whitmarsh, L. (2011). *Engaging the Public with Climate Change* (1st Edition).
- Janoušková, S., Teplý, P., Fatka, D., Teplá, M., Cajthaml, T., & Hák, T. (2020). Microplastics—How and What Do University Students Know about the Emerging Environmental Sustainability Issue? *Sustainability (Switzerland)*, 12(21), 1–18. <https://doi.org/10.3390/su12219220>

- Koçulu, A. (2025). Developing Secondary School Students' Sustainable Living Awareness to Help Achieve the Sustainable Development Goals. *Sustainability (Switzerland)*, 17(11). <https://doi.org/10.3390/su17114757>
- Kyburz-Graber, R. (1999). Environmental Education as Critical Education: How Teachers and Students Handle the Challenge. *Cambridge Journal of Education*, 29(3), 415–432. <https://doi.org/10.1080/0305764990290310>
- Leiva-Brondo, M., Lajara-Camilleri, N., Vidal-Meló, A., Atarés, A., & Lull, C. (2022). Spanish University Students' Awareness and Perception of Sustainable Development Goals and Sustainability Literacy. *Sustainability (Switzerland)*, 14(8). <https://doi.org/10.3390/su14084552>
- Li, J., & Xue, E. (2023). Dynamic Interaction between Student Learning Behaviour and Learning Environment: Meta-Analysis of Student Engagement and Its Influencing Factors. *Behavioral Sciences*, 13(1). <https://doi.org/10.3390/bs13010059>
- Li, Z., Bai, M., Deng, H., Wu, Y., & Cui, R. (2024). Exploring Children's Experiences on School Field Trips from Children's Perspectives. *Tourism Management Perspectives*, 51. <https://doi.org/10.1016/j.tmp.2024.101220>
- Lins, M., Puppini Zandonadi, R., Raposo, A., & Ginani, V. C. (2021). Food Waste on Foodservice: An Overview through the Perspective of Sustainable Dimensions. *Foods*, 10(6). <https://doi.org/10.3390/foods10061175>
- Maoela, M. A., Chapungu, L., & Nhamo, G. (2024). Students' Awareness, Knowledge and Attitudes towards The Sustainable Development Goals at The University of South Africa. *International Journal of Sustainability in Higher Education*, 25(9), 455–473. <https://doi.org/10.1108/IJSHE-11-2023-0518>
- Merya, I. V., Yulianti, Y., & Studi Pendidikan Guru Sekolah Dasar, P. (2023). Pengaruh Model Pembelajaran Problem Based Learning (PBL) terhadap Pemahaman Konsep IPA Siswa. *Papanda Journal of Mathematics and Sciences Research*, 2(1).
- Mogensen, F., Schnack, K. (2010). The Action Competence Approach and the “New” Discourses of Education for Sustainable Development, Competence and Quality Criteria. *Environmental Education Research*, 16(1), 59–74. <https://doi.org/10.1080/13504620903504032>
- Molin, F., Haelermans, C., Cabus, S., & Groot, W. (2021). Do Feedback Strategies Improve Students' Learning Gain? — Results of a Randomized Experiment Using Polling Technology in Physics Classrooms. *Computers and Education*, 175. <https://doi.org/10.1016/j.compedu.2021.104339>
- Msengi, I., Doe, R., Wilson, T., Fowler, D., Wigginton, C., Olorunyomi, S., Banks, I., & Morel, R. (2019). Assessment of Knowledge and Awareness of “Sustainability” Initiatives among College Students. *Renewable Energy and Environmental Sustainability*, 4, 6. <https://doi.org/10.1051/rees/2019003>
- Neubig, C. M., Vranken, L., Roosen, J., Grasso, S., Hieke, S., Knoepfle, S., Macready, A. L., & Masento, N. A. (2020). Action-Related Information Trumps System

- Information: Influencing Consumers' Intention to Reduce Food Waste. *Journal of Cleaner Production*, 261. <https://doi.org/10.1016/j.jclepro.2020.121126>
- Nicholus, G., Muwonge, C. M., & Joseph, N. (2023). The Role of Problem-Based Learning Approach in Teaching and Learning Physics: A Systematic Literature Review. *F1000Research*, 12, 951. <https://doi.org/10.12688/f1000research.136339.1>
- Nurhaliza, N., Rustaman, N., Purwianingsih, W., & Salahuddin, S. (2024). The Effectiveness of Service Learning-ESD Content in Equipping Students with Problem-Solving Skills. *JPPI (Jurnal Penelitian Pendidikan Indonesia)*, 10(4), 102. <https://doi.org/10.29210/020244319>
- Oinonen, I., Paloniemi, R. (2023). Understanding and Measuring Young People's Sustainability Actions. *Journal of Environmental Psychology*, 91. <https://doi.org/10.1016/j.jenvp.2023.102124>
- Oinonen, I., Seppälä, T., & Paloniemi, R. (2024). How Does Action Competence Explain Young People's Sustainability Action? *Environmental Education Research*, 30(4), 499–518. <https://doi.org/10.1080/13504622.2023.2241675>
- Olsson, D., Gericke, N., & Boeve-de Pauw, J. (2022). The Effectiveness of Education for Sustainable Development Revisited – A Longitudinal Study on Secondary Students' Action Competence for Sustainability. *Environmental Education Research*, 28(3), 405–429. <https://doi.org/10.1080/13504622.2022.2033170>
- Ozanne, L. K., Ballantine, P. W., & McMaster, A. (2022). Understanding Food Waste Produced by University Students: A Social Practice Approach. *Sustainability (Switzerland)*, 14(17). <https://doi.org/10.3390/su141710653>
- Parry, S., Metzger, E. (2023). Barriers to Learning for Sustainability: A Teacher Perspective. *Sustainable Earth Reviews*, 6(1). <https://doi.org/10.1186/s42055-022-00050-3>
- Perwitasari, S. I., Hariyono, E., & Susantini, E. (2023). Implementation of ESD (Education for Sustainable Development) in Climate Change Learning: A Literature Review. *IJORER: International Journal of Recent Educational Research*, 4(4), 399–415. <https://doi.org/10.46245/ijorer.v4i4.317>
- Petrun S. E. L., Craig, C. A., Skonicki, E., Gahlon, G., Gilbertz, S., & Feng, S. (2021). Evaluating STEM-Based Sustainability Understanding: A Cognitive Mapping Approach. *Sustainability (Switzerland)*, 13(14). <https://doi.org/10.3390/su13148074>
- Rama Y., Y., Syarifuddin, H., & Ahmad, R. (2019). The Effect of Contextual Teaching and Learning Approach and Motivation of Learning on the Ability of Understanding the Mathematics Concepts of Grade V Student. *IOP Conference Series: Earth and Environmental Science*, 314(1). <https://doi.org/10.1088/1755-1315/314/1/012064>
- ReFed. (2025). *From Surplus to Solutions: 2025 ReFED U.S. Food Waste Report*.
- Sahadeo, S., Naicker, A., Makanjana, O., & Olaitan, O. O. (2025). Awareness, Knowledge and Attitudes of Food and Nutrition Sustainability, and Food Choice Drivers among

- University Students. *Frontiers in Sustainable Food Systems*, 9. <https://doi.org/10.3389/fsufs.2025.1589413>
- Saleem, A., Dare, P. S. (2023). Unmasking the Action-Oriented ESD Approach to Acting Environmentally Friendly. *Sustainability (Switzerland)*, 15(2). <https://doi.org/10.3390/su15021675>
- Samuel, K. (2024). *The Importance of Environmental Education: Teaching Sustainability in the Classroom*. <https://www.eejournals.org/>
- Setioningrum, P., & Subiantoro, A. W. (2023). Food Waste Issue for Enriching Biology Topic: A Case Study at Adiwiyata School. *Jurnal Penelitian Pendidikan IPA*, 9(11), 10059–10066. <https://doi.org/10.29303/jppipa.v9i11.5202>
- Sinakou, E., Donche, V., Pauw, J. B. De, & Van Petegem, P. (2019). Designing Powerful Learning Environments in Education for Sustainable Development: A Conceptual Framework. *Sustainability (Switzerland)*, 11(21). <https://doi.org/10.3390/su11215994>
- Sitompul, C., Gunawan, T., Mesiranta, N., Närvänen, E., & Octavia, J. R. (2025). Impact of Food Waste-Related Course Attendance on Students' Food Waste Reduction Behaviours and Knowledge: A Case Study from Indonesia. *International Journal of Sustainability in Higher Education*, 26(9), 36–54. <https://doi.org/10.1108/IJSHE-04-2024-0244>
- Sun, X., Clarke, A., & MacDonald, A. (2020). Implementing Community Sustainability Plans through Partnership: Examining the Relationship between Partnership Structural Features and Climate Change Mitigation Outcomes. *Sustainability (Switzerland)*, 12(15). <https://doi.org/10.3390/su12156172>
- Suryanti, D., Sinaga, P., & Surakusumah, W. (2018). Improvement of Students' Environmental Literacy by Using Integrated Science Teaching Materials. *IOP Conference Series: Materials Science and Engineering*, 306(1). <https://doi.org/10.1088/1757-899X/306/1/012031>
- Sutia, C., Inabuy, V. (2022). *Ilmu Pengetahuan Alam SMP/MTs Kelas IX* (1st ed.). <https://buku.kemdikbud.go.id>
- Topal, H. F., Hunt, D. V. L., & Rogers, C. D. F. (2021). Exploring Urban Sustainability Understanding and Behaviour: A Systematic Review towards a Conceptual Framework. *Sustainability (Switzerland)*, 13(3), 1–33. <https://doi.org/10.3390/su13031139>
- Torsdottir, A. E., Olsson, D., Sinnes, A. T. (2024). Developing Action Competence for Sustainability – Do School Experiences in Influencing Society Matter? *Global Environmental Change*, 86. <https://doi.org/10.1016/j.gloenvcha.2024.102840>
- Torsdottir, A. E., Olsson, D., Sinnes, A. T., & Wals, A. (2024). The Relationship between Student Participation and Students' Self-Perceived Action Competence for Sustainability in a Whole School Approach. *Environmental Education Research*, 30(8), 1308–1326. <https://doi.org/10.1080/13504622.2024.2326462>

- Torsdottir, A. E., Sinnes, A. T., Olsson, D., & Wals, A. (2024). Do Students Have Anything to Say? Student Participation in a Whole School Approach to Sustainability. *Environmental Education Research*, 30(4), 519–543. <https://doi.org/10.1080/13504622.2023.2213427>
- Trott, C. D. (2021). What Difference Does It Make? Exploring the Transformative Potential of Everyday Climate Crisis Activism by Children and Youth. *Children's Geographies*, 19(3), 300–308. <https://doi.org/10.1080/14733285.2020.1870663>
- Trott, C. D., Weinberg, A. E. (2020). Science Education for Sustainability: Strengthening Children's Science Engagement through Climate Change Learning and Action. *Sustainability*, 12(16), 6400. <https://doi.org/10.3390/su12166400>
- UNESCO. (2017). *Education for Sustainable Development Goals: Learning Objectives*. UNESCO.
- van de Wetering, J., Leijten, P., Spitzer, J., Thomaes, S. (2022). Does Environmental Education Benefit Environmental Outcomes in Children and Adolescents? A Meta-Analysis. *Journal of Environmental Psychology*, 81. <https://doi.org/10.1016/j.jenvp.2022.101782>
- Van Poeck, K., Vandenplas, E., Östman, L. (2024). Teaching Action-Oriented Knowledge on Sustainability Issues. *Environmental Education Research*, 30(3), 334–360. <https://doi.org/10.1080/13504622.2023.2167939>
- Varela-Losada, M., Vega-Marcote, P., Pérez-Rodríguez, U., & Álvarez-Lires, M. (2016). Going to Action? A Literature Review on Educational Proposals in Formal Environmental Education. *Environmental Education Research*, 22(3), 390–421. <https://doi.org/10.1080/13504622.2015.1101751>
- Vilmala, B. K., Karniawati, I., Suhandi, A., Permanasari, A., Khumalo, M. (2022). A Literature Review of Education for Sustainable Development (ESD) in Science Learning: What, Why, and How. *Journal of Natural Science and Integration*, 5(1), 35. <https://doi.org/10.24014/jnsi.v5i1.15342>
- Waluyo, & Kharisma, D. B. (2023). Circular Economy and Food Waste Problems in Indonesia: Lessons from the Policies of Leading Countries. *Cogent Social Sciences*, 9(1). <https://doi.org/10.1080/23311886.2023.2202938>
- Wang, Y., Sommer, M., Vasques, A. (2022). Sustainability Education at Higher Education Institutions: Pedagogies and Students' Competences. *International Journal of Sustainability in Higher Education*, 23(8), 174–193. <https://doi.org/10.1108/IJSHE-11-2021-0465>
- Widayanti, E. Y., Widyawati, W. (2024). Sustainable Development in Islamic Education: Embedding a Zero-Waste-Based Learning Program for Pre-Service Madrasah Teachers. *Cendekia: Jurnal Kependidikan Dan Kemasyarakatan*, 22(2). <https://doi.org/10.21154/cendekia.v22i2.9854>
- Widodo, A. (2021). *Pembelajaran Ilmu Pengetahuan Alam*. UPI Press.

- Xie, P., Zhang, Y., Chen, R., Lin, Z., & Lu, N. (2024). Social Media's Impact on Environmental Awareness: A Marginal Treatment Effect Analysis of WeChat Usage in China. *BMC Public Health*, 24(1). <https://doi.org/10.1186/s12889-024-20721-4>
- Zamora-Polo, F., Sánchez-Martín, J., Corrales-Serrano, M., & Espejo-Antúnez, L. (2019). What Do University Students Know About Sustainable Development Goals? A Realistic Approach to the Reception of This UN Program Amongst the Youth Population. *Sustainability (Switzerland)*, 11(13). <https://doi.org/10.3390/su11133533>