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Faculty of Education, Chiba University

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Summer Institute of
Asia & ASEAN Center for Educational Research

2026.07.26

International Research Session followed by the SDGs Workshop

Place	Time	Detail
Faculty of Education Building 2	09:30-09:45 (15 min)	Reception
	10:00-10:15 (15 min)	Opening Ceremony
	10:30-12:10 (100 min)	Oral Presentation
	12:30-13:30 (60 min)	Lunch
	13:30-16:00 (150 min)	SDGs Workshop ・ Poster Presentation
	16:15-16:45 (30 min)	Closing Ceremony

2026.10.18

ASCENT Student Research Forum 2026

Place	Time	Detail
Online (Zoom) Main Venue: Chiba University, Japan	9:30-10:00 (30 min)	Welcome and Introduction (Main Room)
	10:00-12:00 (120 min)	Presentation Session (Breakout Rooms)
	12:00-12:30 (30 min)	Morning Wrap-up Session (Main Room)
	12:30-13:30 (60 min)	Lunch break
	13:30-13:40 (10 min)	Introduction (Main Room)
	13:40-15:30 (110 min)	Workshop session (Breakout Rooms)
	15:30-16:20 (50 min)	Afternoon Wrap-up Session (Main Room)
	16:20-16:30 (10 min)	Closing Ceremony (Main Room)

Greeting



Daisuke FUJIKAWA

Dean, Graduate School of Education,
Chiba University

On behalf of the Faculty of Education at Chiba University, I would like to express my sincere appreciation for your continued participation and collaboration.

Through the activities of the Asia and ASEAN Center for Educational Research, we have built strong partnerships among universities across the region. These collaborations have contributed significantly to teacher education, educational research, and the development of innovative learning opportunities for students.

We believe that addressing contemporary educational challenges requires not only academic expertise but also collaboration across cultures and national borders. By sharing knowledge and experiences, we can work together to improve education and contribute to a more sustainable and inclusive society.

I sincerely hope that this assembly will strengthen our partnerships and inspire new collaborative initiatives in education and research.

Thank you for your continued support and cooperation.

Greeting



Jun NOMURA, M.D., Ph.D.

Professor, Graduate School of Education
Director of Asia & ASEAN Center for Educational Research,
Chiba University

Dear Distinguished Guests,

Thank you for joining the International Research meeting of the Asia and ASEAN Center for Educational Research. It is a great pleasure to gather with our valued partners from across Asia and the ASEAN region.

As we face increasingly complex global challenges, it is essential to create opportunities for young people to learn, collaborate, and innovate beyond national borders. Our Center is committed to strengthening networks among the next generation of students and young researchers, fostering environments where they can engage in collaborative scientific learning, exchange ideas, and develop solutions together.

Through our partnerships, we aim to build a sustainable international community that empowers young people to grow as globally minded scientists, innovators, and leaders. We look forward to working closely with all of you to expand these opportunities and deepen our shared commitment to the future of science education in Asia and beyond.

Thank you very much.

International Research Session

Purpose of the Research Session

The ability of young researchers to formulate crucial topics related to the development and sustainability of the world is important and speaks to the appreciation of their responsibility as leaders of the next era. Communicating these critical topics to other young people in the intellectual community is a mutually empowering activity. Therefore, this International Research meeting aims at providing a platform for fostering the next-generation of leaders in the fields of science and education.

In this meeting, presenters will show their achievements in science and educational activities. Please find the output of various scientific activities, and exchange knowledge and friendship at the meeting site.

We hope every presenter finds positive suggestions and solutions for the progress of his/her research.

International Research Session

Room 2201 (Physics, Engineering, Mathematics)		
Chairperson	KATO Tetsuya	Professor, Chiba University
Panelist	Fakih Irsyadi	Chiba University
Panelist	Savira Aristi	Chiba University
Panelist	Yen-Yu Chang	Chiba University
Presenter 1	PHON PANHA Royal University of Phnom Penh **XRF Investigation of Atmospheric Particulate Matter Accumulated on Urban Tree Leaves in Phnom Penh, Cambodia: Implications for Urban Ecosystem Health and SDG 15**	
Presenter 2	Kantapon Sangruang Chulalongkorn University **Why Mechanical Energy Seems Difficult: A Preliminary Analysis of Textbooks, Teacher Perspectives, and Student Understanding in Thai context**	
Presenter 3	AMEMIYA Kazuha, MORIYA Misaki Tokyo Metropolitan Tama High School of Science and Technology **A Study on Architectural Education at Specialized Schools in the Context of Reconstruction Architecture Following the Great Kanto Earthquake**	
Presenter 4	THANASARN WANNALANGKA King Mongkut's University of Technology Thonburi **APPLICATION OF ACTIVE INFRARED PHOTONIC SENSORS IN SIMULATING OBJECT VELOCITY MEASUREMENT SYSTEMS**	
Presenter 5	NGUYEN THI THUY LINH Vietnam National University of Education **STEM INTEGRATION IN PHYSICS EDUCATION IN VIETNAM: EMPIRICAL FINDINGS AND AN SDG 15 CASE STUDY**	
Presenter 6	Sathida Bungoed Kasetsart University **Using the 'Village City' Board Game Activity to Enhance Problem-Solving Skills in Analytic Geometry for Grade 10 Students**	
Presenter 7	VONG BUNHIENG Royal University of Phnom Penh **Assessment of Soil Contamination Near Municipal Waste Disposal Sites Using Handheld XRF: Implications for Land Degradation and SDG 15 in Phnom Penh, Cambodia**	

International Research Session

Room 2202 (Life Science, Oceanography, Education, Remote Sensing, Environment, Ocean Energy, Social Science)		
Chairperson	TSUJI Koji	Professor, Chiba University
Panelist	Armelia Ramandha	Chiba University
Panelist	Dorcas Fredua Asimeng	Chiba University
Panelist	Marella Zahra Olala	Chiba University
Panelist	Yuhui Liao	Chiba University
Presenter 1	Tanawat Somyapornjarernchai Chulalongkorn University **ColliNest: An innovation with integrated method for the propagation and conservation of subterranean stingless bees**	
Presenter 2	Muhammad Wildan Ramadhan Bandung Institute of Technology **Spatial Distribution Analysis Of Chlorophyll-A & Sea Surface Temperature In The Flores Sea During The 2017 Southeast Monsoon Using MODIS Aqua Level 3 Satellite Data**	
Presenter 3	Ma. Nigel Kuizon Yniesta University of San Carlos **ANALYSIS OF SCIENCE AND MATHEMATICS PISA 2022 RESULTS TO GARI 2022**	
Presenter 4	Nattaporn Tongpun Kasetsart University **Students' Sensemaking in Physics Learning Innovation Integrating Machine Learning as an Epistemic Tool on Sound and Light**	
Presenter 5	M FAHRI ALFARIZI RASWEN Universitas Gadjah Mada **Assessing Sentinel-2A Imagery Accuracy for Total Suspended Solid (TSS) Mapping in Mrica Reservoir, Banjarnegara, Indonesia**	
Presenter 6	TSURISHIMA Wakana Tokyo Metropolitan Tama High School of Science and Technology **Research and Planning on the Gasification of Forest Residues as an Untapped Resource for Biomass Utilization**	
Presenter 7	Nabilah Shafira Milennianti Bandung Institute of Technology **ASSESSING OCEAN THERMAL ENERGY CONVERSION (OTEC) POWER POTENTIAL IN THE NORTH BALI SEA: THERMAL VARIABILITY AND ENSO-INDUCED IMPACTS**	
Presenter 8	Ingkarat Yimlamai Chulalongkorn University **Reducing greenhouse gas emission through households food waste composing : A case study of Lopburi province, Thailand**	

International Research Session

Room 2203 (Geography, Education, Chemistry)		
Chair Person	NOMURA Jun	Professor, Chiba University
Panelist	Joceline Theda Kadarman	Chiba University
Panelist	Hanna Putri Devita	Chiba University
Panelist	Jazmín Videla Heim	Chiba University
Panelist	Sarleen Castro	Chiba University
Presenter 1	Nashriyyah Nur Imani Universitas Gadjah Mada **SPATIOTEMPORAL ANALYSIS OF FOREST COVER CHANGE IN JAMBI PROVINCE (2000–2024) USING HANSEN GLOBAL FOREST CHANGE DATA**	
Presenter 2	Kesini Phuetphian Kasetsart University **Grade 9 Students' Creativity and Innovation Skills in Motor-based Innovation Design**	
Presenter 3	KANG Jun Hiroo Gakuen Senior High School **A Biorefinery Approach to Spent Coffee Grounds through Aqueous Extraction and Carbonization**	
Presenter 4	DO DIEU LY Vietnam National University of Education **Fabricating liquid thermometers from recycled materials and teaching application in Natural Science subject under STEM education orientation**	
Presenter 5	Ariq Zaidan Universitas Gadjah Mada **Analysis of the HSR Whoosh Line as a Growing Mobility Area and Its Effects on Surrounding Regions**	
Presenter 6	SUPAPORN BARRAMEESANGPET Chulalongkorn University **Does "Bio-Based" Mean Safer? Comparing Volatile Organic Compound Exposure from Conventional and Bio-Based Gel and Acrylic Nail Products: A Research Proposal**	
Presenter 7	Maria Gabrielin Christiadiningtyas Universitas Gadjah Mada **Spatial Order of Road Networks as a Reflection of Regional Geographical Diversity in Coastal Indonesia**	
Presenter 8	Alonica Mae Bathan Donayre University of San Carlos **A Lesson Study on Teaching Kinetic Molecular Theory in Grade 10**	

International Research Session

Room 2204 (Information, Education, Biology, Biotechnology)		
Chairperson	MORISHIGE Hina	Project Assistant Professor, Chiba University
Panelist	Dinar Pratiwi Aulia	Chiba University
Panelist	Kunti Khoirunnisaa	Chiba University
Panelist	Sarah Craveiro Martins	Chiba University
Panelist	Thanyaporn Channamom	Chiba University
Presenter 1	Do Huyen Linh Vietnam National University of Education **ZERO-WASTE CONSUMPTION BEHAVIOR OF GENERATION Z: AN EMPIRICAL STUDY IN HANOI, VIETNAM**	
Presenter 2	Achita Malulim Chulalongkorn University **A Needs Assessment of Argument-Driven Inquiry with Simulation for Promoting Climate Literacy in Lower Secondary Science Education**	
Presenter 3	MORIMOTO Riku Chiba University **Exploring the Behavior of TDP43: A Protein Linked to Dementia**	
Presenter 4	Triwit Pinkheaw Kasetsart University **Fostering Students' Understanding of the Nature of Science through the Family Resemblance Approach: Developing Learning Guidelines within a STEM-BCG Context**	
Presenter 5	KUBOTA Akane Chiba Meitoku High School **Effects of Vegetable Waste on the Mycelial Growth of *Pleurotus ostreatus***	
Presenter 6	Ploychompoo Sresakulwiwat King Mongkut's University of Technology Thonburi **SCREENING AND PRELIMINARY CHARACTERIZATION OF TRANSGENIC RICE CALLUS LINE EXPRESSING VP1 PROTEIN OF ENTEROVIRUS A71**	
Presenter 7	Willy Widyatmaka Ardi Bandung Institute of Technology **Instance Segmentation of Rice Panicles for Plot-Level Yield Prediction**	
Presenter 8	Ren Ni Mahidol University **NAVIGATING THE AI-DRIVEN EDUCATIONAL LANDSCAPE: A GROUNDED THEORY APPROACH TO DEVELOPING AN ADAPTIVE LEADERSHIP FRAMEWORK**	

International Research Session

Room 2205 (Education, Social Science, Others)		
Chairperson	SHIMONAGATA Shuji	Professor, Chiba University
Panelist	Claudia Rebeca Nolasco Rodriguez	Chiba University
Panelist	Rizvon Suleimanov	Chiba University
Panelist	Yunchen Xu	Chiba University
Presenter 1	Sarun Saladtuk Chulalongkorn University **SOCRATIC AI-MEDIATED INQUIRY (SAMI) TO ADDRESS SECONDARY STUDENTS' MISCONCEPTIONS ABOUT THE SIMPLE PENDULUM**	
Presenter 2	Hein Htet Aung King Mongkut's University of Technology Thonburi **Filler Frequency and Functional Development Across CEFR Levels in the Oxford Test of English: A Corpus-Based Comparison with Native-Speaker Benchmarks**	
Presenter 3	Whelyn Aura Ravelo Unabia University of San Carlos **Junior high school students' views of nature of science: evidence from a private school in Davao Region, Philippines**	
Presenter 4	JIN XINXIN Mahidol University **Pro-social Attitude-Behavior Gap Among Private Secondary School Students**	
Presenter 5	NGUYEN THI HUYEN Vietnam National University of Education **A Contextualized Pedagogical Framework for Integrating SDG 15 into STEAM Education: A Student-Centered Approach in Secondary Education**	
Presenter 6	FELDY KHALID Bogor Agricultural University **Sustaining Agricultural Innovation: Evidence from Healthy Rice Seed and Crop Management among Rice Farmers in Indonesia**	
Presenter 7	SHASKI GHINA NURFAUZIYAH Bogor Agricultural University **CONSUMER-BASED SENSORY PROFILING OF COMMERCIAL PASTEURIZED RTE SAUSAGES IN THE INDONESIAN MARKET**	

Online Presentation Session

Online Presentation Session

Room 1 – Chair: Mahidol University (Social Sciences, Humanities, Education)		
Chairperson	Poschanan Niramitchainont	Professor, Mahidol University
Panelist	Yangxiangjun Xiong	Mahidol University
Panelist	Linxing Li	Mahidol University
Panelist	Rizvon Suleimanov	Chiba University
Presenter 1	Ashra Delisha Sana Hasmi, Carissa Kenzie Putri Wahyudi, Faiza Azkia Ashabi, Haura Ainun Mahya, Kirsten Bianca Livinlove SMA Negeri 3 Depok (Universitas Indonesia) **Adolescent Menstrual Health Education: Exploring Menstrual Tracker Use, Awareness of Oky, and Educational Media Preferences**	
Presenter 2	Nyoman Ashyuka Premaswari, Roslyn Eleanor Wiguna, Kadek Isyana Nubawa Putri, Ni Putu Vinka Anindiaswari Waishanti Regents School Bali (Udayana University) **How Culture of Masculinity Shapes Deviant Behaviours among Students in School**	
Presenter 3	Nguyen Chau Anh High School of Educational Science (Vietnam National University) **PROBLEMS QUEER TEENS ARE FACING IN VIET NAM: CHALLENGES AND SUPPORTIVE RESPONSES**	
Presenter 4	Ema Matoba Shibaura Institute of Technology Kashiwa Senior High School (Chiba University STELLA Program ASCENT-6E) **Characteristics of Student Anxiety in Junior High School Dance Classes**	
Presenter 5	Makoto Ugajin Shibaura Institute of Technology Kashiwa Senior High School (Chiba University STELLA Program ASCENT-6E) **Differences and Trends Between Scientific Reconstructions of Dinosaurs and Their Media Depictions**	

Room 2 – Chair: Kasetsart University (Engineering and Technology)		
Chairperson	Arunee Eambaipreuk	Professor, Kasetsart University
Panelist	Nattaporn Tongpun	Kasetsart University
Panelist	Sathida Bungoed	Kasetsart University
Panelist	Armelia Ramandha	Chiba University
Presenter 1	Supawida Khunpithak, Tharchagorn Mod-on Wat Rai Khing Wittaya School (Mahidol University) **FireSpreadNet: A Real-Time Wildfire Monitoring Network Using ESP32-CAM**	
Presenter 2	Kalyca Estiningtyas, Nayla Khansa Aulia, Razhaula Mirokeishe, Kezia Putri Ayunda SMA Negeri 3 Depok (Universitas Indonesia) **Integrating Microcontroller-Based Automatic Water Valve and Spatial Analysis to Reduce School Water Negligence**	
Presenter 3	Alvino Tamma Hartadi, Rakan Dhani Kalani, Arka Prabaswara Balapradana Setiawan, Jovan Lemuel Nathanael Sitohang, Fitri Humairah Dahla SMA Negeri 3 Depok (Universitas Indonesia) **Integrated IoT Monitoring and Bio-Phytoremediation System for Industrial and MSME Wastewater Treatment**	
Presenter 4	Hanna Kristina Bandiala Andam, Jainah Louise Ortaliz Galvan, Jairus Jude Gaviola Genegobis, Alan Dominic Pineda Tan, John Carl Niedo Torres San Carlos School of Cebu, Inc. (University of San Carlos) **V.A.N.T.A - Arduino-Based Monitoring of Ammonia Concentrations in Restroom Air Quality**	
Presenter 5	HSU WEN HSIN, HUANG SHANG YU, CHUANG YA-CHI, LIN YU-LE National Keelung Girls' Senior High School (National Taiwan Normal University) **Optimization Strategies for Cable Routing in Offshore Wind Farms: Constrained Caterpillar Graph Modeling and Optimal Clustering Ratio Analysis**	

Online Presentation Session

Room 3 – Chair: Vietnam National University (Engineering and Technology, Computer Science and Information Technology)		
Chairperson	Nguyen Chi Thanh	Professor, Vietnam National University
Panelist	Duong Ngoc Anh	Vietnam National University
Panelist	Hanna Putri Devita	Chiba University
Presenter 1	Vinza Al Qathani, Hanif Muhammad Hamzah, Satria Aji Mulya Kusuma, Kimi Feazka SMA Labschool UPI (Universitas Pendidikan Indonesia) **Technology for Hydroponic Monitoring and Cultivation (TUMBUH) Based on Artificial Intelligence**	
Presenter 2	Sota Sasaki Toin Gakuen Secondary School (Chiba University STELLA Program ASCENT-6E) **Programming Language Differences in Code Generation Cost Using a Local LLM**	
Presenter 3	Athalia Corazon Magaspi Angot, Ashtynne Chloe Ejes, Nyte Rama Flowers, Jairus Corbin Yau Tiu San Carlos School of Cebu, Inc. (University of San Carlos) **GABAY – Artificial Intelligence (AI)-Assisted Navigation Mobile Application for Persons with Disabilities (PWD)**	
Presenter 4	Khanza Anindya Yasmine, Anindita Shalsabila Nur Rahman, Maria Kirana Artanti Hamung, Sherene Putri Mulya, Rommy Aksa Jova SMA Negeri 3 Depok (Universitas Indonesia) **RHIZOFIREWALL: Intercepting Phytophthora capsici Zoospores Using Moisture-Responsive Biodegradable Decoy Granules in Vanilla Plants**	

Room 4 – Chair: Institut Teknologi Bandung (Environmental Science and Sustainability, Chemistry, Biology)		
Chairperson	Saat Mubarrok	Professor, Institut Teknologi Bandung
Panelist	Daniel Bonifasius Sipayung	Institut Teknologi Bandung
Panelist	Punnat Changsalak	Chiba University
Panelist	Joceline Theda Kadarman	Chiba University
Presenter 1	Muhammad Faturahman Putra Suwarto, Khaira Salmaa Haura, Aisha Athifa Yuwono, Zyvanna Aurelya Wijaya SMA Negeri 2 Cirebon (Institut Teknologi Bandung) **Sustainable Green Mussel (*Perna viridis*) Depuration Using Agricultural-Waste Bio absorbents for Microplastics Reduction: A Comparative Study Supporting SDGs 3, 9 and 12**	
Presenter 2	Phunyawee Sirathatanareey, Kanrawi Rungcharoeyphatthanakit, Sirikan Payongsak Wat Rai Khing Wittaya School (Mahidol University) **A Study on Stingless Bee Farming and Honey Properties: A Case Study of Rai Saen Rak, Ko Lat E-Tan Community, Sam Phran District, Nakhon Pathom Province**	
Presenter 3	Raden Arkadhiya Achmad Danendra Alfa Centauri High School (Universitas Pendidikan Indonesia) **The Effectiveness of Black Soldier Fly Larvae in Enhancing Livestock Production**	
Presenter 4	Kensei Iida Hiroo Gakuen Koishikawa (Chiba University STELLA Program ASCENT-6E) **The Effect of the Construction of Myoden Bridge on Avifauna in Edogawa Discharge Channel and the Situation 7 Years After Its Opening**	

Online Presentation Session

Room 5 – Chair: Chiang Mai University (Computer Science and Information Technology, Engineering and Technology, Social Sciences)		
Chairperson	Warunee Suphon	Professor, Chiang Mai University
Panelist	Sarawan Pomsuk	Chiang Mai University
Panelist	Rizvon Suleimanov	Chiba University
Panelist	Punnat Changsalak	Chiba University
Presenter 1	Ramon Ernest C. Kimhoko, Clare Therese E. Owacan, Dmitri Finn D. Lungay, Seith Christian R. Vanzuela San Carlos School of Cebu, Inc. (University of San Carlos) **C.H.U.M - Cellular Holistic Universal Microscope**	
Presenter 2	Vuong Tri Dung, Do Minh Dang, Nguyen Do Quyen High School of Educational Science (Vietnam National University) **Application of Robotics in Post-Injury Rehabilitation for the Elderly: Design, Kinematic Performance, and Clinical Efficacy**	
Presenter 3	Natchaya Sirisutham, Thee Nophaket Chiang Mai University Demonstration School (Chiang Mai University) **Non-Contact Smart Bed for Respiratory Monitoring**	
Presenter 4	Sirawich Pichitpantapong, Angkul Utane, Supanat Wongpia Chiang Mai University Demonstration School (Chiang Mai University) **NeuroPlay : A Computer Vision-Based Gamified Platform for the Assessment and Rehabilitation of Learned Non-Use in Stroke Survivors**	

Room 6 – Chair: University of San Carlos (Chemistry, Medicine and Health Sciences)		
Chairperson	Rita May Tagalog	Professor, University of San Carlos
Panelist	Argie Anthony C. Inciso	University of San Carlos
Panelist	Cristobal A. Rabuya Jr.	University of San Carlos
Panelist	Joceline Theda Kadarman	Chiba University
Presenter 1	Nutatcha Yowcharoensuk, Kueaangkul Chanpo, Kanwara Laopanichkul Chiang Mai University Demonstration School (Chiang Mai University) **Longa Chewie: An Innovative Orthodontic Chew Stick Made from Natural Rubber Reinforced with Longan Extract**	
Presenter 2	Amir Yadzka Razan Kornita Senior High School (IPB University) **Utilizing Lemongrass (*Cymbopogon citratus*) in the Formulation of an Anti-mosquito Lotion**	
Presenter 3	Tawit Choowongkomo Kasetsart University Laboratory School Center for Education Research and Development (Kasetsart University) **AI-Guided Drug Discovery: Cyclic Peptide Inhibitors of the SARS-CoV-2 Main Protease**	
Presenter 4	Peerawich Phookduang Kasetsart University Laboratory School Center for Education Research and Development (Kasetsart University) **Development of Hand Sanitizer Alcohol Gel Infused with Xanthone Extract from Mangosteen Pericarp for Inhibiting Pathogenic Bacteria**	

Online Presentation Session

Room 7 – Chair: Universitas Indonesia (Chemistry)		
Chairperson	Dodi Sudiana	Professor, Universitas Indonesia
Panelist	Vemby Somadias	Universitas Indonesia
Panelist	Anindya Afina Carmelya	Universitas Indonesia
Panelist	Hanna Putri Devita	Chiba University
Presenter 1	Nana Tsuchida Ichikawa Gakuen Ichikawa Senior High School (Chiba University) **Removal of Copper Ions Using Banana Peels**	
Presenter 2	Chonchanok Suwannatup, Jareeyaporn Wongnuam, Saruda Wangrakwong Ongkharak Demonstration School (Kasetsart University) **Detection of Aluminum Ions in Water Using Anthocyanin Extraction from Riceberry Rice**	
Presenter 3	Hoang Minh Quang High School of Educational Science (Vietnam National University) **ANALYSIS OF CHEMICAL METHODS FOR NEUTRALIZING ACIDIC WATER**	
Presenter 4	Azka Sabiq Arfa, Billy Rayendra Nugraha, Chalice Nailasekar Daradjat, Nadim Prasetya Regazzoni SMAN 3 Bandung (Universitas Pendidikan Indonesia) **DETECTION OF BORAX IN WHITE CRACKERS USING A BUTTERFLY PEA ANTHOCYANIN INDICATOR AND ARDUINO UNO R3**	

Room 8 – Chair: Udayana University (Chemistry)		
Chairperson	Ni Wayan Wahyuni	Professor, Udayana University
Panelist	Shiva Putri Zakkyah	Udayana University
Panelist	Naomi Haverim	Udayana University
Panelist	Armelia Ramandha	Chiba University
Presenter 1	Chanyaneut Rattanachoksakul, Thanyapat Sandee, Nampech Chantakun Wat Rai Khing Wittaya School (Mahidol University) **Bio-based Freshness Indicator Film**	
Presenter 2	Azkia Sausan Hidayat Kornita Senior High School (IPB University) **Combustion Time Efficiency of Bio-Briquettes Based on a Mixture of Rice Husk and Coconut Shell**	
Presenter 3	Karin Chiyo Ichikawa Gakuen Ichikawa Senior High School (Chiba University) **Removal of Dirt Adhering to Metal by a Mixture of Ethanol and Gasoline**	
Presenter 4	Natsuki Torikoshi Ichikawa Gakuen Ichikawa Senior High School (Chiba University) **Application of Disposable Hand Warmers to the Thermite Reaction**	

Proceedings

- High School Students -

A Biorefinery Approach to Spent Coffee Grounds through Aqueous Extraction and Carbonization

Jun Kang

Hiroo Gakuen Senior High School, Tokyo, Japan

Purpose and Background:

Spent coffee grounds (SCG) are generated in large quantities worldwide and contain water-extractable compounds and carbon-rich solids. Extracted coffee residues have been converted into carbon materials for supercapacitor applications,[1] while residual moisture has been reported to affect SCG carbonization.[2] This study explores a biorefinery approach in which aqueous extraction is combined with subsequent carbonization of the remaining residue. The objective was to compare untreated wet SCG, dried SCG, and water-extracted residue under the same carbonization temperature, and to establish a reproducible carbonization protocol for further electrode-material evaluation.

Materials and Methods:

Groups A (untreated wet SCG), B (dried SCG), and C (water-extracted residue) were carbonized at 800°C under N_2. After inadequate purging was identified, the pre-purge flow rate was increased from 50 mL/min to 6 L/min. Carbonization yield was calculated on a dry-solid basis, and pressed pellets were used for preliminary apparent-conductivity measurements.

Results and Discussion:

Initial dry-solid-basis carbonization yields were 13.8%, 9.3%, and approximately 0% for Groups A, B, and C, respectively. The abnormal green appearance of Groups B and C suggested that insufficient exclusion of oxygen, rather than moisture or extraction, may have affected the initial results.

After the N_2 pre-purge flow rate was increased from 50 mL/min to 6 L/min, both the carbonization yield and apparent conductivity of Group A increased substantially (Table 1), indicating that the initial carbonization conditions were not sufficiently controlled.

Table 1. Effect of the corrected nitrogen-purging protocol on Group A

N_2 flow rate (mL/min)	Carbonization yield (%)	Apparent conductivity (S/cm)
50	13.8	0.0091
6000	17.5	0.202

Notably, apparent conductivity increased by more than an order of magnitude, from 0.0091 to 0.202 S/cm, while carbonization yield increased from 13.8% to 17.5%. This suggests that revised atmosphere control affected not only carbon recovery but also the electrical properties of the material.

Therefore, the near-zero yield of Group C cannot yet be attributed to moisture or aqueous extraction, and Groups A, B, and C need to be re-evaluated under the corrected protocol. Establishing these conditions provided a more reliable basis for subsequent evaluation of SCG-derived carbon.

REFERENCES

[1] Adan-Mas, A., Alcaraz, L., Arévalo-Cid, P., López-Gómez, Félix. A., & Montemor, F. Coffee-derived activated carbon from second biowaste for supercapacitor applications. Waste Management, 2021, 120, 280–289.

[2] Kim, B., Park, J., Baik, S., & Lee, J. W. Spent coffee derived hierarchical porous carbon and its application for energy storage. Journal of Porous Materials, 2020, 27, 451–463.

Effects of Vegetable Waste on the Mycelial Growth of *Pleurotus ostreatus*

Akane Kubota

Chiba Meitoku High School, Japan

Purpose and Background

Conventional mushroom cultivation relies on sawdust and agricultural by-products as substrate materials. Meanwhile, the effective utilization of food waste and vegetable residue remains a significant challenge. In recent years, research and practical applications using waste materials, such as spent coffee grounds (Tanaka et al., 2022), for mushroom cultivation have been conducted. Therefore, this study investigated the effects of different types and concentrations of vegetable waste on the mycelial growth of *Pleurotus ostreatus*.

Materials and Methods

Vegetable wastes (potato peel, carrot peel, orange peel, spent coffee grounds, spent tea leaves, onion peel, and banana peel) were dried at 100 °C for 24 h and ground into a fine powder. Each vegetable waste powder was added to PDA medium at concentrations of 0.5%, 1.0%, and 2.0%. PDA medium without vegetable waste powder was used as the control. The media were autoclaved at 121 °C for 20 min and poured into Petri dishes. A 5 mm × 5 mm agar block containing *Pleurotus ostreatus* mycelium was placed onto each medium and incubated at 25 °C. Each condition was tested with four replicates (n = 4). Colony diameter was measured with a ruler on days 0, 3, and 6 after inoculation.

Results and Discussion

Mycelial growth at day 6 varied among vegetable waste types and concentrations (Figure 1). Onion peel showed the strongest concentration-dependent decrease, with almost no growth at 2.0%, while potato peel, carrot peel, and spent coffee grounds showed greater growth than the control across all tested concentrations.

The reduction observed with onion peel may be related to its antifungal properties, as red onion peel extract has been reported to inhibit fungal mycelial growth (Elsherbiny et al., 2023). However, the compounds responsible for this effect were not identified in this study. In addition, the effects observed on PDA may not directly reflect fruiting performance under actual cultivation conditions. Further experiments using mushroom cultivation substrates are therefore needed to determine whether similar effects occur during actual cultivation.

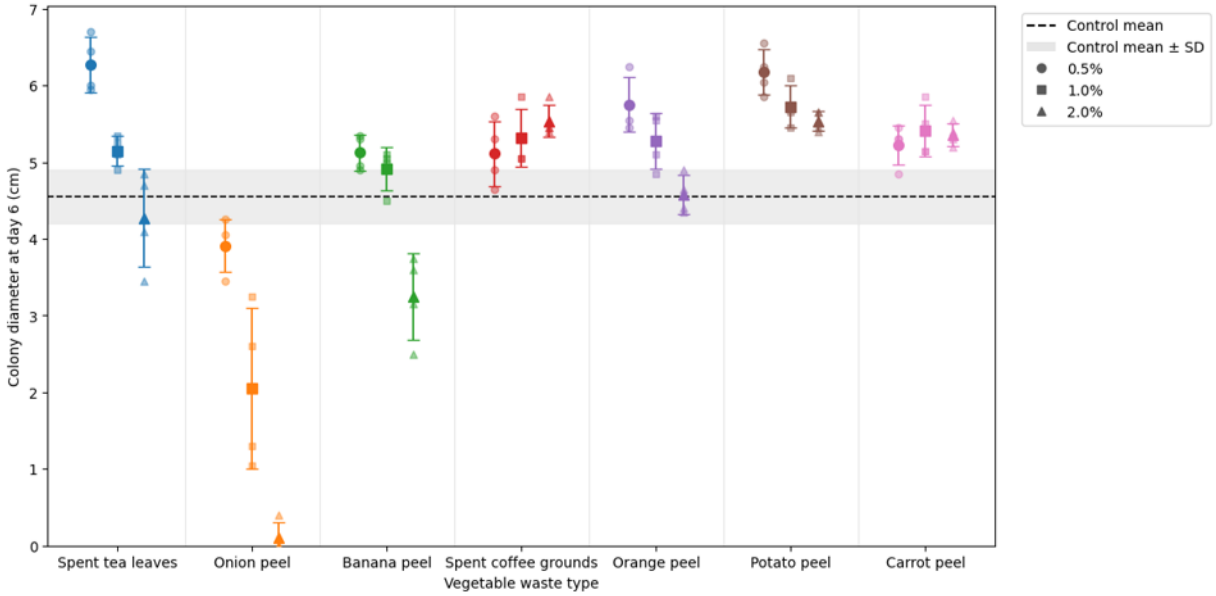

Figure 1. Colony diameter of *Pleurotus ostreatus* at day 6 under different vegetable waste treatments.

REFERENCES

Elsherbiny, E. A., Dawood, D. H., Elsebai, M. F., Mira, A., & Taher, M. A. (2023). Control of dry rot and resistance induction in potato tubers against *Fusarium sambucinum* using red onion peel extract. *Postharvest Biology and Technology*, *195*, 112119.

Tanaka, T. , Inoue, A. , Oka, S. , Mikami, T. , Tanaka, A. , & Gegawa, T. (2022). Trial of *Pleurotus ostreatus* cultivation using coffee grounds. *J. Technology and Education, 29*(1), 17–21. (in Japanese)

Proceedings

- High School Students –
Online

Adolescent Menstrual Health Education: Exploring Menstrual Tracker Use, Awareness of Oky, and Educational Media Preferences

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Abstract

Menstrual health education is essential for adolescents, yet stigma and limited information remain challenges. This study explores menstrual tracker use, awareness of Oky, and educational media preferences through surveys, interviews, and literature reviews. The findings are expected to support more accessible and engaging menstrual health education.

1. Introduction

Menstrual health is an important aspect of adolescent well-being. However, misconceptions, stigma, and limited access to reliable information remain challenges. Digital platforms such as Oky, developed with UNICEF, provide menstrual tracking and educational content to support adolescents in understanding their menstrual health.

2. Methods

This study uses an online questionnaire involving 11 respondents, an interview with a UNICEF representative, and a literature review. The survey examines menstrual tracker use, Oky awareness, and educational media preferences.

3. Results and Discussion

The survey found that 90.9% of respondents had never heard of Oky. This indicates limited awareness of the application among participants. Exploring adolescents' preferred educational media may help make menstrual health information more accessible and engaging.

4. Conclusion

Increasing awareness of Oky and providing engaging educational resources may support adolescent menstrual health education. Digital tools should be developed with consideration of adolescents' needs and preferences.

REFERENCES

Binder, G., Palmer, T., & Tyers-Chowdhury, A. (2026). A results assessment of Oky. UNICEF.

World Health Organization & UNICEF. (2024). Progress on drinking water, sanitation and hygiene in schools 2015–2023.

PROBLEMS QUEER TEENS ARE FACING IN VIET NAM: CHALLENGES AND SUPPORTIVE RESPONSES

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Introduction

A national study involving 2,363 participants across 63 provinces documented discrimination against LGBT people and identified family, school, and workplace settings as important contexts in which it occurs (Luong & Pham, 2016). International reviews indicate that rejection, victimization, and limited support are associated with poorer mental-health outcomes among LGBTQI+ young people (Wilson & Cariola, 2020; de Lange et al., 2022). This paper examines challenges queer teenagers in Viet Nam may encounter and considers practical support at school, at home, and through policy.

Research Method

This paper uses a qualitative document review approach. The primary source was the presentation, "Problems Queer Teens Are Facing Right Now and a Solution for Them," which draws on the report Is It Because I Am LGBT? (Luong & Pham, 2016). It was considered alongside six additional sources: a UNDP country report, a human-rights report on Viet Nam, and peer-reviewed systematic reviews or meta-analyses on LGBTQI+ youth mental health and minority stress (UNDP, 2014; U.S. Department of State, 2024; Dürrbaum & Sattler, 2020; Wilson & Cariola, 2020; de Lange et al., 2022; Hong & Skiba, 2025).

Findings

Across the reviewed sources, three connected patterns stand out. First, discrimination is not confined to one setting: the Vietnamese report identifies family, school, and workplace discrimination, while the country report describes legal and social barriers affecting LGBTQ+ people (Luong & Pham, 2016; UNDP, 2014). Second, teenagers may experience school as unsafe when peers bully or isolate them, staff lack accurate knowledge, or confidential counselling is difficult to access. Third, family rejection and pressure to conform can reduce a young person's sense of safety and belonging. Reviews of international research similarly identify isolation, rejection, victimization, and inadequate support as recurring themes associated with mental-health difficulties (Wilson & Cariola, 2020; de Lange et al., 2022).

Discussion and Conclusion

The findings suggest that the challenges described are interconnected rather than isolated problems. When a school does not intervene in bullying, or a family dismisses a teenager's identity, the young person may have fewer safe places to seek help. This interpretation is consistent with reviews linking minority stressors—including victimization and negative family treatment—to mental-health risks among LGBTQ+ youth (Dürrbaum & Sattler, 2020; de Lange et al., 2022). Immediate responses should include trusted adults, confidential school counselling, privacy protections, and clear procedures for reporting bullying. Over the longer term, schools can provide age-appropriate, evidence-based education about sexual orientation and gender identity, while policymakers can review gaps in legal protection and recognition. These recommendations align with calls for stronger support services and policy action in Viet Nam and in the wider youth mental-health literature (UNDP, 2014; Wilson & Cariola, 2020). Recent research also highlights the importance of social support and access to appropriate services for LGBTQ+ young people (Hong & Skiba, 2025).

REFERENCES

[1] Dürrbaum, T., & Sattler, F. A. (2020). Minority stress and mental health in lesbian, gay male, and bisexual youths: A meta-analysis. Journal of LGBT Youth, 17(3), 298–314. https://doi.org/10.1080/19361653.2019.1586615

[2] de Lange, J., Baams, L., van Bergen, D. D., Bos, H. M. W., & Bosker, R. J. (2022). Minority stress and suicidal ideation and suicide attempts among LGBT adolescents and young adults: A meta-analysis. LGBT Health, 9(4). https://doi.org/10.1089/lgbt.2021.0106

[3] Luong, T. H., & Pham, Q. P. (2016). Is it because I am LGBT? Institute for Studies of Society, Economy and Environment. https://www.undp.org/vietnam/publications/it-because-i-am-lgbt

[4] Hong, C., & Skiba, B. (2025). Mental health outcomes, associated factors, and coping strategies among LGBTQ adolescent and young adults during the COVID-19 pandemic: A systematic review. Journal of Psychiatric Research, 182, 132–141. https://doi.org/10.1016/j.jpsychires.2024.12.037

[5] U.S. Department of State. (2024). 2023 country reports on human rights practices: Vietnam. https://2021-2025.state.gov/reports/2023-country-reports-on-human-rights-practices/vietnam/

[6] Wilson, C., & Cariola, L. A. (2020). LGBTQI+ youth and mental health: A systematic review of qualitative research. Adolescent Research Review, 5, 187–211. https://doi.org/10.1007/s40894-019-00118-w

Characteristics of Student Anxiety in Junior High School Dance Classes

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Purpose and Background:

The purpose of this study is to identify the characteristics of student anxiety in junior high school dance education settings and to highlight current challenges. Dance became a compulsory subject in junior high school curricula under the Course of Study guidelines introduced in 2012. In a survey of junior high school teachers, 1,231 respondents reported feeling anxious about teaching dance classes [1]. Previous research has shown that feelings of embarrassment in physical education classes are primarily related to self-evaluation and peer evaluation [2]. However, the specific situations associated with students' anxiety in dance classes remain insufficiently understood. This study therefore examines anxiety across different dance-class situations and levels of dance experience.

Materials and Methods:

A questionnaire survey was conducted with 539 students in Grades 7–10. The survey assessed students' dance experience and their feelings of enjoyment, anxiety, and accomplishment in dance classes. Anxiety was measured using a four-point scale (1 =I didn't feel it at all , 4 =I felt very), covering technical skills, evaluation, interpersonal relationships, lack of experience, and self-expression. The questionnaire also included open-ended questions about anxiety-provoking situations and experiences that helped reduce anxiety. Quantitative responses were analysed using ANOVA and Chi-Square Test, while open-ended responses were examined through text analysis.

Results and Discussion

Concerns about practical tests and grades had the highest mean anxiety score ($M = 2.80$, $SD = 1.08$; Table 1). Students with no dance experience showed higher overall anxiety scores ($M = 2.64$) than those with 1–3 years ($M = 2.25$) or more than 3 years of experience ($M = 2.04$). A one-way ANOVA indicated a significant difference among the three groups ($F(2, 536) = 12.48$, $p < .001$). These findings suggest that both dance experience and concerns about evaluation are relevant to understanding students' anxiety in dance classes.

Table 1. Mean Anxiety Scores for Dance-Class Situations

Category	**Anxiety-related situation**	**M**	**SD**
Technique	Sense of rhythm	2.05	0.98
Technique	Memorising choreography	2.62	1.07
Evaluation	Practical tests and grades	2.80	1.08
Interpersonal Relationships	Difficulty teaching friends confidently	2.28	1.05
Interpersonal Relationships	Difficulty dancing when friends point out mistakes	2.10	1.03
Experience	Lack of experience or familiarity with dance	2.43	1.14
Expression	Performing in front of an audience	2.72	1.08

REFERENCES

[1] Kakoi, C. (2020). Nationwide survey on the implementation of dance classes. In *Report on the evaluation of dance instruction outcomes* (Section II, pp. 12–13). Japan Sports Agency. [In Japanese]

[2] Sugimura, A., Mochida, H., & Sugimoto, S. (2024). Factors contributing to embarrassment in physical education classes. *Proceedings of the 74th Annual Conference of the Japan Society of Physical Education, Sports, and Health*, 95. https://doi.org/10.20693/jspehssconf.74.0_95 [In Japanese]

FireSpreadNet: A Real-Time Wildfire Monitoring Network Using ESP32-CAM

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Purpose and Background

Wildfires can damage forests and ecosystems and contribute to air pollution, including fine particulate matter known as PM2.5 , which can affect human health (World Health Organization, 2026). This project presents FireSpreadNet, a prototype network designed to monitor multiple locations by combining ESP32-CAM image capture, environmental sensing, wireless data transmission, Firebase Realtime Database, and a web-based dashboard. The system aims to identify visual signs of smoke or flames and display station information to support wildfire monitoring.

Materials and Methods

The prototype uses an ESP32-CAM to capture images for AI-based recognition of smoke or flames. A DHT22 sensor measures temperature and relative humidity. The prototype applies project-defined seasonal thresholds: summer, above 38°C and humidity at or below 40%; rainy season, above 33°C and humidity at or below 60%; and winter, above 35°C and humidity at or below 45%. These thresholds are implementation settings for the prototype and have not been established here as validated wildfire-risk standards. Data are transmitted over Wi-Fi to Firebase Realtime Database and displayed on a website. Functional testing was conducted in a simulated environment using three scenarios: no smoke or flames, smoke detected, and flames detected.

Results and Discussion

In the simulated tests, the system displayed normal status when no smoke or flames were present, sent data to the website when smoke was detected, and sent an alert to the dashboard when flames were detected (Table 1). The website also displayed station locations and status on a map and supported data from multiple stations simultaneously, as described in the project presentation. These results demonstrate the intended data and display workflow under simulated conditions; they do not establish detection accuracy or reliability in real forest environments. Further testing is needed under varied lighting, weather, and network conditions. FireSpreadNet is relevant to SDG 3, SDG 9, and SDG 15 through its focus on health-related smoke impacts, digital monitoring technology, and forest protection (United Nations, n.d.).

Table 1. Functional test results for the FireSpreadNet prototype

Test scenario	Purpose of check	Result observed
No smoke or flames	Check normal-status workflow	Website displayed normal status.
Smoke detected	Check smoke detection and data display	System detected smoke and sent data to the website.
Flames detected	Check flame detection and alert display	System detected flames and sent an alert to the dashboard.

REFERENCES

United Nations. (n.d.). The 17 goals. https://sdgs.un.org/goals

Waveshare. (n.d.). DHT22 temperature-humidity sensor. https://www.waveshare.com/wiki/DHT22_Temperature-Humidity_Sensor

World Health Organization. (2026, July 31). Wildfires. https://www.who.int/news-room/fact-sheets/detail/wildfires-and-health

Integrating Microcontroller-Based Automatic Water Valve and Spatial Analysis to Reduce School Water Negligence

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Purpose and Background:

This research aims to design a cost-effective, off-grid, microcontroller-based retrofit system capable of shutting off water flow automatically without replacing existing taps. Specifically, this system is expected to eliminate user negligence regarding water waste, utilize solar power as an independent renewable energy source, and conduct spatial analysis to map water waste zones in order to optimize school facility management, in alignment with SDG 7, 11, and 13.

Water negligence in schools frequently occurs on a massive scale during daily break hours when water usage reaches its peak. This condition triggers excessive water waste while inefficiently increasing the electricity consumption of water pumps, which often results in depleted clean water reserves at school. On the other hand, current commercial automation solutions generally require high infrastructure replacement costs, generate electronic waste (e-waste), and are difficult to implement on outdoor taps lacking access to the main power grid (off-grid). Therefore, this study presents an automated microcontroller-based water valve retrofit system to address these challenges.

Materials and Methods:

The automatic faucet system is powered by a portable power bank integrated with a 5V DC Mini solar panel for energy replenishment. The core control system utilizes an Arduino Uno R3 (ATmega328P) microcontroller, which processes input from an HC-SR04 ultrasonic distance sensor to detect user presence with a proximity threshold of ≤15 cm. Output signals drive a 5V-24V relay module to actuate a 24V DC normally-closed (NC) solenoid valve connected viafemale double check socket thread fittings to control water flow from the water jerry can reservoir. The testing methodology comprised a field water audit measuring flow rates under damaged/unclosed (40mL/s) and fully opened (170mL/s) conditions to establish baseline water loss. Additionally, sensor logic testing was conducted to verify accuracy at the ≤15 cm threshold, ensuring reliable differentiation between human hands and surrounding objects to eliminate false triggers.

Results and Discussion

Field observations across 62 school taps revealed that 20 ablution taps represent the highest risk for water waste, as roughly 83% of students use them. hurriedly during noon prayer breaks, while 42 hand washing taps see lower risk during meal hours. Without intervention, a fully open tap 170 mL/5 seconds left unattended for just 10 minutes wastes 20.4 Liters of water. By installing the smart retrofit system, the water flow is automatically cut off within 5 seconds once a user leaves, capping maximum water loss at just 170mL/ incident and reducing total water waste by over 95%.

Parameter	Baseline Condition (Before)	Projected Result (Expected After)
Flow Duration per Incident	Indefinite (Until manually turned off)	Capped at 5 seconds (auto shut-off)
Wasted Volume per Incident	Dozens to hundreds of liters	Limited to 170mL
Waste Reduction	0% (on going loss)	~95% reduction in high-risk areas

Table 1

Although real-world field testing remains pending, component-level testing confirms that the Arduino logic and hardware successfully execute automated shut-offs. The projected data in Table 1 demonstrate that once fully deployed, the system is expected to eliminate user negligence and reduce water waste by over 95% without requiring expensive plumbing replacements.

REFERENCES

Santoso, H. (2019). Monster Arduino 2: Panduan Praktis Belajar Arduino untuk Pemula. ElangSakti.com.

INTEGRATED IOT MONITORING & BIO-PHYTOREMEDIATION SYSTEM FOR INDUSTRIAL AND MSME WASTEWATER TREATMENT

A Regulatory-Compliant, Cost-Effective, and Water Conservation Solution in Depok

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1. INTRODUCTION & PROBLEM STATEMENT

The Ciliwung and Pesanggrahan river basins traversing Depok experience severe degradation from unmanaged Micro, Small, and Medium Enterprise (MSME) effluent (principally tofu/tempeh and textile dye workshops). This compromises PDAM Tirta Asasta raw surface water sources and public health.

- **Lack of Real-Time Surveillance:** Municipal agencies lack continuous parameter tracking for shock discharges.
- **Prohibitive Capital Intensity:** Traditional WWTPs impose high CAPEX/OPEX on decentralized operations.
- **Decentralized Footprint:** Scattered production hubs hinder centralized collection and enforcement.

2. REGULATORY FRAMEWORK & WASTEWATER CHARACTERISTICS

Under Indonesian MoEF Regulation No. 5/2014, commercial operations must comply with statutory effluent thresholds prior to environmental discharge.

Wastewater Source	Primary Contaminants	Typical Untreated Baseline	MoEF No. 5/2014 Standard
Tofu & Tempeh Production	Protein, starch, high BOD/COD, acidic pH	pH 4.0–5.5; BOD > 1,500 mg/L; COD > 3,000 mg/L	BOD ≤ 150 mg/L; COD ≤ 300 mg/L; pH 6.0–9.0
Apparel & Dye Workshops	Synthetic dyes, heavy metals, surfactants, TSS	Elevated TSS; high turbidity; synthetic organics	TSS ≤ 100 mg/L; neutral pH
Palm Oil / Food Processing	Free fatty acids, oils, grease, suspended solids	High lipid concentration; elevated COD	Oils & Grease ≤ 10 mg/L

3. INTEGRATED SOLUTION & METHODOLOGY

IoT Monitoring Subsystem

- **Hardware Instrumentation:** Submersible pH glass electrodes, optoelectronic turbidity (TSS) sensors, and conductive TDS probes driven by ESP32/Arduino microcontrollers.
- **Telemetry & Edge Logic:** Continuous data logging via GSM/NB-IoT or LoRaWAN. Runs comparison logic against MoEF thresholds to trigger instant automated webhooks during deviations.

Bio-Phytoremediation & Aquaponics Subsystem

- **Phytoremediation Basins:** Retention lagoons with native macrophytes (*Echinodorus palaefolius* and *Ipomoea aquatica*) to absorb nitrates/phosphorus and accelerate BOD/COD reduction.
- **Budikdamber Integration:** Catfish (*Clarias gariepinus*) aquaponics convert residual organics into bioavailable plant nutrients.

4. FEASIBILITY, SDG ALIGNMENT, AND CONCLUSION

Key System Advantages

- **Affordability & Scalability:** Uses open-source hardware and local flora; scalable from 200L drum units to multi-tier factory systems.
- **Compliance Logging:** Generates verifiable time-series data for regulatory reporting and environmental audits.

Sustainable Development Goals (SDGs)

- **SDG 6 (Clean Water):** Prevents point-source pollution of local river basins.
- **SDG 12 (Responsible Production):** Equips MSMEs with viable circular treatment.
- **SDG 13 (Climate Action):** Enables closed-loop graywater reuse.

Conclusion: Combining affordable IoT telemetry with natural wetland flora provides Depok with an actionable, scalable paradigm for urban watershed restoration while maintaining local business viability.

REFERENCES

1. Indonesian Minister of Environment and Forestry Regulation No. 5 Year 2014 concerning Wastewater Quality Standards.
2. Undhira Research Journal: Phytoremediation Efficiency of Water Spinach (*Ipomoea aquatica*) in Domestic/Agricultural Wastewater.
3. UNY Scientific Journal: Study on Water Spinach and Wetland Macrophytes as Wastewater Phytoremediators.
4. United Nations Sustainable Development Goals: Goal 6: Clean Water and Sanitation.

Technology for Hydroponic Monitoring and Cultivation (TUMBUH) Based on Artificial Intelligence

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Purpose and Background

Indonesia is an agrarian country, yet urban farmland keeps shrinking as land is converted to industry and housing. IoT-based hydroponics, such as the Nutrient Film Technique (NFT), allows crops to be grown in narrow spaces such as rooftops and balconies while crucial parameters (TDS, temperature, pH) are monitored remotely. Earlier work such as HIPOI 1.0 (Musayyanah et al., 2023) monitors lettuce environments with an ESP32 but offers no visual plant analysis, while deep-learning disease detection (Chen et al., 2023) needs large datasets and computing capacity that simple hydroponic setups lack. This study designs TUMBUH, a low-cost IoT hydroponic system for lettuce that (1) monitors pH, TDS and temperature in real time, (2) uses lightweight computer vision for early detection of fungal, bacterial and viral infection, and (3) lets users control actuators remotely through a web page.

Materials and Methods

An ESP32 microcontroller with Wi-Fi reads a DHT11 temperature sensor, a DFRobot Sen0244 analog TDS sensor (0–1000 ppm, ±10% F.S.) and a pH-4502C module (pH 0–14), chosen for low cost and 3.3–5.5 V compatibility. TDS is estimated from electrical conductivity using an empirical factor of 0.55–0.8. When temperature reaches the user-set optimum, an 8×8 cm 12 V DC fan switches on; TDS above the optimum triggers fresh-water dilution and below it triggers AB-mix nutrients; pH at or below the optimum triggers base and above it triggers acid. A USB camera sends images to an external computer running a MobileViT classifier (Mehta & Rastegari, 2022) trained for 10 epochs on lettuce images (healthy, fungal, bacterial, viral), and an Ollama-based chatbot gives care advice. The prototype measures 30×30×33 cm with 2-inch pipe and UV-plastic walls. Optimal lettuce ranges are 20–25 °C (Zulfarosda et al., 2020), pH 6.0–7.0 and 560–840 ppm (Farmee, 2023).

Results and Discussion

The TUMBUH 1.0 web dashboard shows real-time ppm, pH and temperature (updated every 30 minutes), allows users to add nutrients, acids, bases, or fresh water, operate the fan, and set minimum and maximum limits per growth phase with lettuce recommendations, raises beep and pop-up alerts outside the ideal range, plots historical data, and reports AI disease detections. A power analysis shows the system could run on a 100 W solar panel: it needs 0.075 kWh/day (Table 1), while the panel yields about 0.5 kWh/day in the dry season and 0.25 kWh/day in the rainy season in Bandung. The prototype currently still uses mains power during development.

Table 1. Daily energy demand of TUMBUH 1.0

Component	Power (W)	Run time (h/day)	Energy (Wh/day)
ESP32 microcontroller	0.825	24	19.8
12 V DC fan	2.4	8	19.2
Nutrient circulation pump	6	6	36
Total	**9.225**	**–**	**75 (0.075 kWh)**

REFERENCES

Chen, X., Wang, Y., Zhang, H., & Li, R. (2023). Deep learning-based plant disease detection in hydroponic systems. Frontiers in Plant Science, 14, 1227011.

Farmee. (2024). Tabel pH dan PPM tanaman hidroponik. https://farmee.id/tabel-ph-dan-ppm-tanaman-hidroponik/

Mehta, S., & Rastegari, M. (2022). MobileViT: Light-weight, general-purpose, and mobile-friendly vision transformer. arXiv. https://arxiv.org/abs/2110.02178

Musayyanah, M., Harianto, H., Adrianto, Y. R., & Budiardjo, H. (2023). Sistem HIPOI 1.0: Hidroponik indoor berbasis Internet of Things untuk tanaman selada dengan teknik NFT. Jurnal Electron, 5(1), 1–8.

Zulfarosda, R., Purnamasari, R. T., & Julaikha, S. (2020). Pengaruh variasi kelat pupuk mikro Fe terhadap pH larutan nutrisi dan berat tanaman selada. Jurnal Ilmiah Hijau Cendekia, 5(1), 12–17.

Programming Language Differences in Code Generation Cost Using a Local LLM

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Purpose and Background

Programming language choice may affect the output length and generation time of a local large language model (LLM). This study compared output token count, total decoding time, and time per token across seven languages to distinguish differences in output quantity from differences in decoding speed.

Materials and Methods

Llama 3.1 8B ran on a laptop CPU (Intel Core i7-1355U, 16 GB RAM, Windows 11). Thirty tasks were generated in Python, JavaScript, TypeScript, Java, C++, Haskell, and Clojure, with five repetitions in each of six sessions (6,300 generations). Task-language order was randomized by session. Time per token was total decoding time divided by output token count. For each task-language pair, the median of five repetitions was calculated within each session, followed by the median across sessions. The 210 values were compared using the Friedman test (Friedman, 1937), matching 30 tasks. Pairwise comparisons used Wilcoxon signed-rank tests with Holm correction across 21 pairs per metric ($\alpha = .05$).

Results and Discussion

Output token count and total decoding time differed significantly among languages (Table 1), with 16 of 21 corrected pairwise comparisons significant for each metric. Language-level medians ranged from 63.00 tokens and 10.28 s for Haskell to 125.00 tokens and 20.51 s for Java. Median time per token ranged from 162.58 to 165.60 ms/token, with no significant overall or corrected pairwise difference. Under these conditions, differences in total decoding time may be related to output quantity; causation and equal decoding speeds are not established. Results are limited to this model, CPU environment, and task set. Both correct and incorrect outputs were included; future work will jointly assess correctness and generation cost.

Table 1. Friedman test results across 30 matched tasks.

Metric	χ^2 (df = 6)	p	Kendall's W
Output token count	108.311	4.60×10^{-21}	0.602
Total decoding time	103.986	3.69×10^{-20}	0.578
Time per token	7.329	0.292	0.041

REFERENCES

Friedman, M. (1937). The use of ranks to avoid the assumption of normality implicit in the analysis of variance. Journal of the American Statistical Association, 32(200), 675–701. https://doi.org/10.1080/01621459.1937.10503522

RHIZOFIREWALL: Intercepting Phytophthora capsici Zoospores Using Moisture-Responsive Biodegradable Decoy Granules in Vanilla Plants

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Purpose and Background

Vanilla cultivation is severely threatened by Phytophthora capsici, a pathogen spreading via motile zoospores that use chemotaxis to infect host roots, causing sudden wilt. Conventional fungicides are ineffective as Phytophthora cell walls lack chitin. This study evaluates RHIZOFIREWALL, a preventive system using 2-4 mm moisture-responsive decoy granules. Applying an "Attract-Trap-Control" mechanism, these granules release chemoattractants (e.g., glutamic acid) to divert zoospores from vanilla roots. A prototype Precision Applicator Machine for bilateral root-safe zone (2-3 cm) deposition is also tested.

Materials and Methods

An in-vitro experimental design simulated the vanilla rhizosphere using P. capsici zoospores, vanilla root exudates (positive control), and RHIZOFIREWALL granules (alginate, chitosan, glutamic acid). Three tests were conducted: (1) Moisture Activation: measuring hydration and chemoattractant release across varying soil moisture levels; (2) Chemotaxis and Interception Assay: tracking zoospore migration and encystment between root exudates and decoy granules over 2 hours; (3) Applicator Machine Precision Test: evaluating bilateral distribution accuracy within the safe zone using 20 insertions on loose soil.

Results and Discussion

RHIZOFIREWALL successfully manipulated P. capsici navigation. Within 2 hours, 87% of zoospores actively migrated toward the granules instead of actual root exudates, undergoing forced encystment to break the infection cycle. The moisture response test confirmed granules remained dormant at <40% moisture and activated at >80% moisture, preventing premature degradation in the field. Furthermore, the Precision Applicator Machine achieved 96% accuracy, placing granules exactly 2.5 cm from the main root with uniform bilateral distribution, ensuring the safety of roots and mycorrhizae.

Variable/Indicator	Result	Description
Migration to Root (Pos. Control)	92%	Pathogens successfully located the host.
Migration to Granule (RHIZOFIREWALL)	87%	Granules successfully deceived pathogens.
Granule Encystment Rate	95%	Approaching zoospores were effectively immobilized.
Root Protection Rate	98%	Decoys intercepted pathogens before infection.
Applicator Precision	96%	Precise placement (<0.5 cm deviation).

Table 1. Efficacy Evaluation of P. capsici Zoospore Interception

REFERENCES

Appiah, A. A., van West, P., Osborne, M. C., & Gow, N. A. (2005). Potassium homeostasis influences the locomotion and encystment of zoospores of plant pathogenic oomycetes. Fungal Genetics and Biology, 42(3), 212-223.

Tyler, B. M. (2002). Molecular basis of recognition between Phytophthora pathogens and their hosts. Annual Review of Phytopathology, 40(1), 137-167.

Sustainable Green Mussel (*Perna viridis*) Depuration Using Agricultural-Waste Bio absorbents for Microplastics Reduction: A Comparative Study Supporting SDGs 3, 9 and 12

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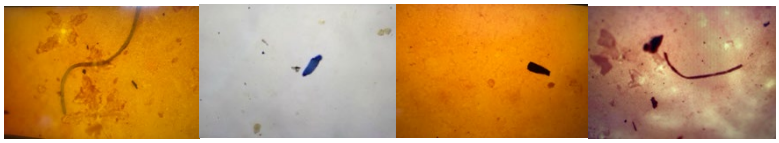
Purpose and Background:

Cirebon city is a small coastal city that is famous for its aquaculture industry. Previous studies show that microplastic contamination across five sides of Cirebon beaches reveal that the average of microplastic contamination reach 166-583 particle per kilogram (Ratu and Utami, 2025). Green mussels have a higher risk of contamination because of its nature as a filter feeder. Depuration for mussels commonly uses treated seawater and ultraviolet system, but existing literature show that adding biochar can help efficiency of depuration to coagulate microplastics (Daud et al., 2025). Therefore, this study aims a comparative study between rice husk and coconut husk biochar to determine the most effective biochar to maximize depuration process of green mussels.

Materials and Methods:

The green mussels were taken from the Bondet River Mouth, Cirebon Regency. Each depuration method was applied for 72 hours, with the same salinity (35‰), oxygen treatment, and at a temperature of 30°C. All three sample was treated with the standard depuration procedure a, with the addition of rice husk biochar and with coconut husk biochar added. After depuration, the mussels were submerged in a 20% KOH solution for 72 hours, with each sample was added up to three times of the mussel's weight. Then added a concentrated solution of NaCl (1,2 gram/cm^3) for 24 hours to float the microplastic particles then further analysis under the microscope to locate the microplastics.

Results and Discussion



Our research found that the abundance of microplastic in mussels who went through depuration without added biochar were 47,5 particles/gram, with added 5 grams of rice husk biochar were 35,75 particles/gram. And lastly, with added 5 grams of coconut husk biochar were 17,4 particles/gram. This means that coconut husk biochar works better to maximize mussel's depuration process in eliminating microplastic contamination under its body. Overall, biochar has shown a very promising quality and potential to be utilized to contribute into mitigating microplastic contamination in green mussels (*Perna viridis).*

REFERENCES

Daud, A., Birawida, A.B., Ambeng, A., Sila, N., Putro, G. (2025). Depuration of mussels (Pilsbryoconcha exilis) from microplastics using banana peel adsorbents in coastal areas of Indonesia. *Journal of Water and Development, Volume 64, 113—114.*

Ratu, K.A., Utami, D.A. (2026). Microplastic Pollution in Beach Sediments Influenced by Fishing and Tourism in Cirebon, Indonesia. Riset Geologi dan Pertambangan, Volume 36, 1—2.

Sugianto, A., Suryandari, A., Afidah, P.N., Sari, A., Buwono, N.R., Hartati, R., Payus, C.M. (2025). The characteristics of microplastics and the associated metals on the surfaces of microplastics in green mussels (Perna viridis) collected from different water depths in the Bekasi Estuary, West Java, Indonesia*. Environmental Advances, Volume 20, 2—3.*

Yunanto, A., Sarasita, D., Yona, D. (2021). Analisis Mikroplastik Pada Kerang Kijing (*Pilsbryoconcha exilis*) di Sungai Perancak, Jembrana, Bali. *Journal of Fisheries and Marine Research Vol 5(2), 445-451.*

A Study on Stingless Bee Farming and Honey Properties: A Case Study of Rai Saen Rak, Koh Lat E-Tan Community, Sam Phran District, Nakhon Pathom Province

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Purpose and Background

Stingless bees are widely recognized for their ecological and economic value, particularly regarding honey properties and natural pollination. However, despite their local presence, community members often lack proper management knowledge, leading to underexploited resources or neglect. This study was inspired by observations within our neighborhood and further developed through the Community Engagement Program (CEP) at the local learning center of Koh Lat E-Tan, located near our school, where an active stingless bee farm integrated with organic agriculture was discovered. Therefore, the purpose of this research is to investigate the management practices for raising stingless bees at Koh Lat E-Tan, identify the vegetation serving as key food sources in the area, and evaluate the physical and chemical characteristics of local stingless bee honey based on reference standards and previous literature to provide foundational data for local awareness and future agricultural applications.

Materials and Methods

To achieve these objectives, the study was structured into three main steps. First, a local orchard at Koh Lat E-Tan, managed by local expert Mr. Prathom Pho Daeng and housing over 200 stingless bee colonies, was selected as the primary study site. Second, primary data were collected through interviews with the local expert and a botanical survey of food plants within a 300-meter radius. Finally, reference standards and previous research data from Duangphakdee et al. (2010) were reviewed to evaluate the honey properties.

Results and Discussion

The findings from the study at the local learning center, Koh Lat E-Tan, reveal three key aspects. First, regarding farming and management, the local orchard successfully maintains over 200 stingless bee colonies using traditional wisdom combined with organic agricultural practices, focusing on natural colony splitting, proper hive shading, and resin (propolis) management. Second, for floral food sources, the 300-meter radius survey identified a diverse year-round supply of nectar and pollen plants, such as fruit trees and local wildflowers, which sustain the colonies continuously. Third, concerning honey properties, Duangphakdee et al. (2010) and Santos et al. (2021) indicate that local stingless bee honey exhibits a unique, slightly tangy flavor profile rich in antioxidants and antibacterial qualities (Santos et al., 2021), highly influenced by the diverse local flora. These results highlight that integrating traditional bee-rearing knowledge with organic farming not only supports local biodiversity (SDG 15) and sustainable production (SDG 12) but also provides a valuable educational framework to strengthen community livelihoods (SDG 8).



Overview of the study at the local learning center in Koh Lat E-Tan: (from left to right) stingless bee hive inspection, traditional hive structure, surrounding floral food sources (nectar and pollen plants), field survey with the local expert, and harvested local stingless bee honey products.

REFERENCES

Duangphakdee, O., Rodim, P., Phiancharoen, M., & Chomphupan, S. (2010). *The study of stingless bee keeping for medicinal honey production and the biologically active compounds from its products*. King Mongkut's University of Technology Thonburi.

Santos, A. C., Biluca, F. C., Braghini, F., Gonzaga, L. V., Costa, A. C. O., & Fett, R. (2021). Phenolic composition and biological activities of stingless bee honey: An overview based on its aglycone and glycoside compounds. *Food Research International*, *147*, 110553. https://doi.org/10.1016/j.foodres.2021.110553

THE EFFECTIVENESS OF BLACK SOLDIER FLY LARVAE IN ENHANCING LIVESTOCK PRODUCTION

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Purpose and Background

The rising cost of conventional feed ingredients is a major challenge for livestock farmers. Global fishmeal prices increased by over 62% between the second quarter of 2025 and the second quarter of 2026, while soybean meal prices fluctuated between about USD 284 and 318 per metric ton over the same period (IMF, 2026). Both ingredients also carry environmental costs, including land use change from soybean production and overfishing linked to fishmeal (Vatsanidou et al., 2025). Black Soldier Fly (BSF) *(Hermetia illucens)* larvae contain 32 to 53% protein (Lu et al., 2022) and can process organic waste, which makes them a potential alternative feed source. However, their effectiveness under field conditions still needs to be tested.

Materials and Methods

This study used a descriptive case study at the BSF Maggot Farm in Maleer, Bandung, Indonesia. Data were collected through direct observation and interviews with the farm manager during a visit in October 2026. The farm produces 300 to 500 kg of maggots per month, allocated to internal breeding (50%), livestock feed (25%), and commercial sales (25%). An AI-based prediction model (GPT-4o) was used to estimate the monthly feed requirement per 100 birds or 1,000 fish and the expected effects on body weight, egg count, and product quality. Predictions were compared with field observations in a qualitative comparison, because the farm does not track headcount per species and the livestock were still in the early raising phase.

Results and Discussion

Table 1 compares the AI predictions with the field data. The effectiveness of BSF larvae in enhancing livestock production remains inconclusive, because the livestock are still in the early growth phase and weight or egg production cannot yet be measured. The AI model predicted no significant increase in body weight or egg count, and the farm manager observed no noticeable change. The model also predicted higher meat protein, eggshell thickness, and yolk color, and the farm manager expects better quality, but laboratory testing is needed to verify this. For now, BSF larvae serve as a feed supplement rather than the main determinant of production outcomes. Beyond feed performance, commercial adoption of BSF larvae at Maleer Maggot House is hampered by three obstacles: high buyer volatility driven by hobbyist consumers, market price distortions caused by seasonal producers, and the lack of a connected supply chain between BSF larvae producers and large-scale livestock farmers.

Table 1. *AI Predictions Compared with Field Data on BSF Larvae Feeding*

Parameter	AI Predictive Model	Field Data
Maggot feed amount	Poultry: 33 to 50 kg/month per 100 birds. Catfish: 22 to 30 kg/month per 1,000 fish	125 kg/month for catfish, layers, and broilers combined
Body weight and egg count	No significant increase compared with standard commercial feed	No noticeable change observed
Product quality	Significant increase in meat protein, eggshell thickness, and yolk color	Improvement expected by farm manager, not yet tested in a laboratory

REFERENCES

International Monetary Fund. (2026). *Global price of fish meal* [PFISHUSDQ] [Data set] and *Global price of soybean meal* [PSMEAUSDQ] [Data set]. FRED, Federal Reserve Bank of St. Louis. Retrieved October 24, 2026, from https://fred.stlouisfed.org/series/

Lu, S., Taethaisong, N., Meethip, W., Surakhunthod, J., Sinpru, B., Sroichak, T., Archa, P., Thongpea, S., Paengkoum, S., Purba, R. A. P., & Paengkoum, P. (2022). Nutritional composition of black soldier fly larvae (*Hermetia illucens* L.) and its potential uses as alternative protein sources in animal diets: A review. *Insects, 13*(9), Article 831. https://doi.org/10.3390/insects13090831

Vatsanidou, A., Konstantinidi, S., Bonos, E., & Skoufos, I. (2025). Comparative life cycle assessment of animal feed formulations containing conventional and insect-based protein sources. *AgriEngineering, 7*(9), Article 275. https://doi.org/10.3390/agriengineering7090275

The Effect of the Construction of Myoden Bridge on Avifauna in Edogawa Discharge Channel and the Situation 7 Years After Its Opening

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Purpose and Background

Myoden Bridge was built to improve access to the Tokyo Gaikan Expressway. Chiba Prefecture initiated the project in 2004; substructure construction began in 2009, superstructure construction in 2014, and the bridge opened in 2019. The prefecture's wildlife monitoring report (1998–2020) found no conspicuous overall changes in bird species numbers or counts before and after construction, although temporary behavioral changes and declines in some species were observed. The report also noted regional declines in flying-bird numbers across Tokyo Bay (Chiba Katsunan Civil Engineering Office & IDEA Consultants, 2021). I therefore reanalyzed the monitoring data statistically and conducted a follow-up survey in 2025–2026, approximately seven years after the bridge opened. I hypothesized that bird counts would decline during construction and gradually recover after opening.

Materials and Methods

Reanalysis: Monitoring counts were modeled in R with negative binomial generalized linear models (GLMs) for the periods before and after a selected time boundary, because the data were overdispersed. Inputting species, time boundary and season (which accounts for seasonal differences) gives a p-value for the before/after difference. The direction of change was determined for species that were possible from the coefficient or the pivot point of the trend. Comparison: I collected data from August 2025 to July 2026 using line censuses along predetermined routes at a set walking speed. I used R for statistical analysis and QGIS for geographic analysis. I compared the recent survey with the 1998–2020 monitoring data using negative binomial GLMs that included period and season. The abundance ratio (2025–2026 / 1998–2020) and its 95% confidence interval (CI) were estimated while accounting for seasonal differences. Comparisons were limited by differences in survey methods and tidal coverage: the historical survey used point censuses at low, middle, and high tide, whereas my survey used line censuses at low tide only.

Results and Discussion

The historical before/after GLMs identified several tests with unadjusted p-values below 0.05 around construction milestones. In the separate breakpoint-and-slope analysis, 8 of the 11 species showed decreasing trends and 3 showed increasing trends (Table 1). These patterns suggest species-specific changes in bird counts, but do not prove that construction caused them. The results of multiple tests should be interpreted cautiously because multiple-comparison correction was not applied. In the comparison of 2025–2026 with 1998–2020, 7 of 15 species had estimated abundance ratios with 95% confidence intervals entirely below 1. For the other 8 species, the confidence intervals included 1, so a clear difference in estimated abundance was not detected. The results did not establish a general recovery in bird abundance. The observed patterns may also reflect regional population trends and differences in survey methods and tidal conditions. Future work will examine bird counts by distance from the bridge and compare regional trends to help distinguish local changes from broader population changes.

Table 1. Species with changes detected in each analysis.

Analysis	Change	Species
Historical reanalysis	Decrease trend (8)	*Grey-tailed Tattler, Terek Sandpiper, Dunlin, Lesser Sand Plover, Black-tailed Gull, Little Tern, Black-headed Gull, Eurasian Wigeon*
Historical reanalysis	Increase trend (3)	*Eurasian Oystercatcher, Eurasian Coot, Black-necked Grebe*
2025–2026 vs. 1998–2020	Lower estimated abundance (7)	*Whimbrel, Black-tailed Gull, Grey-tailed Tattler, Ruddy Turnstone, Great Cormorant, Dunlin, Common Pochard*
2025–2026 vs. 1998–2020	No clear difference detected (8)	*Eurasian Oystercatcher, Black-necked Grebe, Red-breasted Merganser, Greater Scaup, Eurasian Coot, Northern Pintail, Great Crested Grebe, Little Egret*

REFERENCES

Chiba Katsunan Civil Engineering Office, & IDEA Consultants, Inc. (2021). *Myōden-bashi shinsetsu ni tomonau monitaringu chōsa kekka hōkokusho* [Monitoring survey results report for the construction of Myoden Bridge].

Application of Robotics in Post-Injury Rehabilitation for the Elderly: Design, Kinematic Performance, and Clinical Efficacy

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Introduction:

Post-injury mobility loss in elderly individuals leads to rapid muscle atrophy, extended hospital stays, and severe loss of daily independence. Globally, over 37 million elderly fall injuries require medical care annually (World Health Organization data), while specialized physical therapy faces a 40% specialist shortage in senior care bandwidth. Traditional rehabilitation equipment is prohibitively expensive ($15,000–$80,000+) and lacks portable, home-based accessibility. The purpose of this study is to formulate a lightweight (<3kg), cost-effective robotic exoskeleton providing high-dosage, adaptive biofeedback therapy tailored for geriatric motor recovery and safe ambulation assistance.

Research Method:

This study implements a closed-loop control and biofeedback architecture consisting of three primary layers: (1) a sensory acquisition layer utilizing surface Electromyography (sEMG) muscle sensors with <15ms latency and dual 6-axis IMUs running at 200Hz on the thigh and shank frames coupled with foot pressure insoles for continuous gait tracking; (2) an adaptive AI control unit powered by an ESP32 microcontroller executing an impedance control algorithm to calculate exact dynamic torque based on the patient's remaining muscle strength; and (3) robotic actuation utilizing a 24V planetary gear brushless DC (BLDC) motor delivering 35 Nm of smooth, back-drivable joint assistance. The mechanical structure features an ultra-lightweight (<2.8 kg) 3D-printed carbon-fiber PETG composite exoskeleton frame designed through additive manufacturing. Clinical testing and kinematic evaluation were conducted across a cohort of 24 subjects over a 6-week intervention period.

Findings:

Clinical evaluation of the prototype demonstrated statistically significant motor recovery improvements across all primary metrics compared to standard therapy. Key outcomes include a 42% improvement in gait symmetry and a 35% reduction in metabolic energy strain, enabling patients to train twice as long per session without exhaustion. Furthermore, patients achieved a walking speed progression from a baseline of 0.42 m/s to 1.18 m/s at week 6, successfully reaching the community ambulation threshold (>0.8 m/s) required for independent living two weeks faster than the control group. Economic analysis of the Bill of Materials revealed a total prototype fabrication cost of $295.00 USD, representing a ~98% cost reduction compared to commercial clinical systems.

Table 1. Bill of Materials and prototype cost breakdown for the lower-limb robotic exoskeleton.

No	Component	Specification & Material	Qty	Unit / Total Cost
1	Brushless DC Gear Motors	24V BLDC with 10:1 Planetary Gearbox	2	$85.00 / $170.00
2	3D Structural Frame	Carbon PETG High-Density Print	1 set	$45.00 / $45.00
3	Microcontroller & Sensors	ESP32 + Dual 6-DOF IMUs + sEMG	1 set	$32.00 / $32.00
4	Power & Battery Pack	24V 5000mAh High-Discharge LiPo	1 pack	$28.00 / $28.00
5	Hardware & Straps	Medical neoprene, fasteners	1 set	$20.00 / $20.00

Discussion and Conclusion:

The findings confirm that adaptive, low-cost robotic assistance significantly accelerates gait recovery in elderly patients while substantially reducing physical strain on clinical therapists and expanding healthcare access in resource-limited settings. System reliability was validated through 50,000 continuous cyclic motion stress tests without frame deformation or torque degradation, and integrated safety kill-switches disengage in under 10 ms. Future work will focus on longitudinal clinical trials across larger geriatric populations and refining cloud-based tele-rehabilitation monitoring.

REFERENCES

[1] World Health Organization. (2024). World Report on Ageing and Health. Geneva: World Health Organization.

[2] Smith, J. A., & Lee, K. T. (2021). The impact of green spaces on urban well-being: A cross-national study. Journal of Environmental Psychology, 75, 101593.

[3] Journal of NeuroEngineering and Rehabilitation. (2025). Cost analysis and additive manufacturing in robotic exoskeletons for geriatric rehabilitation. JNER, 22(1), 45-58.

Non-Contact Smart Bed for Respiratory Monitoring

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Purpose and Background

Continuous bedside observation can be difficult for caregivers. This project developed an under-mattress prototype to monitor bed occupancy and motion potentially associated with respiration, and to provide remote caregiver alerts. This work focused on engineering prototype development without human testing. Clinical diagnosis requires validated sleep testing (Kapur et al., 2017).

Materials and Methods

Six force-sensitive resistors (FSRs) were arranged beneath the mattress in shoulder, chest, and hip/leg zones. A piezoelectric sensor with MCP6002 signal conditioning supplemented motion sensing. Two ADS1115 16-bit analog-to-digital converters acquired sensor signals (Texas Instruments, 2024). A bedside ESP32 processed minimum signal values and peak-to-peak amplitude (Vpp) within approximately 3-second windows. The documented decision logic classified an empty bed when the minimum feature was ≥12,000; otherwise, Vpp ≥300 indicated occupancy with detectable motion. Vpp <300 across two consecutive windows (approximately 6 seconds) triggered a low-motion alert. These are prototype signal thresholds, not physiological criteria.

Status messages were published via MQTT to a Raspberry Pi hub approximately every 3 seconds. The hub supported SQLite storage, a Flask dashboard, and Google Sheets synchronization every 5 minutes. A caregiver ESP32 subscribed to status messages and controlled LEDs and a buzzer. Alerts remained latched until manual reset. Communication loss exceeding 10 seconds was configured to trigger an alert. Evaluation was limited to prototype development and documented control functions. No testing involving human participants or patients was conducted.

Results and Discussion

The engineering outcome was an integrated prototype architecture combining under-mattress sensing, wireless status transmission, and caregiver notification. Table 1 summarizes its documented control functions, not results from human testing. Clinical respiratory recordings, diagnostic accuracy, and patient outcomes were not evaluated. The approximately 6-second interval is a configured decision window, not a measured clinical response time. Threshold calibration for different mattresses and signal-processing verification remain necessary. Motion artifacts and continuing respiratory effort during airway obstruction may limit interpretation. Accordingly, this work does not establish clinical apnea detection, mortality reduction, or reduced caregiver workload. Future work should first quantify performance using controlled non-human mechanical inputs and communication-failure tests, followed by ethically approved human validation against reference respiratory measurements.

Table 1. Documented prototype status logic and caregiver outputs

Input condition or state	Configured output
Empty-bed state	Yellow LED
Occupied state with detectable motion	Green LED
Low-motion or bed-exit alert condition	Red LED and buzzer
Motion signal returns after an alert	Alarm retained until manual reset

REFERENCES

[1] Kapur, V. K., Auckley, D. H., Chowdhuri, S., Kuhlmann, D. C., Mehra, R., Ramar, K., & Harrod, C. G. (2017). Clinical practice guideline for diagnostic testing for adult obstructive sleep apnea: An American Academy of Sleep Medicine clinical practice guideline. *Journal of Clinical Sleep Medicine, 13*(3), 479–504. https://doi.org/10.5664/jcsm.6506

[2] Texas Instruments. (2024). *ADS111x ultra-small, low-power, I2C-compatible, 860SPS, 16-bit ADCs with internal reference, oscillator, and programmable comparator* (Rev. E) [Data sheet]. https://www.ti.com/lit/ds/symlink/ads1115.pdf

NEUROPLAY: A COMPUTER VISION-BASED GAMIFIED PLATFORM FOR THE ASSESSMENT AND REHABILITATION OF LEARNED NON-USE IN STROKE SURVIVORS

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Purpose and Background:

Up to 80% of acute stroke survivors experience persistent upper-limb motor deficits. Without engaging continuous biofeedback, over 70% of home patients abandon their rehabilitation regimens within three months. This behavioral suppression leads to the "Learned Non-Use" cycle, where patients over-rely on their unaffected arm, causing an irreversible loss of neuroplastic potential. Traditional robotic rehabilitation is highly effective but prohibitively expensive for rural communities. The purpose of this project is to develop "NeuroPlay", a zero-cost hardware, webcam-driven physical therapy platform that transforms therapeutic motor exercises into engaging clinical gameplay to overcome learned non-use and democratize neurorehabilitation.

Materials and Methods:

The platform was developed as a client-side web application to ensure universal access without specialized sensors. The system utilizes a standard RGB webcam to capture patient movements. Google's MediaPipe Hands AI model, running via WebAssembly, extracts 21 3D hand keypoints in real-time. To address camera jitter while preserving pathological tremor data, a dual exponential low-pass kinematic filter was integrated. The gamified physics engine, built using HTML5 Canvas, structures a curriculum of 9 progressive physical therapy levels based on motor relearning theory. Furthermore, an AI-driven hand detection system with countdown timers strictly validates the target arm, effectively preventing compensatory cheating movements.

Results and Discussion:

NeuroPlay successfully replaces opaque AI diagnostic black-boxes with transparent, quantitative kinematic biofeedback. During simulated testing, the system accurately tracked hand movements and calculated essential clinical telemetry, including Movement Smoothness (using normalized jerk) and Active Spatial Reach Envelope (percentage of workspace accessed). The system successfully differentiates between the left and right arm, providing a Bilateral Asymmetry Index to directly screen for learned non-use. Additionally, the platform features a Zero-Hardware Demo Mode and elderly accessibility designs (3-tier font scaler, bilingual interface). Figure 1 illustrates the system's ability to operate seamlessly via a browser, merging patient gamification with clinical reporting.

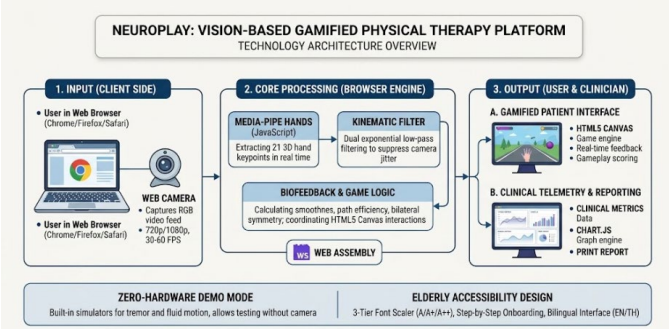

Figure 1. Technology architecture of the NeuroPlay platform demonstrating client-side processing.

REFERENCES

Balasubramanian, S., Melendez-Calderon, A., Roby-Brami, A., & Burdet, E. (2015). On the analysis of movement smoothness. Journal of NeuroEngineering and Rehabilitation, 12(1), 112.

Taub, E., Uswatte, G., Mark, V. W., & Morris, D. M. (2006). The learned nonuse phenomenon: Implications for rehabilitation. Eura Medicophys, 42(3), 241-256.

Longa Chewie: An Innovative Orthodontic Chew Stick Made from Natural Rubber Reinforced with Longan Extract

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Purpose and Background

Orthodontic chewies help improve clear aligner seating, but commercial products are often imported and made from synthetic polymers. Thailand's abundant natural rubber and longan agricultural by-products offer opportunities to develop locally sourced alternatives. Longan seeds and pericarps contain bioactive compounds with potential antibacterial properties. This study aimed to develop a natural rubber-based orthodontic chewie incorporating longan extracts as a value-added dental material.

Materials and Methods

Longan extracts were screened for phenolics, tannins, and antibacterial activity against *S. mutans*. Sixteen natural rubber (NR) and deproteinized natural rubber (DPNR) formulations were prepared with varying extract contents and additives. Prototypes were compared with a commercial chewie for Shore A hardness, compressive strength, antibacterial activity and preliminary cytotoxicity.

Results and Discussion

Both longan extracts tested positive for phenolic compounds and tannins. The seed extract showed MIC and MBC values of 6.25%, while the pericarp extract showed corresponding values of 7.5%, indicating bactericidal activity against *S. mutans* under the experimental conditions.

Figure 1. Longa Chewie



Table 1. Summary of experimental results

Parameter	Longa Chewie prototypes	Commercial chewie
Shore A hardness	24.50–41.88	46.50
Compressive Strength	Four prototypes showed markedly higher values.	Relatively high
Antibacterial activity	Observed in several formulations	No inhibition observed
Cytotoxicity	Two formulations performed best; several others showed favorable results	Favorable results

Several prototypes showed promising mechanical properties, with hardness values approaching those of the commercial chewie and superior compressive resistance in four formulations. Antibacterial activity was observed in several prototypes, including some without longan extracts. Preliminary cytotoxicity testing showed favorable results for selected formulations, although clinical safety remains unconfirmed. Overall, Longa Chewie demonstrates the potential to transform Thai natural rubber and longan by-products into a value-added orthodontic material. Further studies on durability, biocompatibility and clinical effectiveness are required.

REFERENCES

Pichayakorn, W., Suksaeree, J., Boonme, P., Taweepreda, W., & Ritthidej, G. C. (2012). Preparation of deproteinized natural rubber latex and properties of films formed by itself and several adhesive polymer blends. *Industrial & Engineering Chemistry Research, 51*(41), 13393–13404. https://doi.org/10.1021/ie301985y

Wang, M., Chen, T., Wang, Q., & Shi, Y. (2023). Antioxidant, bacteriostatic and preservative effects of extractable condensed tannins isolated from longan pericarps and seeds. *Plants, 12*(3), Article 512. https://doi.org/10.3390/plants12030512

Utilization of Lemongrass *(Cymbopogon citratus)* in the Formulation of an Anti-Mosquito Lotion

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Purpose and Background:

Dengue fever remains a major public health concern worldwide, especially in tropical regions such as Indonesia. According to Indonesia's Ministry of Health, approximately 130,000 cases were reported in Indonesia in 2025. Although various mosquito-control measures have been implemented, dengue transmission remains a concern. Developing an accessible, plant-based topical formulation may offer another approach to reducing mosquito contact. The objective of this research is to formulate a lemongrass-based preparation and observe mosquito landing behaviour following its application.

Materials and Methods:

To achieve the desirable viscosity of the Lotion, the use of shea butter and olive oil are necessary. A pH test was done by taking a 0.5 gram sample of the lotion and dissolving it in distilled water[1]. An irritation test was conducted by applying the lotion onto volunteers and observing for 15 minutes for any signs of irritation, Any visible redness, itching, or other reactions were recorded[2]. An observation is then done by applying the lotion onto a volunteer and observing the mosquitoes' reaction.

Results and Discussion:

Table 1. Comparison of pH

N/A	Formulation			SNI STANDARD
	Control	Filtered	Non Filtered	
pH Level	6	5	5	4,5 - 8

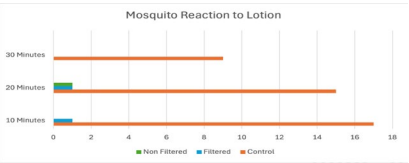
The control formulation had a pH of 6, while both filtered and non-filtered formulations had a pH of 5. All three formulations were within the SNI skin-pH range of 4.5–8.

Table 2. Results of skin irritation test

Volunteer	Formulation		
	Control	Filtered	Non Filtered
1	(-)	(-)	(-)
2	(-)	(-)	(-)
3	(-)	(-)	(-)

Based on these observations, all three formulations showed no apparent skin irritation during the 15-minute observation period.

Table 3. Number of mosquito landing



The control showed substantially more mosquito landings than both the filtered and non-filtered formulations. This suggests that the formulations reduced mosquito landings during the observation period.
Note: Control, Filtered, and non filtered as follows; Orange, Blue, Green.

The lemongrass-based formulations showed fewer observed mosquito landings than the control during the 30-minute observation period. Both formulations also had a skin-compatible pH and produced no apparent irritation during the 15-minute observation. These results suggest that the formulation has potential as a plant-based mosquito repellent. However, further testing is needed before its effectiveness and suitability for regular use can be established

REFERENCES:

[1] Hidayati, N., Mustofa, C. H., & Sugesti, A. (2022). Formulasi dan uji sifat fisis pasta gigi gel ekstrak daun mangga bacang (*Mangifera Foetida lour.*) dengan kombinasi konsentrasi Na CMC dan carbomer (pH test). *Cerata Jurnal Ilmu Farmasi*, 13(2), 91-98. https://doi.org/10.61902/cerata.v13i2.609
[2] Puspita, Y. D., Hairiyah, N., & Ilmannafian A. G. (2025). Analysis of adding galanga oil (*Alpinia Galanga L.*) concentration in the making of mosquito repellent lotion. *Jurnal Teknologi Pertanian Andalas*, 29(1), 102-112. https://doi.org/10.25077/jtpa.29.1.102-112.2025

AI-Guided Drug Discovery: Cyclic Peptide Inhibitors of the SARS-CoV-2 Main Protease

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Purpose and Background:
The SARS-CoV-2 main protease (M^{pro}) cleaves viral polyproteins and is a validated antiviral target. Cyclic peptides closed by a disulfide bond between two terminal cysteines (CYX) resist enzymatic degradation and bind with high specificity. A tetrapeptide library built from 20 amino acids yields 160,000 sequences, making exhaustive docking impractical. This study aimed to build an AI-driven active-learning pipeline to efficiently design and screen cyclic tetrapeptides against M^{pro}, and to validate the top candidate experimentally.

Materials and Methods:
A Gradient Boosting model ($R^2 = 0.785$) was trained on GOLD docking scores from 8,000 cyclic tripeptides (CYX-AA_1-AA_2-AA_3-CYX) using seven physicochemical descriptors per residue plus pairwise interaction terms. A genetic algorithm (300 individuals, 150 generations) proposed ~50 tetrapeptide candidates per active-learning cycle, docked against the 8HBK M^{pro} crystal structure (GOLD 5.3, PLP scoring). Over six cycles the model was retrained on each cycle's docking results. The top candidate (CYX-IWRM-CYX) was synthesized and tested in vitro via fluorogenic substrate assay (ex. 360 nm / em. 460 nm); IC_{50} was benchmarked against Paxlovid.

Results and Discussion:
The pipeline screened ≈1,067× fewer compounds than exhaustive docking while identifying two top candidates: CYX-IWRM-CYX (score 101.34) and CYX-FRRQ-CYX (93.20), both above the 3-mer best of 83.71 and library average of 53.0. CYX-FRRQ-CYX's dual arginine residues (+2 net charge) complement the S1/S2 pockets while phenylalanine anchors the hydrophobic S2 sub-pocket—analogous to Paxlovid. CYX-IWRM-CYX was validated experimentally, inhibiting M^{pro} with $IC_{50} = 10.0$ nM versus 19.2 nM for Paxlovid (~2-fold greater potency). Only ~300 docking evaluations were required to surpass exhaustive 8,000-compound screening.

Table 1. Top docking candidates vs. reference compounds.

Compound	GOLD Score	vs. Avg (+%)	IC_{50} (nM)	Status
CYX-IWRM-CYX	101.34	+91 %	10.0	Validated
CYX-FRRQ-CYX	93.20	+76 %	TBD	In silico
CYX-WFW-CYX (3-mer best)	83.71	+58 %	TBD	Reference
Paxlovid	—	—	19.2	Clinical ref

Conclusion:
An AI active-learning pipeline produced CYX-IWRM-CYX ($IC_{50} = 10.0$ nM), outperforming Paxlovid ~2-fold while exploring only ~0.19 % of the tetrapeptide space. Future work includes IC_{50} validation for CYX-FRRQ-CYX, cell-permeability assays, and extension to other viral protease targets.

REFERENCES:
1. Muramatsu, T. et al. (2016). SARS-CoV 3CL protease cleaves its C-terminal autoprocessing site by novel subsite cooperativity. Proceedings of the National Academy of Sciences, 113(46), 12997–13002.
2. Jin, Z. et al. (2020). Structure of M^{pro} from SARS-CoV-2 and discovery of its inhibitors. Nature, 582, 289–293.
3. Doak, B. C., & Kihlberg, J. (2017). Drug discovery beyond the rule of 5 — opportunities and challenges. Expert Opinion on Drug Discovery, 12(2), 115–119.
4. Verdonk, M. L. et al. (2003). Improved protein–ligand docking using GOLD. Proteins: Structure, Function, and Bioinformatics, 52(4), 609–623.
5. Pedregosa, F. et al. (2011). Scikit-learn: Machine learning in Python. Journal of Machine Learning Research, 12, 2825–2830.
6. Settles, B. (2010). Active learning literature survey. Computer Sciences Technical Report 1648, University of Wisconsin–Madison.
7. Hammond, J. et al. (2022). Nirmatrelvir for vaccinated or unvaccinated adult outpatients with Covid-19. New England Journal of Medicine, 386(15), 1397–1408.
8. Daina, A., Michielin, O., & Zoete, V. (2017). SwissADME: A free web tool to evaluate pharmacokinetics, drug-likeness and medicinal chemistry friendliness of small molecules. Scientific Reports, 7, 42717.

Development of Hand Sanitizer Alcohol Gel Infused with Xanthone Extract from Mangosteen Pericarp for Inhibiting Pathogenic Bacteria

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Purpose and Background:

Conventional alcohol-based hand sanitizers provide antimicrobial activity, but alcohol evaporates rapidly after application. Mangosteen (*Garcinia mangostana L.*) pericarp is an agricultural by-product containing xanthones, a group of bioactive compounds reported to have antibacterial properties. This study aimed to develop an alcohol-based hand sanitizer gel containing mangosteen pericarp extract and evaluate its inhibitory activity against three bacterial species: *Cutibacterium acnes, Staphylococcus aureus,* and *Escherichia coli.*

Materials and Methods:

Dried mangosteen pericarp was ground into a fine powder. Twenty grams of the powder were soaked in 86 mL of 95 % ethanol for three days, protected from light. The mixture was filtered, and the solvent was evaporated at 70 °C for 12 hours to obtain a concentrated extract. The extract was incorporated into an alcohol-based gel at 0.73% w/v using Carbopol 940 as the gelling agent. The final formulation contained 71.35% ethanol and had a pH of 5.0. Antibacterial activity was evaluated using the paper disc diffusion method on LB agar. The inoculated plates were incubated at 37 °C for 24 hours, and the inhibition zones were measured and recorded.

Results and Discussion:

The formulated gel showed varying antibacterial activity against the three tested bacteria. As shown in Table 1, the gel was most effective against C. acnes, producing the largest zone of inhibition at 12 mm—compared to 7 mm for the xanthone in distilled water control. In contrast, it showed weak activity against S. aureus (2 mm) and no inhibitory effect against E. coli. These results indicate that the gel's antibacterial strength depends heavily on the bacterial species. This matches previous findings on mangosteen pericarp compounds, though exact results often vary based on extraction methods, gel formulation, and target bacteria. Further studies are needed to confirm the formulation's consistency and real-world effectiveness.

Table 1. Inhibition zones of the tested samples against three bacterial species.

Substance / Bacterial Species	Xanthone with distilled water	Xanthone-infused gel	Negative control	Ampicillin
Cutibacterium acnes	7 mm	12 mm	0 mm	16 mm
Staphylococcus aureus	8 mm	2 mm	0 mm	32 mm
Escherichia coli	0 mm	0 mm	9 mm	11 mm

Note*: Inhibition-zone diameters are reported as shown in the project results.*

REFERENCE

1.Albuquerque, B. R., et al. (2023). Insights into the chemical composition and in vitro bioactive properties of mangosteen (Garcinia mangostana L.) pericarp. Foods, 12(5), Article 994. https://pmc.ncbi.nlm.nih.gov/articles/PMC10000740/

2. Li, H., et al. (2025). Development of xanthone derivatives as effective broad-spectrum antimicrobials. Science Advances, 11(10), eadt4723. https://pmc.ncbi.nlm.nih.gov/articles/PMC11881906/

Detection of Aluminum Ions in Water Using Anthocyanin Extraction from Riceberry Rice

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Purpose and Background

Aluminum ion (Al^{3+}) detection is critical due to its potential neurotoxicity and linkage to Alzheimer's disease. This study presents a colorimetric approach for detecting aqueous Al^{3+} using an anthocyanin extract derived from Riceberry rice.

Material and Methods

The chemicals utilized in this research were riceberry rice, distilled water, methanol, ethanol, sodium acetate, potassium chloride, hydrochloric acid, aluminum nitrate nonahydrate, sodium nitrate, potassium nitrate, silver nitrate, lead(II) nitrate, mercuric nitrate, calcium nitrate dihydrate. All chemicals were purchased in analytical grade. The absorbance of anthocyanin solution was measured by UV-visible spectrophotometer V5100/UV5100, METASH.

Anthocyanins were extracted using distilled water, methanol, and ethanol, and quantified via the pH differential method. The extract was evaluated as a colorimetric probe for metal ions. Extraction mass of rice berry rice, extraction time, and pH were systematically optimized. The limit of detection (LOD) for Al^{3+} was then studied by varying the concentration of the ion in a range of 0.5 mM to 0.1 M observed by naked-eye. The selectivity was last examined under optimal conditions.

Result and Discussion

Among the evaluated solvents, aqueous extraction exhibited the highest efficiency for Riceberry anthocyanins which was confirmed by the amount of anthocyanin content using pH different method (reported as 1.7, 2.0, 4.9 mg/L, respectively). The resulting extract acted as a visual colorimetric indicator, exhibiting distinct spectral transitions upon complexation with Al^{3+} which resulted in the color change of solution from violet to pink. The results of optimization studies have shown that a 10 g of riceberry rice and an extraction time of 5 minutes yielded the most obviously colorimetric resolution. Al^{3+} was consistently detected across pH 5–7. This stability is attributed to the spatial availability of nucleophilic hydroxyl functional groups, which sustain metal-coordination capacity despite pH-dependent structural equilibria of the anthocyanin core (Oliveira Filho et al., 2021). Under these optimal conditions, the limit of detection (LOD) for Al^{3+} was determined to be 0.001 M observed by naked-eye. Interference assays against eight competitive cations revealed distinct cross-reactivity exclusively with Ag^{+} (yielding a black air-sensitive complex), Pb^{2+}, and Hg^{2+}. Notably, these ions interfered with aluminum detection only at high concentrations of 0.1 M or greater, confirming that the sensor exhibited high selectivity under optimal conditions.

REFERENCES

Bonfiglio, R., Scimeca, M., & Mauriello, A. (2023). **The impact of aluminum exposure on human health. Archives of Toxicology**, 97(11), 2997–2998. https://doi.org/10.1007/s00204-023- 03581-6

Chua, L. S., Wahab, N. S. A., & Soo, J. (2023). **Water-soluble phenolics, flavonoids, and anthocyanins extracted from jaboticaba berries using maceration with ultrasonic pretreatment**. Food Chemistry Advances, 3, Article 100387. https://doi.org/10.1016/j.focha.2023.100387

Oliveira Filho, J. G., Braga, A. R. C., de Oliveira, B. R., Gomes, F. P., Moreira, V. L., Pereira, V. A. C., & Egea, M. B. (2021). **The potential of anthocyanins in smart, active, and bioactive eco-friendly polymer-based films: A review.** Food Research International, 142, Article 110202. https://doi.org/10.1016/j.foodres.2021.110202

Teng, Z., Jiang, X., He, F., & Bai, W. (2020). **Qualitative and quantitative methods to evaluate anthocyanins**. eFood, 1(5), 339–346. https://doi.org/10.2991/efood.k.200909.001

ANALYSIS OF CHEMICAL METHODS FOR NEUTRALIZING ACIDIC WATER

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Introduction:

Acidic water can damage aquatic ecosystems and also make some metals move more easily which makes it hard to manage water quality. Neutralisation uses alkaline materials to soak up acidity and lift the pH. The efficiency of neutralisation and the practical trade-offs depend on the material type and the conditions in which it is used. This study compares the evidence on chemical, waste-derived methods to judge their effectiveness and sustainability.

Research Method:

This study used data that already existed because the researcher did not perform new experiments. The conclusions come from four published studies that examined chemical neutralisation of water from the Kopili River the use of alkaline agents on acid mine drainage (AMD) limestone treatment and passive materials that are locally available. The review looked at the dosage used the pH, the stability of neutralisation the treatment conditions and how well contaminants were removed. The numbers from the studies were not taken as a direct ranking because the water chemistry and the experimental methods were not the same.

Findings:

Kapil and Bhattacharyya (2017) found that calcium oxide (CaO) was one of the five chemicals in Table 1 and needed the amount to lift the pH of the Kopili River water from 3.2 to 7. Calcium carbonate ($CaCO_3$) in contrast required the largest amount. In a study on acid mine drainage Abfertiawan et al. (2024) Reported that a mix of 18% calcium hydroxide and 82% sodium hydroxide had the lowest optimal dosage of 800 mg/L. Sodium hydroxide gave the highest final pH of 6.92 while calcium hydroxide showed the best stability of pH.

Brăhaița and others (2017) showed that limestone treatment worked best when the flow rate, contact time and particle size were right. Under conditions the pH reached 6.26. Tests with limestone particles (5–10 mm) and a low flow rate of 25 mL/min were more effective. Turingan and colleagues (2020) found that recycled concrete aggregate could be used for neutralisation and to remove contaminants. In a 60-minute test with particles of 2.00–3.35 mm the final pH was 6.78. The removal rates were 94% for iron 78% for nickel 92% for aluminium and 28% for sulfate. A later jar test reached a pH of 12.42 showing that high alkalinity can exceed the desired treatment level.

The amount of chemical needed to raise the pH of the water at the Kopili River plant to 7 is given in Table 1.

Material	**Amount Required to Reach pH 7 (g/m^3)**
CaCo3 (Limestone)	45.41
Na2CO3 (Soda ash)	37.1
NaOH (Caustic soda)	20
Ca(OH)2 (Hydrated lime)	18.52
CaO (Quicklime)	17.94

Discussion and Conclusion:

The results show that there is no neutralisation method that is always best. Chemical agents can give controllable neutralisation but limestone lets us use passive treatment and recycled concrete aggregate lets us reuse material and remove contaminants. Still neutralisation effectiveness changes with the water chemistry, the dosage and the operating conditions. Sustainability means finding a balance between neutralisation efficiency, pH stability, the amount of material used, safety and waste reuse. Future research should test the materials under the same conditions and consider both water quality effects and environmental trade-offs

REFERENCES

[1] Kapil, N., & Bhattacharyya, K. G. (2017). A comparison of neutralization efficiency of chemicals with respect to acidic Kopili River water. *Applied Water Science*, *7*(5), 2209-2214.

[2] Abfertiawan, M. S., Rusman, M. R., Hasan, F., & Anwar, S. Dari Air Asam ke Proses Netralisasi: Menyingkap Efikasi dan Stabilitas Agen Alkali untuk Pengolahan Air Asam Tambang.

[3] Brăhaița, I. D., Pop, I. C., Baciu, C., Modoi, C., Popița, G., & Truță, R. M. (2017). The efficiency of limestone in neutralizing acid mine drainage–a laboratory study. *Carpathian journal of earth and environmental sciences*.

[4] Turingan, C. O. A., Singson, G. B., Melchor, B. T., Alorro, R. D., Beltran, A. B., & Orbecido, A. H. (2020). Evaluation of efficiencies of locally available neutralizing agents for passive treatment of acid mine drainage. *Minerals*, *10*(10), 845.

DETECTION OF BORAX IN WHITE CRACKERS USING A BUTTERFLY PEA ANTHOCYANIN INDICATOR AND ARDUINO UNO R3

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Purpose and Background

White crackers (*kerupuk putih*) are a widely consumed tapioca-based food (Sari, 2015). Additives used to improve texture or shelf life can, when misused, endanger consumers (BPOM RI, 2019). Because white crackers are neutral in colour and uniform, additives such as borax cannot be recognised by eye, but pH can serve as an early indicator. Butterfly pea (*Clitoria ternatea* L.) anthocyanins shift from blue to green and yellow under alkaline conditions (Aprilliani et al., 2022; Marpaung, 2020), and an Arduino-controlled colour sensor can convert this response into digital data (Iwanto et al., 2018). This study developed an Arduino Uno R3-based prototype for early borax detection in white crackers.

Materials and Methods

This experiment used a descriptive quantitative approach. Four market brands of white crackers (PMHD, DDN, RP, AJI) and a positive control (crackers mixed with borax) were tested. The prototype integrated an Arduino Uno R3, a TCS3200 colour sensor and a DS18B20 temperature sensor for thermal compensation. Butterfly pea mass (1, 2 and 3 g in 100 mL water) was optimised from the sensor voltage, and the system was calibrated with vinegar, cracker and detergent solutions. Sample extracts (1:10 in distilled water) were reacted with the indicator and RGB values recorded before and after. As red (ΔR) and green (ΔG) changes correlated most strongly with pH, pH was estimated as:

$$\mathrm{pH} = 6.5 + (0.07 \times \Delta R) - (0.02 \times \Delta G) + (400.0 \times (0.332 - \mathit{Ratio}R))$$

where 6.5 is the extract's initial pH and *Ratio*R corrects for ambient light; pH ≥ 8.5 was classed as "Danger".

Results and Discussion

Raising butterfly pea mass from 1 to 3 g increased mean sensor voltage (0.16, 0.21, 0.27 V) as anthocyanin concentration rose; 2 g was optimal, giving stable readings without sensor saturation. As shown in Table 1, all four brands had estimated pH values of 7.31–7.94 (mean ≈ 7.67), below the 8.5 threshold, i.e. weak alkalinity normal for tapioca foods. The borax-spiked control turned the indicator cloudy yellowish-green with an estimated pH of 9.38 ("Danger"). The prototype is thus sensitive to alkaline compounds, and none of the tested brands indicated significant borax content based on the device parameters. A natural anthocyanin indicator with microcontroller sensing thus offers a simple, portable, objective early borax screen.

Table 1. Estimated pH of white cracker samples (RGB as R, G, B; "Danger" if pH ≥ 8.5)

Sample	Mean RGB before	Mean RGB after	pH (est.)	Status
PMHD	509.7, 575.2, 464.7	516.4, 574.4, 471.6	7.94	Safe
DDN	506.7, 573.6, 460.1	537.7, 594.9, 482.7	7.79	Safe
RP	508.1, 572.7, 461.2	535.4, 590.9, 483.4	7.65	Safe
AJI	510.6, 575.0, 463.9	538.2, 591.2, 479.7	7.31	Safe
Control (+ borax)	509.7, 575.2, 464.7	515.6, 577.0, 490.2	**9.38**	**Danger**

REFERENCES

Aprilliani, F., Ayuningtyas, L. P., & Lestari, H. A. (2022). Bunga telang (*Clitoria ternatea* L.) sebagai indikator pH dalam sistem kemasan pintar. *Agroteknika, 5*(2), 87–97.

Badan Pengawas Obat dan Makanan Republik Indonesia. (2019). *Peraturan Badan Pengawas Obat dan Makanan Nomor 11 Tahun 2019 tentang bahan tambahan pangan*. BPOM RI.

Iwanto, Suryadi, D., & Priyatman, H. (2018). *Rancang bangun alat pendeteksi kadar boraks pada makanan menggunakan sensor warna TCS3200 berbasis Arduino Uno R3*. Jurusan Teknik Elektro, Fakultas Teknik, Universitas Tanjungpura.

Marpaung, A. M. (2020). Tinjauan manfaat bunga telang (*Clitoria ternatea* L.) bagi kesehatan manusia. *Journal of Functional Food and Nutraceutical, 1*(2), 63–85.

Sari, D. (2015). *Strategi peningkatan pendapatan agroindustri kerupuk tepung tapioka di Kelurahan*. Neliti.

Bio-based Freshness Indicator Film

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Purpose and Background

Plastic packaging is slow to degrade and therefore has a severe impact on the environment, while Thailand generates abundant agricultural waste, particularly Namwa banana peels (Musa sapientum). Meanwhile, consumers often find it difficult to assess the freshness of perishable foods, leading to food waste and health risks. Butterfly pea (Clitoria ternatea) anthocyanins change color with pH (Saptarini et al., 2015), and spoiled food releases volatile basic compounds such as ammonia, so they can serve as a natural freshness indicator. Namwa banana peel was chosen as the pectin source because its pectin had the highest anhydrouronic acid content (66.67%) among the banana varieties studied, meeting food-grade pectin criteria (Khamsucharit et al., 2018), and the peel is readily available in Thailand. This project therefore develops a bio-based freshness indicator film from Namwa banana peel pectin and butterfly pea anthocyanin extract, aiming to (1) investigate the extraction of pectin and anthocyanin, and (2) evaluate the film-forming capacity and physical properties of films containing varying volumes of anthocyanin extract.

Materials and Methods

Pectin extraction was carried out using Namwa banana peels by dicing, blanching at 90°C for 5 min, acidifying to pH 3.0, extracting at 85°C, precipitating with ethanol, and grinding into powder (as shown in the left image) (Khamsucharit et al., 2018).

Anthocyanin extraction was performed by macerating dried butterfly pea flowers in 70% ethanol (pH 3.0) for 24 h, followed by filtration and evaporation (Saptarini et al., 2015).

Film preparation was done by dissolving pectin powder, adding glycerol, and mixing with anthocyanin extract before casting and drying (as shown in the right image) to monitor raw chicken freshness (Saenhang et al., 2022).





Results and Discussion

Pectin was successfully extracted from Namwa banana peels and used to fabricate fully biodegradable bio-films. The formulation containing 10–15% v/v anthocyanin extract from butterfly pea flowers showed the best physical properties, flexibility, and color response. The film effectively monitored the freshness of raw chicken through distinct color changes visible to the naked eye, shifting from pinkish-purple to blue and greenish-yellow in correspondence with pH.

REFERENCES

Khamsucharit, P., Laohaphatanalert, K., Gavinlertvatana, P., Sriroth, K., & Sangseethong, K. (2018). Characterization of pectin extracted from banana peels of different varieties. *Food Science and Biotechnology, 27*(3), 623–629. https://doi.org/10.1007/s10068-017-0302-0

Saenhang, D., Saenyang, C., & Saenyang, W. (2022). *Biofilm for food preservation like banana* [Science project report, Prakit Wetchasak School]. PubHTML5. https://pubhtml5.com/tlpc/rnwj/

Saptarini, N. M., Suryasaputra, D., & Nurmalia, H. (2015). Application of butterfly pea (*Clitoria ternatea* Linn) extract as an indicator of acid-base titration. *Journal of Chemical and Pharmaceutical Research, 7*(2), 275–280. https://www.jocpr.com/articles/application-of-butterfly-pea-clitoria-ternatea-linn-extract-as-an-indicator-of-acidbase-titration.pdf

Combustion Time Efficiency of Bio-Briquettes Based on a Mixture of Rice Husk and Coconut Shell

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Purpose and Background:

According to official data from Statistics Indonesia, the country generates 10.7 million metric tons of rice husks [1] and over 330,000 metric tons of coconut shells annually [2], yet most remains underutilized or discarded. Therefore, processing this local waste on a small scale is a sustainable effort that turns agricultural waste into valuable and eco-friendly energy. The objective of this research is to determine the extent to which the combination of these two types of waste affects combustion efficiency, while also identifying the most optimal burn time ratio.

Materials and Methods:

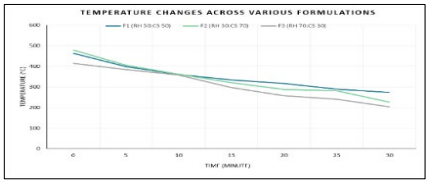
Table 1. Composition of briquette formulations

Formulation Code	Rice Husk (g)	Coconut Shells (g)	Tapioca starch (g)	Hot Water (mL)
F1	50	50	10	90
F2	30	70	10	90
F3	70	30	10	90

Materials include rice husk, coconut shell, tapioca starch, and hot water, with the formulation presented beside the table. The biomass was carbonized, sieved to a 60-mesh size, mixed with a binder, pressed for 20 minutes, and dried in the sun for 5 days before being tested on a stove, combustion tests were conducted for 30 minutes to measure temperature stability, ash residue, and the combustion rate.

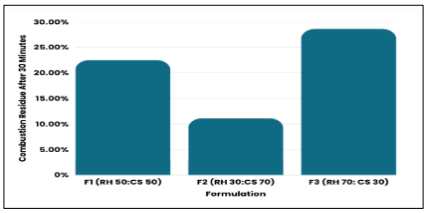
Results and Discussion:

Table 2. Temperature stability during 30-minute combustion



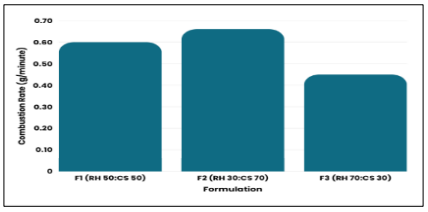
Temperature monitoring shows that Formulation F1 had the most stable temperature. The starting temperature was 463.55 °C and slowly dropped to 273.60 °C by the end of the test.

Table 3. Ash residue content and structural integrity after 30-minute combustion



Combustion residue after 30 minutes showed F2 left the lowest ash content at 11.1% while keeping its structure intact. In contrast, Formulations F1 and F3 produced higher ash residues due to the silica content in rice husks.

Table 4. Combustion rate and effeciency of formulation



The combustion rate results show that Formulation F2 achieved highest efficiency with a burn rate of 0.66 g/min due to dense coconut shell lignin [3]. Higher coconut shell content improves density and heat retention, while higher rice husk content increases porosity and residue.

Conclusion:

Rice husk and coconut shell mixtures are effective for producing eco-friendly biobriquettes. Formulation F2 (30 RH : 70 CS) gives the best overall performance with the highest combustion rate efficiency, highest peak temperature, and lowest combustion residue after 30 minutes.

REFERENCES:

[1] Badan Pusat Statistik. (2023). *Statistik Tanaman Pangan Indonesia 2022*. BPS. https://www.bps.go.id
[2] Badan Pusat Statistik. (2023). *Statistik Tanaman Perkebunan Indonesia 2020–2022*. BPS. https://www.bps.go.id
[3] Qistina, I., Sukandar, D., & Trilaksono, T. (2016). Kajian kualitas briket biomassa dari sekam padi dan tempurung kelapa. *Jurnal Kimia VALENSI*, *2*(2), 136–142. researchgate.net/publication/311422046

Proceedings

- Undergraduate Students /
Postgraduate Students -

XRF Investigation of Atmospheric Particulate Matter Accumulated on Urban Tree Leaves in Phnom Penh, Cambodia: Implications for Urban Ecosystem Health and SDG 15

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Purpose and Background:

Tree leaves serve as natural passive collectors of airborne particulate matter (PM), making them effective biomonitors of urban air pollution. Deposited PM can obstruct stomata, reduce photosynthetic efficiency, inhibit plant growth, and increase physiological stress. These particles may subsequently transfer to soils, urban green spaces, and agricultural lands, contributing to broader environmental contamination. Major sources of PM deposition on leaf surfaces include road dust, vehicle emissions, construction activities, and industrial aerosols. In Cambodia, rapid economic growth and accelerating urbanization have significantly increased vehicle registrations, raising growing concerns over urban air quality (Ministry of Information, 2025). In densely populated cities such as Phnom Penh, heavy traffic and ongoing infrastructure development continuously emit airborne pollutants that pose risks to both public health and the environment (GGGI & AFD, 2024). This study aims to characterize airborne PM accumulated on tree leaves collected from two locations in Phnom Penh using X-ray fluorescence (XRF) spectroscopy and to compare pollution levels between these sites. In addition, heavy metal contamination across different tree species is investigated to identify species with the highest pollutant accumulation and evaluate their potential as biomonitors of urban air pollution.

Materials and Methods:

Several sets of leaf samples were collected from two different sites in Phnom Penh, the capital city of Cambodia, including heavy traffic and green university areas. Tree selection was based on accessibility in those two areas. A total of six sets of tree leaves, where each set comprises of three leaf samples, were collected from two mango trees, one longan tree located along Phnom Penh-Hanoi Friendship Blvd., and java plum, star apple, and yellow bells trees located in the National Polytechnic Institute of Cambodia campus. Surface elemental composition of each leaf sample was determined by using a handheld XRF spectrometer (HITACHI X-MET8000). Measurements were performed via direct surface scanning on the back and front of the leaves, focused on three selected areas (head, middle, and tail) of the leaf blade for mango and java plum leaves, and two scanning areas (head and tail) for star apple, longan, and yellow bells leaves.

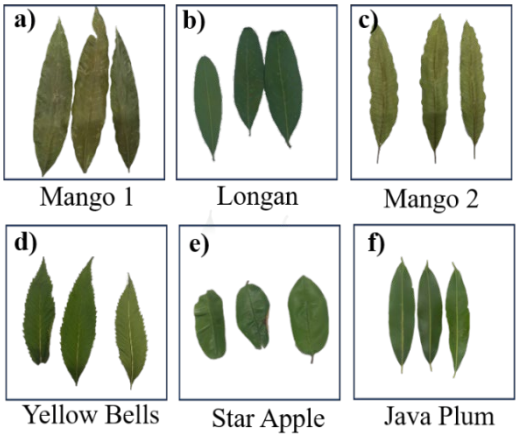

Fig 1. The collected leaf samples.



Fig 2. Handheld XRF used for the measurements.

Results and Discussion

The XRF analysis shows both natural and trace elements on tree leaves collected from the two sites, indicating that urban vegetation can effectively capture atmospheric PM. According to the analysis results in Table 1, Si is the dominant element in all samples, suggesting that road dust and soil particles are the major contributors to deposited PM, while other elements such as S, Fe, Cu, Zn, and Ni are also detected, indicating additional inputs from traffic-related activities, as consistently shown by Thorpe and Harrison (2008) and

WHO (2021). Leaf samples collected from the heavy traffic sites (Phnom Penh–Hanoi Friendship Boulevard) generally contain higher proportions of crustal particles than those collected from NPIC area, reflecting the greater influence of vehicle movement and road dust resuspension in high-traffic environments (Seinfeld & Pandis, 2016).

Along Phnom Penh–Hanoi Friendship Blvd., mango leaf samples show higher Si contents than longan leaves, indicating a greater ability to trap dust particles. In contrast, longan leaf samples exhibit relatively higher S and P, suggesting a difference in particle deposition and leaf characteristics. Additionally, in NPIC area, java plum accumulates a greater diversity and percentage of trace elements, including Cu, Ni, Zn, Pd, and Pt, than star apple and yellow bells, indicating superior efficiency in capturing airborne contaminants.

Table 1. Average elemental composition (%) of tree leaf samples determined by handheld XRF analysis.

	Average (%)					
Element	**Black Plum**	**A Star apple**	**Yellow Bells**	**Mango 1**	**Mango 2**	**Longan**
Si	41.22	41.05	30.30	65.90	68.07	35.04
S	5.07	16.61	12.62	12.14	9.17	31.63
P	5.00	12.02	25.45	6.72	6.44	22.34
Al	11.42	10.28	7.02	4.69	5.95	7.48
Fe	6.92	6.39	1.68	4.17	4.19	2.57
Mn	11.59	2.33	0.42	2.93	2.64	0.21
Pd	6.59	5.44	0.31	0.31	0.41	0.12
Mg	1.92	-	21.57	1.84	1.95	0.19
Cu	3.68	0.41	0.12	0.71	0.81	0.18
Au	1.55	1.31	-	-	-	-
Ta	0.91	0.57	0.09	0.06	0.06	0.05
Zn	0.21	1.26	0.23	0.11	0.11	0.08
Ni	0.38	0.60	0.14	0.07	0.06	0.07
Hf	0.70	0.22	-	-	-	-
Mo	0.64	0.28	-	0.01	0.03	-
Nb	0.48	0.37	-	0.01	0.02	-
W	0.36	0.21	0.03	0.03	0.04	0.02
Ag	0.67	-	-	-	-	-
Zr	0.37	0.04	0.02	-	-	-
Co	0.28	0.19	-	0.02	0.03	0.01
Re	0.23	0.13	-	0.03	0.03	0.01
Ir	0.15	0.05	-	-	-	-
Cr	-	0.16	-	0.01	0.01	-
Y	0.02	0.02	-	-	-	-
Pt	0.01	0.00	-	-	-	-

REFERENCES

Gajbhiye, T., Tiwari, A., Malik, T. G., Dubey, R., Pandey, S. K., Alharby, H. F., & Hakeem, K. R. (2024). *SEM-EDS-based rapid measurement and size-fractionated speciation of airborne particulate matter and associated metals utilizing plant leaves.* Environmental Science and Pollution Research, 31, 47144–47156. https://doi.org/10.1007/s11356-024-34222-9

Global Green Growth Institute, & Agence Française de Développement. (2024). *Situation assessment report: Air quality monitoring in Cambodia.*

Ministry of Information. (2025, January 15). *Cambodia registers over 410,000 vehicles in 2024. Portal Ministry of Information.* https://information.gov.kh/articles/149337

Sæbø, A., Popek, R., Nawrot, B., Hanslin, H. M., Gawrońska, H., & Gawroński, S. W. (2012). *Plant species differences in particulate matter accumulation on leaf surfaces.* Science of the Total Environment, 427–428, 347–354.

Seinfeld, J. H., & Pandis, S. N. (2016). *Atmospheric chemistry and physics: From air pollution to climate change (3rd ed.).* John Wiley & Sons, Inc.

Thorpe, A., & Harrison, R. M. (2008). *Sources and properties of non-exhaust particulate matter from road traffic: A review.* Science of the Total Environment. *400(1–3)*, 270–282. https://doi.org/10.1016/j.scitotenv.2008.06.007

Weerakkody, U., Dover, J. W., Mitchell, P., & Reiling, K. (2018). *Quantification of the traffic-generated particulate matter capture by plant species in a living wall and evaluation of the important leaf characteristics.* Science of the Total Environment, 635, 1012–1024.

World Health Organization. (2021). *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. World Health Organization.

Why Mechanical Energy Seems Difficult: A Preliminary Analysis of Textbooks, Teacher Perspectives, and Student Understanding in Thai context

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Purpose and Background

Mechanical energy is a fundamental concept included in compulsory science curricula worldwide, including Thailand. According to Thailand's Basic Education Core Curriculum A.D. 2008 (revised in 2017), Grade 8 students are expected not only to understand kinetic energy, potential energy, and the conservation of mechanical energy, but also to be able to design and conduct investigations into the factors affecting kinetic and potential energy, interpret evidence concerning the conversion between these forms of energy, and use the law of energy conservation to explain energy transformation and transfer in different real-life situations.

Despite its curricular importance, mechanical energy remains difficult for many students to understand. Prior studies have documented students' alternative conceptions concerning the nature, location, and transformation of energy. For example, some students appear to associate energy primarily with motion and therefore fail to recognize that an object at rest may possess gravitational potential energy because of its position within a system (Samsudin, 2021; Utama, 2025). Some students may also struggle to identify the relevant objects, forces, and systems involved in energy changes, limiting their ability to apply conservation principles consistently when explaining physical phenomena (Halilović, 2021). Such difficulties suggest that successful learning requires more than recalling the equations for kinetic and potential energy. It is essential to help students develop a coherent understanding of energy as a quantity associated with a system, recognize relationships among force, position, motion, and energy, and trace energy transformations across situations.

Students' understanding can be shaped by how energy is represented in curricular materials and by teachers' pedagogical decision-making. Examining textbooks, teacher perspectives, or student understanding separately can identify particular problems, but it provides only a partial account of how challenges in teaching and learning mechanical energy are produced and sustained. This preliminary study addresses this gap by examining mechanical energy from three interconnected perspectives: the intended curriculum (textbooks), teachers' perceived teaching challenges, and students' resulting conceptual understanding. By bringing these sources of evidence together, the study aims to provide a more comprehensive account of both the visible and less readily recognized challenges surrounding mechanical energy education in Thailand. The findings may also help to establish a foundation for developing teaching approaches that move beyond these challenges.

Materials and Methods

This study employed a multi-source survey research drawing on textbooks, teachers, and students. Three science textbooks commonly used in Thai schools were purposively selected and analyzed. The general details of example textbooks are shown below:

Table 1. General details of the three science textbooks analyzed

Textbook	Year	Pages	Pages (In the energy units)
A	2025	273	30
B	2025	216	16
C	2025	285	20

Ten junior secondary science teachers, all teaching at Grade 8 with a mean teaching experience of 15.1 years (range = 1–34 years), participated in semi-structured interviews exploring perceived challenges in teaching mechanical energy and conservation of energy in Thai classrooms. 8 out of 10 teachers were female. All of them completed their bachelor's degree in education or science. The interviews took place for around 20 minutes. Interviews were audio-recorded, transcribed verbatim, and analysed thematically to identify recurring perceived instructional difficulties. The background information of interviewees is presented in the following:

Table 2. Background information of participating teachers (n = 10)

Teacher	Gender	School's Province	Years' Experience	Teacher	Gender	School's Province	Years' Experience
A	male	Pathum Thani	1	F	female	Bangkok	20
B	male	Pathum Thani	11	G	female	Bangkok	3
C	female	Pathum Thani	9	H	female	Bangkok	4
D	female	Pathum Thani	17	I	female	Saraburi	29
E	female	Bangkok	34	J	female	Bangkok	23

In addition to textbook analysis and teacher interviews, this study also investigated how students understood energy after learning. 70 students (48 male, 22 female) were asked to undertake a written conceptual assessment on energy. Open-ended items examined: (1) energy transformation; (2) relationships between energy and motion; and (3) application of the law of conservation of energy. Responses were qualitatively categorised and quantitatively summarised to identify patterns of understanding and misconceptions the participating students may have. After each data source was analyzed, findings across the three sources were carefully compared to identify possible connections concerning challenges in teaching and learning energy in the Thai context.

Results and Discussion

The three textbooks represented mechanical energy in notably different ways. Publisher A seemed to emphasize energy as a relational property within a system through everyday contexts and inquiry activities. Publisher B seemingly prioritized equations, worked examples, and calculation-based exercises, whereas Publisher C seemingly adopted a hybrid approach, integrating infographics and real-life situations to build conceptual understanding alongside quantitative content. Despite these differences, all three used the phrase "energy disappears" when mechanical energy decreased. Without explicit clarification that energy is transferred to other forms or surroundings, this wording may reinforce the idea that energy is destroyed, rather than transformed or transferred. In terms of teacher interviews, this study found that participating teachers identified several challenges: students' limited mathematical skills, the nature of energy concept, students' existing knowledge that stationary objects possess no energy, students' confusion among energy-related terms, and insufficient instructional time. Student conceptual assessment results (n = 70) showed a mean score of 6.66 out of 15 (44.38%, SD = 3.51). In detail, participating students seemed to have challenges in sense-making of relationships between energy and motion and conservation of energy, echoing teachers' concerns about stationary-object energy and calculation readiness. Also, other learning difficulties were found: misinterpreting object motion, misapplying conservation principles, confusing energy-related terms, and failing to use graphical data as evidence, including describing energy as "disappearing," which echoes the same language found across all three textbooks. These patterns closely mirror the challenges reported by teachers and reflect the conceptual gaps observed in textbooks

The convergence across the three datasets suggests that students' difficulties may involve not only mathematical demands but also fragmented connections among motion, position, energy transformation, and conservation. Although the present study may not be able to establish causal relationships among textbook representations, classroom instruction, and student understanding, the recurring patterns indicate areas that may warrant closer attention. For example, the potential value of making system boundaries and energy transfer more explicit to students, clarifying potentially ambiguous expressions such as "energy disappears," and providing students with opportunities to connect qualitative explanations, graphical evidence, and quantitative relationships to make sense of why energy can be regarded as a system.

However, given the limited number of textbooks, teachers, and students included, what this study found could offer preliminary evidence that may inform further investigation and discussion concerning textbook design, classroom instruction, and assessment of mechanical energy in the Thai context.

REFERENCES

Utama, R., Kusumaningtyas, D. A., Toifur, M., Mustava, O., & Salamah, A. N. (2025). Qualitative analysis of students' misconceptions on energy conservation in mechanical systems. *Kasuari: Physics Education Journal (KPEJ)*, *8*(2), 487-499.

Samsudin, A., Afif, N. F., Nugraha, M. G., Suhandi, A., Fratiwi, N. J., Aminudin, A. H., Adimayuda, R., Linuwih, S., & Costu, B. (2021). Reconstructing students' misconceptions on work and energy through the PDEODE*E tasks with think-pair-share. *Journal of Turkish Science Education*, *18*(1), 118-144.

Halilović, A., Mešić, V., Hasović, E., & Dervić, D. (2021). Students' difficulties in applying the law of conservation of mechanical energy: Results of a survey research. *The European Educational Researcher*, *4*(2), 171-192.

APPLICATION OF ACTIVE INFRARED PHOTONIC SENSORS IN SIMULATING OBJECT VELOCITY MEASUREMENT SYSTEMS

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Purpose and Background

Traffic accidents are a major issue primarily caused by over-speeding. Implementing automated speed assessment using sensor technology is a crucial approach to increasing accuracy and reducing human error. This project aims to simulate an automated speed detection system utilizing the principles of optics and kinematics. The design integrates Active Infrared (Active-IR) sensors and a microcontroller to detect and calculate object velocity. Furthermore, the study explores the physical limitations of the hardware, specifically how the inverse square law of infrared radiation affects signal amplitude and photo-response latency, ensuring the optimal configuration for accurate measurements.

Materials and Methods

The hardware architecture consists of an Arduino Uno R3 microcontroller, two Active-IR proximity sensors (utilizing GaAs LEDs and photodiodes), an I2C OLED display (128x64), and an active piezoelectric buzzer, powered by an external 5V DC supply with a common ground setup. Two sensors were placed at fixed distance intervals (Δd). The velocity was calculated using the linear kinematic equation $v = \frac{\Delta d}{\Delta t}$, where Δt is the time difference between the two sensor triggers, recorded using the microcontroller's internal timer.

To calibrate the system and determine the percentage error, video frame-rate analysis was utilized as a standard reference, calculated by the equation $\Delta t_{video} = (\frac{\Delta F}{FPS}) \times 1000$. The software was programmed to evaluate the calculated speed; if the velocity exceeded a predefined limit of 30 cm/s, the system triggered an auditory alarm via the buzzer and displayed an "OVER SPEED" warning on the OLED screen.

Results and Discussion

Hardware signal analysis via an oscilloscope revealed that the Active-IR sensors maintained a stable maximum voltage ($V_{max} \approx 5V$) and minimum voltage ($V_{min} = 0V$) at a proximity range of 2-6 cm, indicating perfect saturation. Beyond 8 cm, the performance significantly decreased due to the physical limitations of infrared intensity dictated by the inverse square law ($E \propto I/R^2$).

Velocity measurement tests conducted at varying sensor intervals (10, 20, 30, 40, and 50 cm) demonstrated different levels of accuracy. The 20 cm interval yielded the highest stability and accuracy, showing the lowest average error of exactly 1.47% when compared to the video frame-rate reference. Intervals longer than 30 cm exhibited increased errors (up to 4.42% at 50 cm) primarily due to accumulated kinetic friction slowing down the test object over the longer distance. Overall, the logic system successfully executed real-time visual and auditory warnings based on the 30 cm/s threshold, proving the system's efficiency in combining physics concepts with digital electronics.

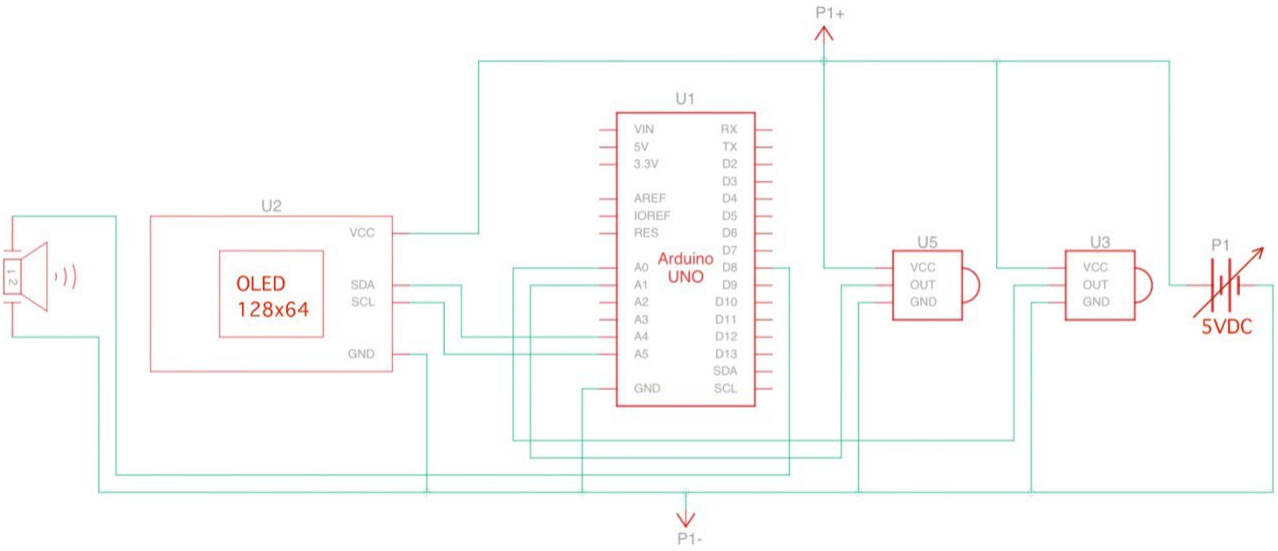

Figure 1: Schematic diagram of the Active-IR sensor array and internal timer system

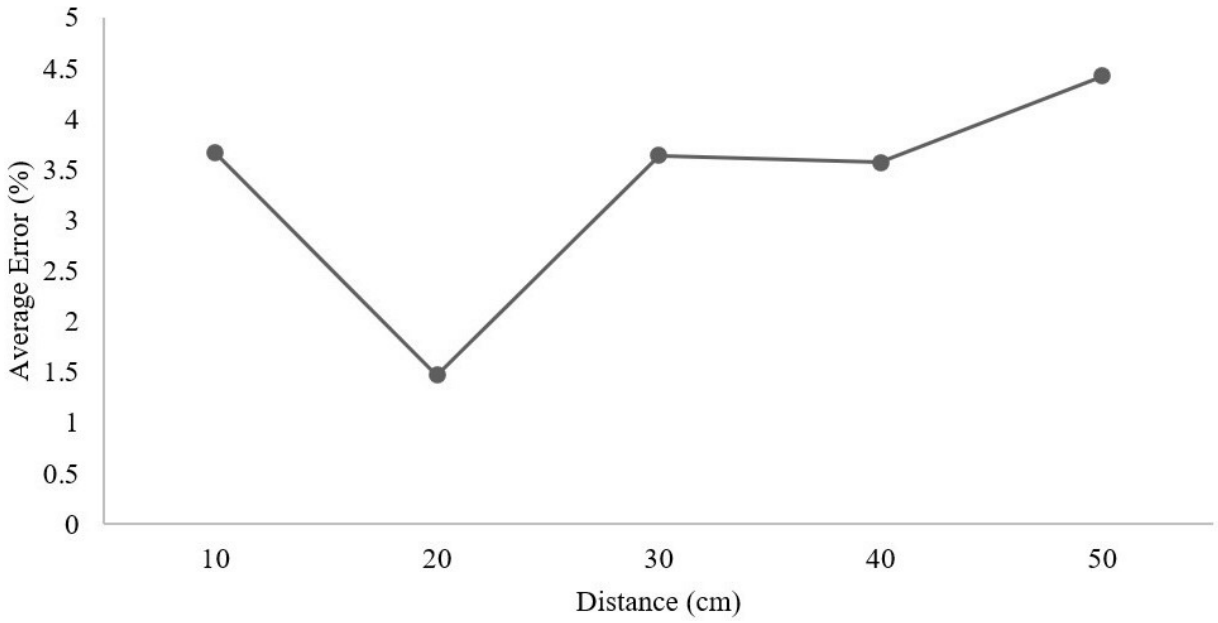

Figure 2: Average error percentage of the measured velocity at distances from 10 cm to 50 cm

REFERENCES

Guerrero-Ibáñez, J., Zeadally, S., & Contreras-Castillo, J. (2018). Sensor technologies for intelligent transportation systems. *Sensors*, *18*(4), 1212. doi:10.3390/s18041212

Halliday, D., Resnick, R., & Walker, J. (2013). *Fundamentals of physics* (10th ed.). Hoboken, NJ: John Wiley & Sons.

Klein, L. A. (2001). *Sensor technologies and data requirements for ITS*. Boston, MA: Artech House.

Kubínová, Š., & Šlégr, J. (2015). Physics demonstrations with the Arduino board. *Physics Education*, *50*(4), 472-474.

Texas Instruments. (2015). *LM393 dual differential comparator datasheet*. Dallas, TX: Author.

STEM INTEGRATION IN PHYSICS EDUCATION IN VIETNAM: EMPIRICAL FINDINGS AND AN SDG 15 CASE STUDY

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Purpose and Background

Sustainable development has become an important dimension of contemporary education, requiring students to develop interdisciplinary competencies for addressing environmental challenges. The United Nations 2030 Agenda emphasizes education for sustainable development through SDG Target 4.7, while SDG 15 focuses on protecting terrestrial ecosystems and biodiversity (United Nations, 2015). In Vietnam, STEM education was formally introduced into secondary schools through Official Document No. 3089/BGDĐT-GDTrH in 2020. However, despite strong policy support, effective classroom implementation remains uneven and constrained by institutional and pedagogical challenges. Using empirical data from National Research Project No. 503.01-2021.06, this study examines STEM teaching competency among secondary teachers and proposes a Grade 8 physics STEM case study aligned with SDG 15.

Materials and Methods

This study employed a sequential mixed-methods design from October to December 2024. Quantitative data were collected from 700 secondary school teachers across 25 schools in Northern, Central, and Southern Vietnam and supported by 48 semi-structured interviews. The instrument measured internal STEM teaching competency (27 items: STEM content knowledge, pedagogical skills, technology integration) and external factors (23 items: school leadership, student factors, learning environment). Data were analyzed using SPSS 27.0 through Cronbach's Alpha, EFA, t-test, ANOVA, and multiple linear regression.

Results and Discussion

Results showed that teachers demonstrated relatively strong subject-matter knowledge but remained limited in interdisciplinary lesson design and technology integration. No statistically significant differences were observed by gender or school level ($p > .05$). Regional comparison identified significant differences only in pedagogical skills ($F = 4.266$, $p = .014$), while teachers with fewer than ten years of experience demonstrated higher adaptive STEM competency ($p < .05$). The multiple linear regression model accounted for 36.1% of the variance in STEM teaching competency (Adjusted $R^2 = .361$, $F = 133.07$, $p < .001$), suggesting that external institutional support is crucial (Table 1).

Table 1. Multiple linear regression model predicting STEM teaching competency (NLS)

Predictor Variables	B	SE	β	t	p	VIF
Model Constant	0.801	0.172	—	4.664	< .001	—
School Leadership (QL)	0.496	0.034	.487	14.757	< .001	1.189
Student Factors (HS)	0.185	0.038	.159	4.817	< .001	1.190
Learning Environment (MT)	0.116	0.029	.123	3.984	< .001	1.045

School leadership emerged as the strongest predictor ($\beta = .487$), suggesting that administrative support and institutional policy conditions are strongly associated with teachers' STEM implementation capacity. This result indicates that teacher competency alone cannot ensure successful STEM implementation without adequate institutional support mechanisms. Conversely, qualitative findings exposed severe systemic barriers: examination-oriented curriculum pressure, rigid 45-minute lesson increments, and a lack of laboratory facilities, consistent with barriers to STEM implementation reported in previous international studies (Margot & Kettler, 2019).

Physics Education Case Study

Based on the empirical findings indicating that institutional constraints significantly hinder STEM implementation (β = .487), a low-cost Grade 8 physics STEM intervention was designed entitled *"Designing a Floating Rescue Raft from Recycled Materials Based on Archimedes' Principle for Climate Adaptation and SDG 15."* The project connects physics education with sustainability education by using post-disaster plastic waste as recycled engineering materials. Severe flooding events such as Typhoon Yagi (2024) often leave large quantities of unmanaged plastic waste that negatively affect terrestrial environments. Through designing a functional rescue raft from recycled materials, students develop awareness of sustainable material reuse and environmental protection while applying scientific knowledge to authentic sustainability challenges. From a physics perspective, students investigate *Archimedes' Principle*, equilibrium conditions of floating bodies ($\overrightarrow{F_A} + \vec{P} = \vec{0}$), and buoyancy force calculated by $F_A = \rho.g.V$, where ρ represents fluid density, g gravitational acceleration, and V displaced fluid volume. During the design stage, students may use Generative AI tools to compare structural alternatives before prototype construction. Performance evaluation applies the 360-degree assessment framework adapted from Le et al. (2025), integrating self-assessment (20%), peer evaluation (60%), and student feedback (20%).

Table 2. Five-stage engineering design process for the Archimedes rescue raft project

Engineering Stage	**Core Pedagogical Activities & SDG 15 Integration**
1. Problem Identification	Students analyze flood data and plastic waste accumulation after natural disasters to identify an engineering problem related to plastic waste management and protection of terrestrial ecosystems.
2. Scientific Investigation	Students conduct experimental inquiries into Archimedes' Principle, mapping relationships between mass, fluid density, and buoyancy force.
3. Solution Design	Student teams sketch technical designs, using Generative AI tools (e.g., ChatGPT-assisted design suggestions) to compare alternative structural configurations and estimate possible raft loading capacity before prototype construction.
4. Prototype & Testing	Teams construct a physical scale model using 10 recycled plastic bottles and local adhesives, testing stability under multiple incremental loads.
5. Evaluation & Presentation	Groups present solutions digitally, comparing experimental results with physics calculations and reflecting on how recycled material reuse can reduce environmental pollution and support ecosystem sustainability.

In conclusion, although Vietnamese teachers have developed foundational STEM competency, institutional support remains the primary determinant of successful implementation. Systematic 360-degree feedback combining teacher self-assessment, peer review, and student evaluations can inform personalized professional development to bridge existing pedagogical gaps.

REFERENCES

Khuat, T. T. H., Le, K. Q., & Nguyen, Q. V. (2026). *Assessing STEM teaching competence of secondary school teachers in Vietnam: Current status and evaluation* [Unpublished research report]. National Research Project No. 503.01-2021.06, VNU University of Education.

Le, T. T. H., Nguyen, T. T. L., Khuat, T. T. H., Le, K. Q., Nguyen, Q. V., Vu, T. T., & Nguyen, T. T. H. (2025). Criteria, tools, and procedures for assessing the STEM teaching competence of secondary school teachers in Vietnam. *Proceedings of the 5th Hanoi Forum on Pedagogical and Educational Sciences*, 77–92.

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: A systematic literature review. *International Journal of STEM education*, *6*(1), 2. https://doi.org/10.1186/s40594-018-0151-2

Ministry of Education and Training. (2020). *Official document No. 3089/BGDĐT-GDTrH on guidelines for implementing STEM education in secondary education*.

Nguyen, T. L. N., Nguyen, V. D., & Nguyen, T. T. H. (2025). *Factors influencing the STEM teaching competence of secondary school teachers* [Unpublished internal research report]. National Research Project No. 503.01-2021.06, VNU University of Education.

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development* (A/RES/70/1). United Nations General Assembly.

Using the 'Village City' Board Game Activity to Enhance Problem-Solving Skills in Analytic Geometry for Grade 10 Students

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Purpose and Background

Contemporary mathematics education extends beyond the mere memorization of formulas and theorems; it places significant emphasis on the cultivation of higher-order thinking skills. Prominent among these are problem-solving skills, which are recognized as critical 21st-century competencies essential for learning, career success, and daily life (Baroody & Coslick, 1993). In the context of Analytic Geometry specifically concepts such as calculating distances, determining midpoints, and identifying coordinates on a Cartesian plane students must employ spatial visualization and connect mathematical concepts to real-world scenarios. However, students frequently encounter difficulties grasping these topics through traditional lecture-based instruction and standard exercises.

To address this pedagogical challenge, the integration of game-based learning (Gamification/Board Games) offers a compelling approach. Recent multidisciplinary research highlights that board games function as effective spaces for mathematical learning, enabling learners to interact with complex content in a highly engaging manner (Bayeck, 2020). Implementing a role-playing board game activity where students act as "city developers" constructs a challenging and meaningful learning environment. By simplifying complex societal systems into accessible game mechanics, board games provide an appropriate environment to further explore active learning and systems thinking (Bayeck, 2020). Additionally, game-based learning acts as a virtual micro-society where students can experiment through trial and error, effectively reducing the cognitive load required to understand complex systemic concepts (Tsai et al., 2021). Furthermore, it fosters students' awareness of the learning process, enhances their understanding of complex problems, and highlights the importance of strategic planning within a societal context. Consequently, this study aims to develop and investigate the effectiveness of the "Village City" board game activity which integrates game mechanics in enhancing students mathematical problem-solving skills.

Consequently, this study aims to develop and investigate the effectiveness of the "Village City" board game activity. Specifically, this research seeks to address the following questions:

1. How can the board game increase students' engagement and learning motivation?
2. How does it improve students' mathematical problem-solving skills in analytic geometry?

Materials and Methods

This study employed a quasi-experimental research design to investigate the effects of the "Village City" board game activity on students' mathematical problem-solving skills. The sample consisted of 40 Grade 10 students enrolled during the second semester of the 2025 academic year at Mathayomwatsing School, selected via cluster random sampling. The intervention was conducted over a period of 4 weeks. Data were collected utilizing a mathematical problem-solving test and behavioral observation forms.

The "Village City" board game was purposefully designed around three core educational characteristics to foster active learning:

- Real-life Simulation: The game contextualizes learning by placing students in the role of urban developers. This design reflects real-world dilemmas, requiring learners to make critical developmental decisions under authentic societal constraints and simulated crisis events.
- Mathematical Problem-solving: To progress and resolve urban challenges, students must actively apply analytic geometry. They calculate distances between points and determine midpoints on a Cartesian plane to identify the most strategic locations for public facilities, thereby using mathematical knowledge to solve concrete problems.
- Sustainable Development Goals (SDGs) Integration: The gameplay mechanics require players to make decisions that balance three key dimensions of sustainability: economic growth, environmental preservation, and quality of life. This ensures that students evaluate the broader societal impacts of their mathematical solutions.



Figure 1: the implementation of the "Village City" board game learning activity in the classroom.

Results and Discussion

The implementation of the "Village City" board game activity led to meaningful outcomes regarding students' mathematical problem-solving abilities, engagement, and systems thinking.

First, students showed noticeable enthusiasm and increased learning motivation in completing the tasks. By assuming the roles of urban developers, they were eager to explore the simulated situational problems and demonstrated a strong commitment to finding solutions. The game-based learning process sparked their focus and encouraged active classroom participation, with approximately 85% of students actively engaging in the activities, significantly shifting them away from traditional lecture-based difficulties. Because board games are highly interactive, they encourage students to take the initiative to explore and exchange information with their peers, thereby successfully promoting a student-centered learning process (Tsai et al., 2021).

Second, students' problem-solving approaches reflected systematic mathematical thinking grounded in appropriate mathematical knowledge. Based on an assessment aligned with a 70% performance criterion, 31 out of 40 students (77.5%) demonstrated measurable improvement in their problem-solving abilities through the activity. They successfully applied their knowledge of analytic geometry—specifically, calculating the distance between two points and determining midpoints—to simulated real-world contexts. They analyzed in-game situations to select the most appropriate coordinates, demonstrating an ability to connect abstract mathematical concepts to practical societal constraints. This gameplay context directly enabled students to transfer their thinking perspectives when navigating dilemmas, thereby fostering more robust decision-making abilities (Tsai et al., 2021).

Overall, these findings highlight the benefits of using role-playing board game activities in mathematics education. By requiring students to balance economic, environmental, and quality-of-life dimensions, the tasks encourage them to plan problem-solving steps systematically and apply mathematics to real-world scenarios.

The findings have significant implications for mathematics education. First, the "Village City" board game effectively enhances students' engagement and motivation by transforming complex problem-solving tasks into interactive and enjoyable challenges. Second, this gamified approach successfully shifts the educational paradigm from formal to informal learning, enabling students to acquire and apply mathematical skills in a relaxed and highly interactive environment. Future research should investigate the long-term effects of the "Village City" board game on students' mathematical problem-solving skills, learning motivation, and retention of analytic geometry concepts. Additionally, the implementation of the game should be extended to larger and more diverse student populations to further maximize the potential of game-based learning.

REFERENCES

Baroody, A. J., & Coslick, R. T. (1993). *Problem solving, reasoning, and communicating, K-8: Helping children think mathematically*. Macmillan.

Bayeck, R. Y. (2020). Examining board gameplay and learning: A multidisciplinary review of recent research. *Simulation & Gaming*, *51*(4), 411-431. https://doi.org/10.1177/1046878119901286

Tsai, J.-C., Liu, S.-Y., Chang, C.-Y., & Chen, S.-Y. (2021). Using a Board Game to Teach about Sustainable Development. *Sustainability*, *13*(9), 4942. https://doi.org/10.3390/su13094942

Assessment of Soil Contamination Near Municipal Waste Disposal Sites Using Handheld XRF: Implications for Land Degradation and SDG 15 in Phnom Penh, Cambodia

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Purpose and Background:

Municipal solid waste disposal sites are recognized as potential sources of environmental contamination due to the release of hazardous substances from decomposing waste, leachates, and particulate emissions. These contaminants can accumulate in nearby soils and alter soil quality, affecting terrestrial ecosystems, vegetation, microorganisms, and biodiversity. Soil contamination around landfill and waste disposal areas often involves potentially toxic elements such as Pb, Zn, Cu, Cr, Ni, and Fe. Monitoring these elements is important as they may persist in soils and contribute to long-term land degradation. The rapid urbanization and economic development in Cambodia have recently resulted in a massive increase in municipal solid waste (MSW) generation in Phnom Penh, the capital city. Recent environmental reports show that waste generation in this city routinely exceeds 2,800 to 3,000 tons per day (JICA, 2024). In this study, soil contamination associated with Dangkor municipal landfill in Phnom Penh is investigated by using a handheld X-ray fluorescence (XRF) spectrometer. Soil samples collected at varying distances from the landfill and from a low-pollution control site in the Arey Ksat public park were analyzed to determine the concentrations of potentially toxic elements (PTEs). The measured concentrations were then evaluated to assess the environmental impact of landfill activities on soil quality and land degradation.

Materials and Methods:

This study was conducted in Phnom Penh, Cambodia, to evaluate soil contamination associated with municipal waste disposal activities. A total of sixteen surface soil samples were collected by using non-probability sampling from two study sites in Phnom Penh: Dangkor landfill, representing the potentially contaminated area, and Arey Ksat public park, which served as a control site due to its relatively low human activity pollution. For the Dangkor landfill, 10 soil samples were collected using a distance-pattern sampling design: 10 m, 50 m, 100 m, 150 m and 250 m from the landfill boundary, with two replicate samples at each distance. In addition, 6 soil samples were collected from the control site, giving a total of 16 soil samples for analysis.

During sample collection, leaves, stones, and other surface debris were carefully removed to minimize contamination. Topsoil samples were collected from a depth of 0–5 cm using a clean plastic scoop, as this surface layer is the most directly affected by landfill leachate, atmospheric deposition, and other human activities. Approximately 200–300 g of soil was collected from each sampling point and stored in labeled plastic bags. The intact samples were then analyzed using a handheld XRF (Hitachi X-MET8000) in Alloy Mode with a 60 s measurement time to determine their elemental composition with several measuring points to ensure reliability and accuracy of the results.

Results and Discussion

The evaluation of soil contamination at waste disposal sites focuses primarily on PTEs, specifically As, Cd, Cr, Cu, Fe, Pb, Ni and Zn, due to their environmental persistence and severe ecological risks (Podlasek et al., 2024). Global studies on municipal sanitary landfills demonstrate that improper waste segregation, such as the disposal of e-waste and plastics, results in targeted heavy metal loading within surrounding topsoil profiles (Podlasek et al., 2024). Regionally, the data obtained from Dangkor landfill (Table 1) confirmed that these specific toxic elements frequently migrate into nearby lower-lying soils via uncontained leachate plumes and atmospheric deposition.

As shown in Table 1, the target PTEs exhibit clear localized profiles compared to the Arey Ksat control site baseline (Table 2). At the 10 m boundary, Zinc (Zn) (0.115%–0.138%) and Copper (Cu) (0.048%–0.098%) reach their absolute peaks, representing up to a 5-fold increase over the control site as illustrated in Table 2.

Arsenic (As) also peaks near the landfill (0.010%–0.030%) before dropping completely to 0.000% at 250 m. Chromium (Cr) behaves similarly, remaining restricted to the nearest 50 m zone (0.015%–0.020%). Conversely, Lead (Pb) reveals an inverted gradient, climbing from 0.023% at 10 m to its highest values at 250 m (0.028%–0.035%), suggesting secondary accumulation from off-site vehicular traffic or localized open burning.

When contrasted with previous data showing landfill impacts globally and regionally, the elevated topsoil PTE levels, particularly the prominent percentage-level Zn, Cu and As footprint, indicate ongoing, long-term metal loading. While well-managed, lined sanitary facilities keep PTE levels safely within tight margins, the raw element peaks found within the immediate vicinity of the Dangkor site underline the high vulnerability of unlined, tropical dumping areas. These high element burdens are purely human doing and highlight the urgent need for targeted containment to prevent further land degradation.

Table 1: Toxic elemental concentrations in the Dangkor landfill

Element	Atomic percentage (%) of the detected elements from the contamination site									
	L10-1	L10-2	L50-1	L50-2	L100-1	L100-2	L150-1	L150-2	L250-1	L250-2
Fe	25.020	20.53	29.978	28.443	27.153	31.880	21.973	13.135	16.385	18.898
Zn	0.115	0.138	0.083	0.065	0.078	0.095	0.065	0.045	0.030	0.033
Cu	0.098	0.048	0	0	0	0	0	0.015	0.001	0.013
Ni	0.043	0.030	0.010	0.008	0.008	0.010	0.023	0.033	0.020	0.010
As	0.025	0.010	0.005	0.010	0.030	0.018	0.01	0.008	0	0
Pb	0.023	0.033	0.008	0.005	0.010	0.018	0.015	0.005	0.028	0.035
Cr	0.020	0.020	0.020	0.015	0	0	0	0	0	0

Table 2: Toxic elemental concentrations in the Arey Ksat site

Element	Atomic percentage (%) of the detected elements from the control site					
	A1-1	A1-2	A2-1	A2-2	A3-1	A3-2
Fe	10.700	12.890	13.863	12.285	11.880	12.973
Zn	0.030	0.04	0.0375	0.025	0.035	0.0375
Cu	0	0	0	0.005	0.015	0
Ni	0.020	0.02	0.035	0.025	0.028	0.015
As	0	0.008	0.003	0.015	0	0
Pb	0.033	0.005	0.018	0.005	0.035	0.013
Cr	0	0	0	0	0.02	0

REFERENCES

Japan International Cooperation Agency. (2005). *The study on solid waste management in the municipality of Phnom Penh, Kingdom of Cambodia*. JICA.

Pheakdey, D. V. (2023). *Environmental pollutions of landfilled municipal solid waste and its energy recovery potential* [Doctoral dissertation, Hiroshima University]. Hiroshima University Repository. https://hiroshima.repo.nii.ac.jp/record/2001762/files/k9339_3.pdf.

Podlasek, A., Vaverková, M. D., Jakimiuk, A., & Koda, E. (2024). Potentially toxic elements (PTEs) and ecological risk at waste disposal sites: An analysis of sanitary landfills. *PLOS ONE*, ***19***(5). https://doi.org/10.1371/journal.pone.0303272.

Wei, J. (2021). Heavy metal pollution in the soil around municipal solid waste incinerators and its health risks in China. *Environmental Research*, *203*, Article 111658. https://doi.org/10.1016/j.envres.2021.111658.

Xaypanya, P., Takemura, J., Chiemchaisri, C., Seingheng, H., & Tanchuling, M. A. N. (2018). Characterization of landfill leachates and sediments in major cities of Indochina peninsular countries—Heavy metal partitioning in municipal solid waste leachate. *Environments*, ***5***(6). https://doi.org/10.3390/environments5060065.

ColliNest: An innovation with integrated method for the propagation and conservation of subterranean stingless bees

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Purpose and Background

Stingless bees are advanced eusocial insects that play a pivotal role in maintaining tropical biodiversity, ecological balance, and food web functions. Their honey and propolis possess potent antioxidant, antimicrobial, and anti-inflammatory properties, making them highly valuable in traditional and modern medicine. In Thailand, ***Tetragonula (Tetragonilla) collina*** has garnered significant attention as its premium products command prices 3–10 times higher than traditional honey, driving economic returns for rural communities. However, because *T. collina* exclusively inhabits complex underground cavities and termite mounds to safeguard brood cells, its artificial cultivation remains a major challenge. Consequently, these valuable products are primarily obtained via wild harvesting, an unsustainable practice that threatens the species with extinction, particularly as rapid urbanization has driven over 96% of recent global deforestation within these vital rainforest ecosystems. Based on our extensive literature review and our own observations of *T. collina* in its natural habitat is heavily bottlenecked by the extensive time worker bees require to scout and prepare subterranean sites. To mitigate these challenges, this study developed 'ColliNest' an innovative, relocatable artificial nesting system engineered to meet the species' specific structural requirements. Integrated with geographic information technology to identify optimal propagation zones, this system aims to accelerate colony growth, foster conservation efforts, and empower stakeholders toward sustainable meliponiculture in alignment with global sustainable development goals.

Methodology

Experimental design in completely randomized design (CRD) 3 replications 4 experiments.

Experiment 1: Study of behavior and internal nest structures of *T. collina.*

1.1 Investigated the maximum foraging distance of *T. collina.*

1.2 Investigated the internal structure of the nests and the population of *T.collina* by AI Detection.

Experiment 2: Development of ColliNest to induce the expansion of *T. collina* nests.

2.1 Determined the optimal type of materials for preparing the artificial nest (ColliNest).

2.2 Constructed ColliNest for inducing the expansion of stingless bee nest.

2.3 Examined the effect of the ColliNest diameters (at least 4 different diameters) on the successful integration of complete nest components.

Experiment 3: Investigation of the environmental conditions suitable for relocating *T. collina* nests

3.1 Three different areas were investigated: Forest area, community area, agriculture area.

3.2 In each area, examined the abundance of food plants within the foraging distance. Then, measured the physical factors influencing stingless bee habitation.

3.3 Used the obtained data to establish the criteria for selecting the target area for ColliNest relocation.

Experiment 4: Study of the effects of using ColliNest combined with geographic information technology system (GIS) on the success of nest relocation.

4.1 Utilized the environmental data obtained from Experiment 3, in addition to geographic and atmospheric information, to search for optimal relocation sites for ColliNest.

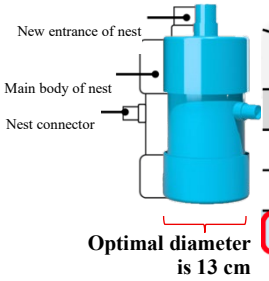
4.2 During 6 weeks following relocation, analyzed foraging activities, physical parameters, honey and propolis production.

Results and Discussion

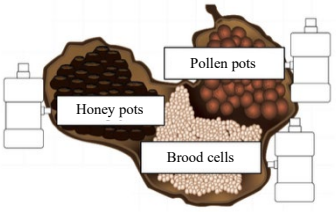
1. The maximum foraging range of 1,200 m was observed, further than the reported typical foraging range of 900 m. The nests showed consistent arrangement of components, which include pollen pots, brood cells, and honey pots. The average population size per nest was 4,318±334 bees. A higher proportion of nest components correlated with a larger population, as the numbers of pollen pots and honey pots are essential for nest expansion.

2. PVC was the most suitable material for constructing ColliNest due to its physical parameters being similar to natural nests. The most suitable positions were next to pollen pots (2), and honey pots (4), possibly because ColliNest provided extra space for food storage. By contrast, placing ColliNest next to brood cells (3) did not induce brood cells relocation, possibly due to the bees' tendency to guard their nests. **The optimal ColliNest diameter was 13 cm**, close to the natural nest's diameter. The minimum population size at this diameter was also similar to that of the natural nests (as observed in Experiment 1).

Table 1. Comparison of physical parameters within the materials



parameters / Nest Materials	Temp (°C)	RH (%)
Natural Nest	32.27 ± 0.34	60.22 ± 0.20
Bamboo	25.55 ± 0.91	73.88 ± 0.59
Clay pot	28.00 ± 0.45	55.22 ± 0.76
PVC	32.88 ± 0.97	60.66 ± 0.74



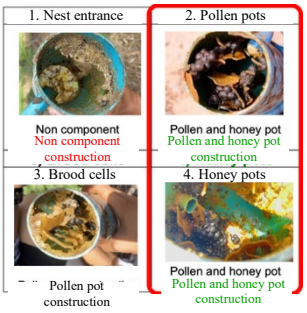


Fig 1. Effect of inducing the expansion behavior of *T.collina*

3. In every area examined, the soil around the nests was mainly clay, which effectively maintained suitable physical parameters for their habitation. In every area investigated, temperature, humidity, and light intensity were correlated with canopy density. The forest, agricultural, and community areas had average percentage of *T. collina*'s main food plants of 76.79±0.01%, 36.59±0.01%, and 52.94±0.01%, respectively. Data obtained from this investigation was used to determine the potential area for ColliNest relocation.

4. A new area was chosen for ColliNest relocation due to favorable conditions according to geographic information technology system (GIS), the data from experiment 3. During 6 weeks after the ColliNest-assisted relocation, the stingless bees exhibited high foraging rates that increased weekly, a propagation success rate of **93 %**, and the products were increased by **3.9-fold**.

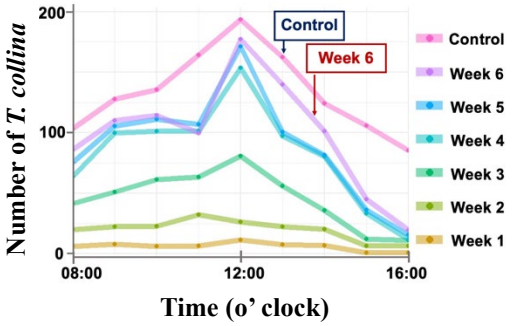
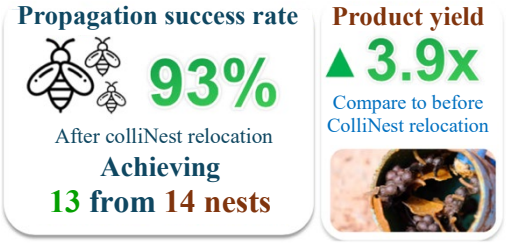


Fig 4. Foraging during 6 weeks following relocation.



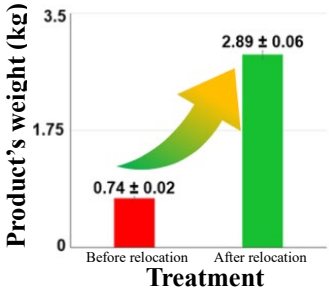


Fig 5. Propagation success rate and product yield after colliNest relocation.

REFERENCES

[1] Jongjitvimol, T., & Poolprasert, P. (2014). Pollen sources of stingless bees (Hymenoptera: Meliponinae) in Nam Nao National Park, Thailand. *NU. International Journal of Science*, 11(1), 1–14.

[2] Jongjitvimol, T., & Wattanachaiyingcharoen, W. (2007). Distribution, nesting sites and nest structures of the stingless bee species, *Trigona collina* Smith, 1857 (Apidae, Meliponinae) in Thailand. *Tropical Natural History,* 7(1), 25–34. https://doi.org/10.58837/tnh.7.1.102916

[3] Sangsawang, B., Hongyon, S., & Suppasat, T. (2016). Wing morphological analysis of *Tetragonilla collina* population from natural colonies, have several nest entrances in the different nesting area. *In Proceedings of the 8th Science Research Conference* (pp. 822–829).

[4] Suppasat, T., & Boonhin, M. (2014). Wing variation in *Tetragonilla collina* based on morphometric and geometric analysis. *In Proceedings of the 52nd Kasetsart University Annual Conference: Science* (pp. 822–829).

[5] Toledo-Hernández, E., Peña-Chora, G., Hernández-Velázquez, V. M., Lormendez, C. C., Toribio-Jiménez, J., Romero-Ramírez, Y., & León-Rodríguez, R. (2022). The stingless bees (Hymenoptera: Apidae: Meliponini): *A review of the current threats to their survival. Apidologie*, 53(1), Article 8. https://doi.org/10.1007/s13592-022-00913-w

SPATIAL DISTRIBUTION ANALYSIS OF CHLOROPHYLL-A AND SEA SURFACE TEMPERATURE IN THE FLORES SEA DURING THE 2017 SOUTHEAST MONSOON USING MODIS AQUA LEVEL 3 SATELLITE DATA

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Purpose and Background

The Flores Sea is one of the major seasonal upwelling regions in Indonesian waters and serves as an important pathway of the Indonesian Throughflow (ITF), which transports water masses from the Pacific Ocean to the Indian Ocean (Rachman et al., 2025). During the southeast monsoon, persistent southeasterly winds induce Ekman transport, allowing colder, nutrient-rich subsurface waters to rise into the euphotic zone. This upwelling process enhances nutrient availability, promotes phytoplankton growth, and increases chlorophyll-a concentration while simultaneously reducing Sea Surface Temperature (SST). Consequently, SST and chlorophyll-a are widely recognized as important indicators of seasonal upwelling and marine primary productivity.

Remote sensing observations from the Aqua MODIS satellite provide an efficient approach for monitoring the spatial distribution of SST and chlorophyll-a over large oceanic areas. Therefore, this study aims to analyze the spatial distribution of chlorophyll-a concentration and Sea Surface Temperature (SST) in the Flores Sea during the 2017 southeast monsoon using Aqua MODIS Level 3 satellite data. The spatial patterns of both parameters are compared to improving the understanding of seasonal upwelling and oceanographic conditions in the Flores Sea.

Materials and Methods:

This study was conducted in the Flores Sea, Indonesia, covering the area between 5°S–9°S and 119°E–127°E. The study area is bounded by 5°S to the north, 9°S to the south, 119°E to the west, and 127°E to the east. The Flores Sea was selected because it is one of the major seasonal upwelling regions in Indonesian waters and is influenced by the Indonesian Throughflow (ITF), making it suitable for investigating the spatial distribution of chlorophyll-a concentration and Sea Surface Temperature (SST).

Table 1. Overview of the Datasets Used in This Study

Parameter	Satellite	Period	Processing Software
Chlorophyll-a	Aqua MODIS Level 3	Jun-Aug 2017	Goggle Earth Engine, Arcmap
SST	Aqua MODIS Level 3	Jun-Aug 2017	Seadas, Arcmap

This study employed a quantitative descriptive approach to analyze the spatial variability of chlorophyll-a concentration and the spatial distribution of SST in the Flores Sea. Chlorophyll-a data processing was conducted using Google Earth Engine (GEE). The satellite data were processed to produce a seasonal chlorophyll-a distribution map representing the southeast monsoon (June–August). The processed outputs were then exported and further analyzed and visualized using ArcMap, where map layouts were prepared for interpretation. Sea Surface Temperature (SST) data were obtained from the NASA Ocean Color website in the form of Aqua MODIS Level 3 products. Monthly SST datasets for June, July, and August 2017 were processed using SeaDAS software to generate spatial distribution maps. The processed SST maps were subsequently analyzed to identify spatial temperature patterns during the southeast monsoon season and compared with the chlorophyll-a distribution to provide an interpretation of seasonal oceanographic conditions in the Flores Sea.

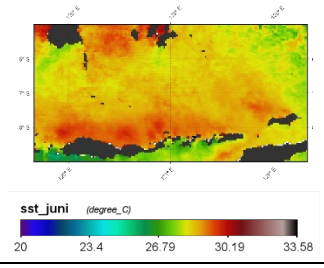
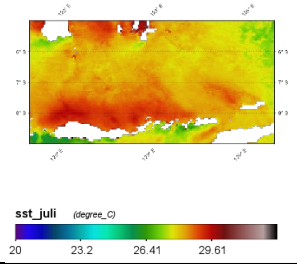
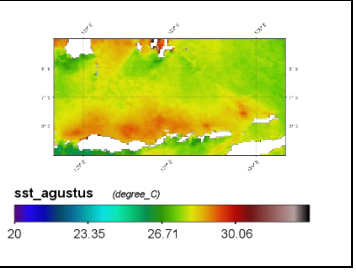
Results and Discussion

a. Sea Surface Temperature (SST)

The spatial distribution of Sea Surface Temperature (SST) during the southeast monsoon (June–August 2017) derived from Aqua MODIS Level 3 satellite data is presented in Table 2. The SST maps were visualized

using a standardized color scale ranging from 20°C to 35°C. The results indicate that the central and northern parts of the Flores Sea were dominated by relatively warm surface waters, represented by orange to reddish colors. In contrast, lower SST values were observed in the eastern and southeastern regions, which are represented by yellow to green colors. The progressive cooling observed from June to August suggests the development of seasonal upwelling, with the strongest cooling occurring in August.

Table 2. Sea Surfacte Temperature June-August 2017

SST June 2017	SST July 2017	SST August 2017
		

b. Chlorophyll-a

The spatial distribution of chlorophyll-a concentration during the southeast monsoon is shown in Image 1. Chlorophyll-a concentrations ranged from 0.100591 to 6.4639 mg.m^{-3}. Areas with higher chlorophyll-a concentrations are represented by red colors, whereas lower concentrations are shown in blue.

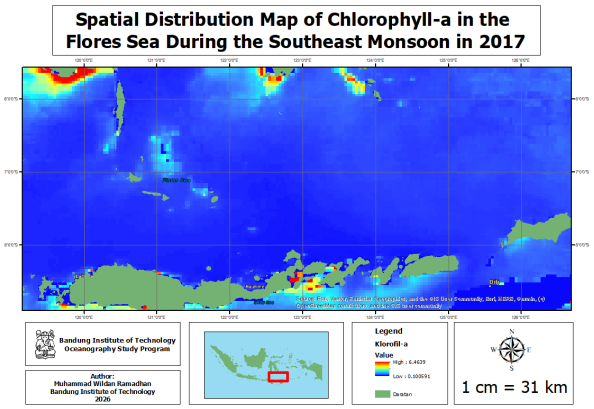


Image 1. Spatial Map of Chlorophyll-a

c. Relationship Between SST and Chlorophyll-a

The spatial distribution of Sea Surface Temperature (SST) and chlorophyll-a concentration during the 2017 southeast monsoon indicates an inverse relationship in the Flores Sea. Areas characterized by relatively low SST generally exhibited higher chlorophyll-a concentrations, whereas regions with warmer SST were associated with lower chlorophyll-a levels. This spatial pattern suggests the influence of seasonal upwelling, particularly in the eastern and southeastern parts of the Flores Sea. During the southeast monsoon (June–August), persistent southeasterly winds induce Ekman transport, causing surface waters to move offshore and allowing colder, nutrient-rich subsurface waters to rise into the euphotic zone. The increased nutrient availability stimulates phytoplankton growth, resulting in elevated chlorophyll-a concentrations (Rachman et al., 2025). Consequently, the simultaneous occurrence of lower SST and higher chlorophyll-a concentration serves as a strong indication of seasonal upwelling and enhanced marine productivity in the Flores Sea (Fikra et al., 2025).

REFERENCES

Fikra, H., Wijaya, Y. J., Kunarso, & Wisha, U. J. (2025). Studi variabilitas upwelling berdasarkan data angin, suhu permukaan laut, dan klorofil-a di Laut Flores. Indonesian Journal of Oceanography (IJOCE), 7(3), 265-274. https://doi.org/10.14710/ijoce.v7i3.27907.

Rachman, H. A., Hidayah, Z., & Yuliardi, A. Y. (2025). Dinamika suhu permukaan laut dan konsentrasi klorofil-a di perairan Laut Flores hubungannya dengan fenomena ENSO dan IOD. *Jurnal Kelautan Tropis*, *28*(1), 53-62.,. https://doi.org/10.14710/jkt.v28i1.25779.

ANALYSIS OF SCIENCE AND MATHEMATICS PISA 2022 RESULTS TO GARI 2022

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Purpose and Background:

Readiness to adopt and integrate AI has become crucial to nations to attempt to enhance educational quality and economic competitiveness (UNESCO., 2021; Barua et al., 2022). The Government AI Readiness Index (GARI) evaluates countries' preparedness in terms of policy, infrastructure, and human capital in 2022. Education systems may benefit from strong national digital infrastructure and policy support related to AI (Selwyn, 2022). The Programme for International Student Assessment (PISA) measures student achievement in reading, science, and mathematics. Countries like Singapore and Malaysia have successfully leveraged AI to improve STEM education and have seen consistent PISA score improvements (Lee et al., 2023). GARI used 39 indicators that came from public data and expert research. In the same year, the Philippines showed an improved ranking of 54th. The ranking showed that the country was doing better in areas like national strategy and data access (Oxford Insights, 2022). In the year 2024, the Philippines ranked 56th with a score of 58.51. The aim of this study is to compare countries' PISA 2022 Mathematics (PMP) and Science (PSP) mean scores with the subcomponents of GARI: Government Pillar (GGP), Technology Sector (GTS), and Data & Infrastructure (GDI) components. Second, it examines the relationship between mean PISA scores in these subjects and the total GARI score. This investigation is important for policymakers seeking to understand whether AI readiness and robust digital infrastructure support improved student outcomes in science and mathematics (UNESCO, 2021; Geng & Su, 2024).

Materials and Methods:

This study employed a quantitative, non-experimental correlational research design to examine the relationship between Government AI Readiness Index (GARI) scores for 2023 and the mean scores in Science and Mathematics from the 2022 PISA. All data used in this study are secondary data. The 2023 GARI data measures AI readiness based on three subcomponents. The 2022 PISA results for Science and Mathematics were obtained from the OECD database. Descriptive statistical analysis was conducted. The following metrics were calculated for PMP, PSP, and overall GARI (OG) score and its subcomponents (GP, TS, DI): mean, median, standard deviation, sample variance, range, minimum, maximum, skewness, kurtosis, and 95% confidence interval. The ranking process utilized Excel's RANK.EXC function. The Spearman correlation coefficient was then calculated by correlating the GARI ranks with the corresponding PISA ranks. A critical value of 0.5 was used to determine statistical significance at the 0.05 alpha level(Field, 2018). Relationships exceeding this threshold were interpreted as statistically significant and indicative of a meaningful monotonic association.

The hypothesis concerning the GARI subcomponents proposes that there may or may not be a monotonic correlation between countries' PISA 2022 Mathematics and Science mean scores and their performance on the Government Pillar, Technology Sector, or Data & Infrastructure components of GARI. (H_{10}): There is no monotonic correlation between countries' PISA 2022 Mathematics and Science mean scores and their Government Pillar, Technology Sector, or Data & Infrastructure GARI subcomponent scores.(H_{11}): There is a significant monotonic correlation between countries' PISA 2022 Mathematics and Science mean scores and their Government Pillar, Technology Sector, or Data & Infrastructure GARI subcomponent scores. Similarly, with regard to the total GARI score, the analysis examines whether there is a significant monotonic correlation with countries' PISA 2022 Mathematics and Science mean scores.(H_{20}): There is no monotonic correlation between countries' PISA 2022 Mathematics and Science mean scores and their total GARI score. (H_{21}): There is a significant monotonic correlation between countries' PISA 2022 Mathematics and Science mean scores and their total GARI score.

Results and Discussion:

The PISA median scores are close to their respective mean, but rather show that PSP has a higher mean. The PISA standard deviations reflect a wide dispersion of scores. PISA range confirms a large disparity in performance levels across countries. Skewness values near zero (+0.03 for Math, 0.03 for Science) indicate nearly symmetric distributions, and negative kurtosis values (–0.76 Math, –1.10 Science) suggest distributions that are slightly flatter than normal, with fewer extreme outliers than a typical bell curve. The confidence intervals at 95% indicates the estimated ranges where the true population means. The overall average GARI score indicates moderate AI readiness and a fairly wide spread of scores across countries. Among the subcomponents, the DI pillar has the highest mean (70.95), whereas the TS pillar has the lowest mean score (40.83) and the widest range (73.05). All GARI variables show mildly negative skewness and kurtosis. Confidence intervals at 95% suggest relatively precise mean estimates, with the narrowest band for the GP (±2.82) and the widest for TS (±3.54).

Table 1.
Spearman's Rank Correlation Coefficients Between PISA Scores and GARI Measures (n = 77)

Variables Compared	Spearman's ρ	ρ vs. α = 0.5	Significance
PSP vs. PMP	0.976*	ρ > 0.5	Significant
PSP vs. OG	0.824	ρ > 0.5	Significant
PMP vs. OG	0.800	ρ > 0.5	Significant
PSP vs. GGP	0.715	ρ > 0.5	Significant
PMP vs. GGP	0.685	ρ > 0.5	Significant
PSP vs. GTS	0.827**	ρ > 0.5	Significant
PMP vs. GTS	0.813**	ρ > 0.5	Significant
PSP vs. GDI	0.780	ρ > 0.5	Significant
PMP vs. GDI	0.754	ρ > 0.5	Significant

All three GARI components demonstrated significant monotonic correlations with both Science and Mathematics scores. For Science, the highest correlation was observed with TS ($\rho = 0.827$), followed by DI ($\rho = 0.780$) and GP ($\rho = 0.715$). For Mathematics, similarly strong correlations were found with TS ($\rho = 0.813$), DI ($\rho = 0.754$), and GP ($\rho = 0.685$). As all correlation coefficients exceeded the alpha threshold of 0.5, the null hypothesis (H_0)—stating there is no monotonic relationship—was rejected. These findings support the alternative hypothesis (H_1), affirming that a country's strength in AI governance, tech-sector development, and infrastructure is positively associated with relatively better student outcomes in STEM subjects. Assessing the correlation between PISA scores and the total GARI score—the correlations were even stronger. The PISA Science score correlated at $\rho = 0.824$, and Mathematics at $\rho = 0.800$ with the total GARI score. These results surpass the significance threshold, leading to the rejection of the second null hypothesis (H_{20}) and the acceptance of the alternative hypothesis (H_{21}).

In summary, the GARI and its subcomponents exhibit statistically significant monotonic correlations with national PISA performance in Science and Mathematics. These findings underscore the importance for governments, especially in low-performing nations, to prioritize structured, policy-driven AI integration in education.

REFERENCES:

United Nations Educational, Scientific and Cultural Organization. (2021). *AI and education: Guidance for policymakers*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000376709

Barua, P. D., Vicnesh, J., Gururajan, R., Oh, S. L., Palmer, E., Azizan, M. M., ... & Acharya, U. R. (2022). Artificial intelligence enabled personalised assistive tools to enhance education of children with neurodevelopmental disorders—a review. *International journal of environmental research and public health*, *19*(3), 1192.

Selwyn, N. (2022). The future of AI and education: Some cautionary notes. *European Journal of Education*, 57, 620–631. https://doi.org/10.1111/ejed.12532

Lee, Alwyn Vwen Yen, Elizabeth Koh, and Chee Kit Looi. "AI in education and learning analytics in Singapore" *Information and Technology in Education and Learning* 3.1 (2023): Inv-p001.

Oxford Insights. *Government AI Readiness Index* (2023) . Accessed November 20, 2024, from https://oxfordinsights.com/ai-readiness/ai-readiness-index/

OECD (2024), *PISA 2022 Technical Report*, PISA, OECD Publishing, Paris,https://doi.org/10.1787/01820d6d-en.

OECD (2019), PISA 2018 Results (Volume I): What Students Know and Can Do, PISA, OECD Publishing, Paris,https://doi.org/10.1787/5f07c754-en.

Geng, X., & Su, Y. S. (2024). Enhancing K-12 students' STEM learning through the integration of the metaverse into online and blended environments: A meta-analysis. *International Journal of Science and Mathematics Education*, *22*(Suppl 1), 111-143.

Field, A. (2018). *Discovering statistics using IBM SPSS Statistics* (5th ed.). SAGE Publications.

Students' Sensemaking in Physics Learning Innovation Integrating Machine Learning as an Epistemic Tool on Sound and Light

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Purpose and Background

Physics education aims to develop students' ability to explain natural phenomena through evidence-based reasoning. This goal is operationalized through sensemaking, the iterative process of constructing, critiquing, and revising explanations to resolve perceived gaps or inconsistencies in understanding, which encompasses an epistemic stance of figuring out mechanisms, a cognitive process of integrating knowledge resources, and the collaborative discourse in which explanations are built and challenged (Odden & Russ, 2019). Research consistently shows that students who engage in sensemaking develop deeper and more transferable understanding than those who focus on answer-seeking (Cannady et al., 2019).

Sound and Light present a particular structural challenge for sensemaking. Because wave behavior is not directly observable, students cannot draw on everyday perceptual experience when constructing mechanistic explanations. This leaves them without a ready input space for Conceptual Blending, the mechanism through which learners integrate fragmented knowledge resources (diSessa, 1993) into a coherent new understanding (Odden, 2021). Conceptual Blending requires a material anchor a concrete, manipulable representation that stabilizes an abstract conceptual structure within shared discourse (Hutchins, 2005). Without it, the Sensemaking Epistemic Game (SEG), a four-step framework of assembling a knowledge framework, noticing a gap, iteratively generating and critiquing an explanation, and reaching resolution (Odden & Russ, 2018), stalls at the first step (Sirnoorkar et al., 2023). Prior approaches using structured questioning, identity-linked reasoning, and digital experimental tools have advanced sensemaking in other contexts but have not produced the kind of shared, actionable input space that Sound and Light require.

This study proposes that machine learning (ML) can fill precisely this structural role. Kim (2022) argues that ML and science share deep epistemic parallels: both build defeasible explanations from evidence and proceed through cycles of data collection, model construction, testing, and revision that map directly onto the SEG structure. Barelli et al. (2024) further show that ML's characteristic properties, opacity that the model's internal mechanism cannot be directly inspected, uncertainty that predictions are probabilistic, and emergence that model behavior arises from the data, compel learners to question model outputs and construct their own explanations, generating the vexing questions that Odden and Russ (2019) identify as the engine of sensemaking. When students train ML models on Sound and Light data and a trained model's output conflicts with prior physics understanding, the model becomes a high-quality source of the knowledge gap that triggers. During explanation-generation, students use the model as evidence and as a testing instrument to check whether their explanation predicts further model behavior. The trained ML model thus serves as an epistemic material anchor, concrete, jointly inspectable, generative of reasoned argument, through which Conceptual Blending can proceed in a domain where it otherwise cannot. This role has not previously been designed or studied in secondary school physics on Sound and Light. This study therefore aims to develop and investigate a physics learning innovation that integrates ML as an epistemic material anchor for students' sensemaking on Sound and Light.

Materials and Methods

This study employs Design-Based Research (DBR) through four iterative phases, Grounding, Conjecturing, Iterating, and Reflecting, to develop and refine the learning innovation alongside its design principles (Hoadley & Campos, 2022). Three research questions guide the work: (RQ1) What characterizes a physics learning innovation on Sound and Light that integrates ML as an epistemic tool to support students' sensemaking? (RQ2) How does students' sensemaking unfold within this innovation according to the SEG framework? (RQ3) What role does ML play in students' epistemic moves during the sensemaking process?

The learning innovation is grounded in three theoretical mechanisms. First, under Knowledge in Pieces (diSessa, 1993), training ML on Sound and Light data forces students to simultaneously activate knowledge resources from wave physics and from the logic of ML, compelling a reorganization of fragmented knowledge that conventional instruction would not trigger. Second, under the SEG (Odden & Russ, 2018), ML output generates high-quality knowledge gaps (Step 1) when model predictions contradict physics intuition, and serves as evidence and testing instrument in the iterative explanation-construction cycle (Step 2). Third, by

creating an input space that students build and can jointly examine, the trained model and its outputs, ML enables Conceptual Blending between physics and ML knowledge to produce a shared understanding of Sound and Light unavailable through either space alone.

In the learning activities, Grade 11 students, working with two physics teachers and one technology teacher, will collect Sound and Light data, train ML models, interrogate model predictions, and collaboratively construct and critique mechanistic explanations. Data will be collected across two DBR iterations from classroom video recordings, transcripts of student group discourse including student–model interactions, worksheets and written explanations, and stimulated-recall interviews. Data will be analyzed qualitatively: thematic and cross-cycle analysis for RQ1; discourse analysis and SEG-based coding adapted for the ML-integrated context for RQ2; and epistemic-move coding for RQ3. Evidence will be triangulated across sources and iterations.

Results and Discussion

The study is currently in the Grounding and Conjecturing phases; empirical findings are not yet available. The primary outcome at this stage is the theoretically grounded learning innovation described above. Crucially, it does not use ML to deliver content or simulate phenomena passively. Instead, students act as model trainers, deciding what data to collect, constructing and evaluating ML models, and explaining what model behavior reveals about Sound and Light. ML output becomes an object of shared scientific reasoning rather than an authority supplying answers.

The study anticipates two contributions. Theoretically, it will extend the SEG framework by characterizing the specific epistemic moves that ML output enables or forecloses in each phase of the sensemaking cycle, and by specifying conditions under which an ML model functions as a material anchor for Conceptual Blending in abstract physics content. Practically, the iterative DBR cycles will produce design principles for integrating ML as an epistemic tool in secondary physics classrooms. Together, these outcomes advance understanding of ML's epistemic role in science learning and the design of environments that sustain, rather than shortcut, sensemaking.

REFERENCES

Barelli, E., Lodi, M., Branchetti, L., & Levrini, O. (2024). Epistemic insights as design principles for a teaching-learning module on artificial intelligence. *Science & Education*, *34*(2), 671–706. https://doi.org/10.1007/s11191-024-00504-4

Cannady, M. A., Vincent-Ruz, P., Chung, J. M., & Schunn, C. D. (2019). Scientific sensemaking supports science content learning across disciplines and instructional contexts. Contemporary Educational Psychology, 59, 101802. https://doi.org/10.1016/j.cedpsych.2019.101802

diSessa, A. A. (1993). Toward an epistemology of physics. Cognition and Instruction, 10(2–3), 105–225. https://doi.org/10.1080/07370008.1985.9649008

Hoadley, C., & Campos, F. C. (2022). Design-based research: What it is and why it matters. Educational Psychologist, 57(3), 207–220. https://doi.org/10.1080/00461520.2022.2079128

Hutchins, E. (2005). Material anchors for conceptual blends. *Journal of Pragmatics*, *37*(10), 1555–1577. https://doi.org/10.1016/j.pragma.2004.06.008

Kim, W. J. (2022). AI-integrated science teaching through facilitating epistemic discourse in the classroom. *Asia-Pacific Science Education*, *8*(1), 9–42. https://doi.org/10.1163/23641177-bja10041

Odden, T. O. B. (2021). How conceptual blends support sensemaking: A case study from introductory physics. Science Education, 105(6), 989–1014. https://doi.org/10.1002/sce.21674

Odden, T. O. B., & Russ, R. S. (2018). Sensemaking epistemic game. Physical Review Physics Education Research, 14(2), 020122. https://doi.org/10.1103/PhysRevPhysEducRes.14.020122

Odden, T. O. B., & Russ, R. S. (2019). Defining sensemaking: Bringing clarity to a fragmented theoretical construct. Science Education, 103(1), 187–205. https://doi.org/10.1002/sce.21452

Park, J., Teo, T. W., Teo, A., Chang, J., Huang, J. S., & Koo, S. (2023). Integrating artificial intelligence into science lessons: Teachers' experiences and views. *International Journal of STEM Education*, *10*(1), Article 61. https://doi.org/10.1186/s40594-023-00454-3

Sirnoorkar, A., Heckendorf, T., Laverty, J. T., & Caballero, M. D. (2023). Characterizing the disruption of sense-making in physics problem solving. Physical Review Physics Education Research, 19(2), 020147. https://doi.org/10.1103/PhysRevPhysEducRes.19.020147

Assessing Sentinel-2A Imagery Accuracy for Total Suspended Solid (TSS) Mapping in Mrica Reservoir, Banjarnegara, Indonesia

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Purpose and Background

Water quality is vital for sustainable resource management. In the Mrica Reservoir, Central Java, high sedimentation from the upstream Serayu Watershed threatens energy production, with Total Suspended Solid (TSS) serving as a primary indicator. High TSS degrades ecosystems, but conventional in situ monitoring faces spatial, temporal, and cost limitations. Alternatively, Sentinel-2A remote sensing offers high resolution and a 5 day revisit time for large-scale monitoring. While existing empirical TSS algorithms are site-specific and designed for environments like the Mahakam Delta, Berau Estuary, or Gili Iyang, Mrica Reservoir exhibits extreme turbidity from agricultural runoff and soil erosion. These optical properties, dominated by strong soil particulate backscattering, necessitate a localized accuracy assessment to determine the most suitable model.

Materials and Methods

1. **Study Area**

The study was conducted in the Mrica Reservoir (7°30'57" S, 109°39'30" E), Banjarnegara Regency, Central Java, Indonesia. The reservoir covers an inundation area of approximately 1,250 hectares. The primary hydrological input comes from the Serayu River in the east, which acts as the main pathway transporting high volumes of suspended sediment from the upstream watershed.

2. **Reasearch Workflow and Data Acquisition**

The workflow initiated by concurrently acquiring a Sentinel-2A Level-2A image (September 2, 2025) and 32 in situ water samples via purposive sampling (September 13, 2025). Laboratory TSS concentrations were determined using the standard gravimetric method (0.45 µm filtration and drying at 103°C–105°C). Image processing involved NDWI water body delineation and surface reflectance extraction to evaluate Parwati, Jaelani, and Syarif Budhiman empirical algorithms. Using simple linear regression, the model with the highest correlation coefficient (r) and lowest Normalized Mean Absolute Error (NMAE) was selected for spatial mapping. Notably, an 11 day acquisition time gap due to cloud cover and a vertical sediment profile bias from subsurface sampling at 30 cm depth position this study as a preliminary assessment.

3. **Image Prosessing and TSS Algorithm**

Initial image processing masked the terrestrial area to isolate the water body via the Normalized Difference Water Index (NDWI), exploiting the reflectance difference between the Green (Band 3) and Near Infrared (Band 8) bands. Following water masking, remote sensing reflectance (Rrs) values from the Blue (Band 2), Green (Band 3), and Red (Band 4) channels were extracted at the 32 field sampling coordinates. To adapt Landsat-derived empirical algorithms, Landsat's visible bands were substituted with Sentinel-2A's corresponding spectral bands sharing similar center wavelengths: Band 2 (Blue), Band 3 (Green), and Band 4 (Red).

The Syarif Budhiman algorithm, a red band exponential model originally developed for the Mahakam Delta, is formulated as:

$$TSS\ (mg/L) = 8.1429 * (exp^{(23.704*0.94*(Rrs654.59))}) \quad (1)$$

The Parwati algorithm, a red band exponential model formulated for industrial waste waters in Berau, is expressed as:

$$TSS\ (mg/L) = 3.3238 *\ exp^{(34.099*(Rrs))} \quad (2)$$

The Jaelani algorithm, a band ratio model utilizing blue and green bands developed for clear waters in Gili Iyang, is calculated as:

$$TSS\ (mg/L) = 1.5212 \left(\frac{logRrs\ Blue}{logRrs\ Green}\right) - 0.3698 \quad (3)$$

4. **Accuracy Assessment**

The estimated TSS values from the three algorithms were statistically validated against 32 in situ measurements using four performance metrics: Correlation Coefficient (r), Coefficient of Determination (R^2), Root Mean Square Error (RMSE), and Normalized Mean Absolute Error (NMAE).

Results and Discussion

1. Statistical Validation of the Empirical Algorithms

Statistical validation revealed significant disparities in algorithm performance. The Syarif Budhiman algorithm achieved the highest accuracy (r = 0.709, R^2 = 0.504) and lowest error margins among existing models, demonstrating high stability despite slight underestimations at peak turbidity. Conversely, the Parwati algorithm consistently overestimated concentrations (RMSE = 62.97 mg/L) due to its original calibration for estuarine industrial waste rather than agricultural mud runoff, while the Jaelani algorithm failed completely (r = -0.083, NMAE = 1.49) as severe signal saturation of its blue-to-green ratio yielded impossible negative values. To overcome these limitations, a new local model formulated via simple linear regression on the Sentinel-2A Red Band successfully minimized absolute and relative errors (RMSE = 29.36 mg/L, NMAE = 0.3375). Ultimately, the Syarif Budhiman algorithm was retained for final spatial mapping due to its superior overall variance explanation (R^2 = 0.504), while the local model is recommended for addressing localized extreme sediment surges.

2. Implementation of the Optimal Algorithm for TSS Mapping

Implementing the Syarif Budhiman algorithm on the September 2, 2025, Sentinel-2A imagery revealed an extreme Total Suspended Solid (TSS) spike across Mrica Reservoir, peaking at 518 mg/L near the inlet due to primary hydrological and sediment inputs. While 2017–2024 reference data based on National Water Quality Standards (PP No. 22/2021) showed the main water body consistently within Class I (≤ 25 mg/L) or Class II (≤ 50 mg/L), this 2025 surge degraded water quality to Class III (≤ 100 mg/L), with multiple areas exceeding the Class IV threshold (> 400 mg/L).

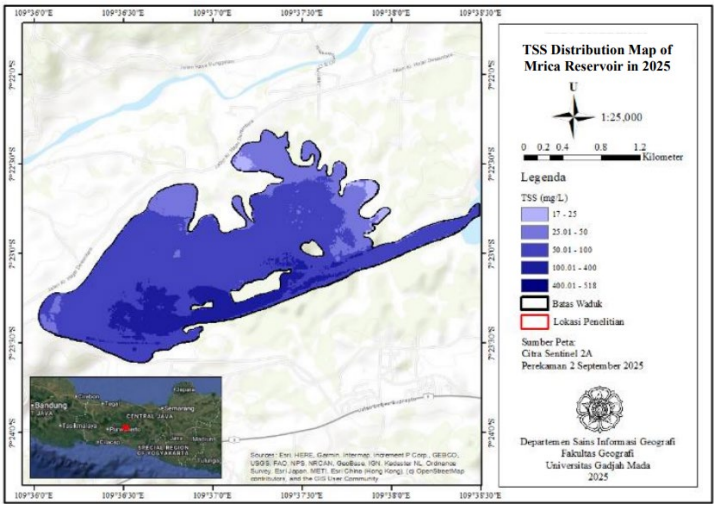

Figure 1. Total suspended solid distribution map using the Syarif Budhiman algorithm in 2025.

REFERENCES

Astuti, A., Widada, S., & Satriadi, A. (2023). Aplikasi citra Landsat multitemporal untuk analisis distribusi Total Suspended Solid (TSS) di Waduk Gajah Mungkur tahun 2012-2022. *Jurnal Penginderaan Jauh dan Sistem Informasi Geografis*, *15*(1), 45–60. https://doi.org/10.36040/semsina.v4i01.8008

Budhiman, S., Murtini, S., & Syarif, I. (2004). Study on suspended sediment distribution using remote sensing data. In *Proceedings of the 25th Asian Conference on Remote Sensing*. Asian Association on Remote Sensing.
Caballero, I., Steinmetz, F., & Navarro, G. (2018). Evaluation of the first year of operational Sentinel-2A data for retrieval of suspended solids in medium- to high-turbidity waters. *Remote Sensing*, *10*(7), 982. https://doi.org/10.3390/rs10070982

Jaelani, L. M., Limehuwey, R., Kurniadin, N., Pamungkas, A., Koenhardono, E. S., & Sulisetyono, A. (2016). Estimation of TSS and Chl-a concentration from Landsat 8-OLI: The effect of atmosphere and retrieval algorithm. *IPTEK, The Journal for Technology and Science*, *27*(1), 16–23. https://doi.org/10.12962/j20882033.v27i1.1217

Parwati, E., & Purwanto, A. (2017). Time series analysis of Total Suspended Solid (TSS) using Landsat data in Berau coastal area, Indonesia. *International Journal of Remote Sensing and Earth Sciences*, *14*(1), 61–70. https://doi.org/10.30536/j.ijreses.2017.v14.a2676

ASSESSING OCEAN THERMAL ENERGY CONVERSION (OTEC) POWER POTENTIAL IN THE NORTH BALI SEA: THERMAL VARIABILITY AND ENSO-INDUCED IMPACTS

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Purpose and Background:

One of the most promising ocean energy technologies is Ocean Thermal Energy Conversion (OTEC), which utilizes a temperature difference of ≥ 20°C between the warm ocean surface and the colder deep sea (Neill and Hashemi, 2018). The seas around Bali have high OTEC potential due to this met temperature difference. Furthermore, Bali particularly Buleleng Regency which is near to the North Bali Sea has a high population of approximately 820.480 people (2025). As one of the world's most popular international tourist destination, Bali also has a high electricity demand, providing a strong rationale for OTEC development. Bali is also part of the electricity interconnection network with Java, known as 'JAMALI'. Therefore, if an OTEC power plant is developed on Bali Island, the generated electricity is expected to support the power supply for both Java and Bali. This study aims to evaluate the potential net power output of OTECand examine the influence of ENSO on OTEC performance, thereby assessing its potential to provide a reliable long term electricity supply.

Materials and Methods:

The study area is located in the North Bali Sea at 8°0'56.8"S, 115°9'54.5"E, approximately 5.375 kilometers from the nearest coastline (Figure 1 - Left, the white area indicates the absence of data). Ocean temperature data from 2015 to 2025 were utilized to capture the effects of the ENSO and IOD phenomena. The temperature data were obtained from the Copernicus GLORYS12V1 reanalysis product at surface and a depth of 763 meters, which was selected for deep-ocean temperatures based on the vertical profiles of the selected site (Figure 1 – Right)

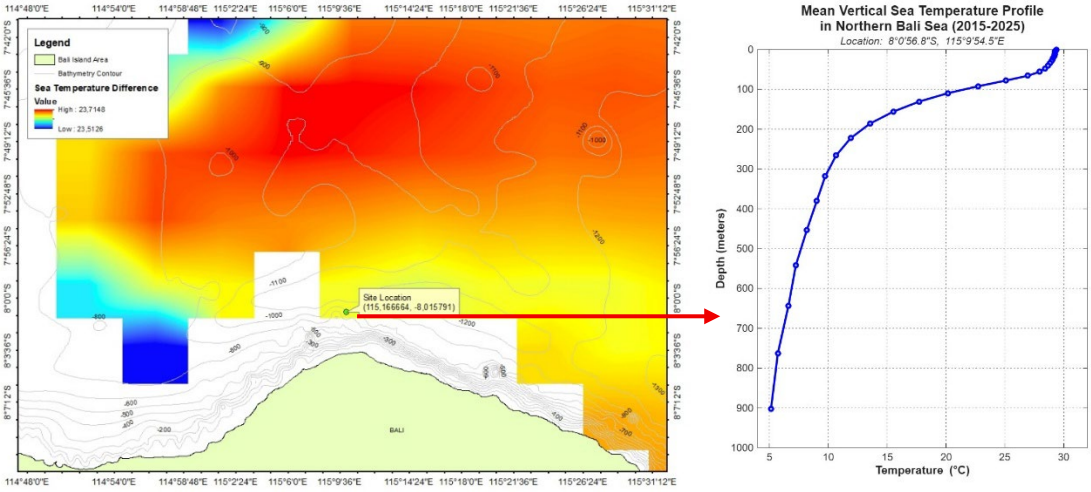

Figure 1 Spatial Distribution of Temperature Differences in the Northern Bali Sea (Left) and Vertical Profile of the Selected Site (Right)

The net power was calculated using the Nihous Temperature Ladder framework (Nihous, 2007) as follows:

$$Pnet = \frac{Q_{cw}\rho c_p 3\gamma_{tg}}{8T}\left\{\frac{3\gamma}{2(1+\gamma)}\Delta T^2 - 0.18\Delta T^2{}_{design} - 0.12\left(\frac{\gamma}{2}\right)^{2.75}\Delta T^2{}_{design}\right\}$$

With a cold water flow rate of 28.09 m³/s, a warm water flow rate of 16.84 m³/s, and a turbine-generator thermal efficiency of 85% from Firdaus et al. (2026) as the reference for the OTEC power plant used.

Results and Discussion

Data from 2015 to 2025 show that the temperature difference between the surface and the deep ocean consistently exceeds 20°C (Figure 2 - Left). The average OTEC capacity is 68.05 MW, peaking at 82.00 MW (Figure 2 - Right). From mid-2015 to early 2016, the ONI value surged dramatically, peaking between +2.6 and +2.8, which falls within the Super El Niño category. This strong El Niño cooled Sea Surface Temperatures (SST) in Western and Central Indonesia due to the weakening of the Western Pacific Warm Pool. Consequently, the temperature gradient (ΔT) between the surface and deep waters in North Bali decreased substantially, reducing the generated power to a minimum of approximately 52.76 MW.

In contrast, a triple-dip La Niña phenomenon occurred from mid-2020 through mid-2022, with ONI intensities ranging from -0.8 to -1.2. During this period, the annual trend (represented in red) increased steadily and remained in the upper range between 68 and 69 MW, while the monthly fluctuations (represented in black) rarely fell below 60 MW. Interestingly, the maximum power output occurred in early 2016 (around January–February). Other significant peaks approaching this maximum were observed in late 2016 (~81 MW) and from late 2023 to early 2024 (~79 MW). Although these peaks occurred during El Niño years (early 2016 and early 2024), they may have been driven by strong local monsoon patterns which temporarily transports warm surface waters from the Java Sea into the North Bali Sea. This suggests that a possible lag time—the duration required for temperature anomalies in the Pacific Ocean to propagate through Indonesian Throughflow (ITF)—plays a critical role. In conclusion, the North Bali Sea holds great potential for OTEC development, as the minimum 20°C temperature difference is consistently met throughout the year, ensuring reliable and stable power generation under both El Niño and La Niña conditions.

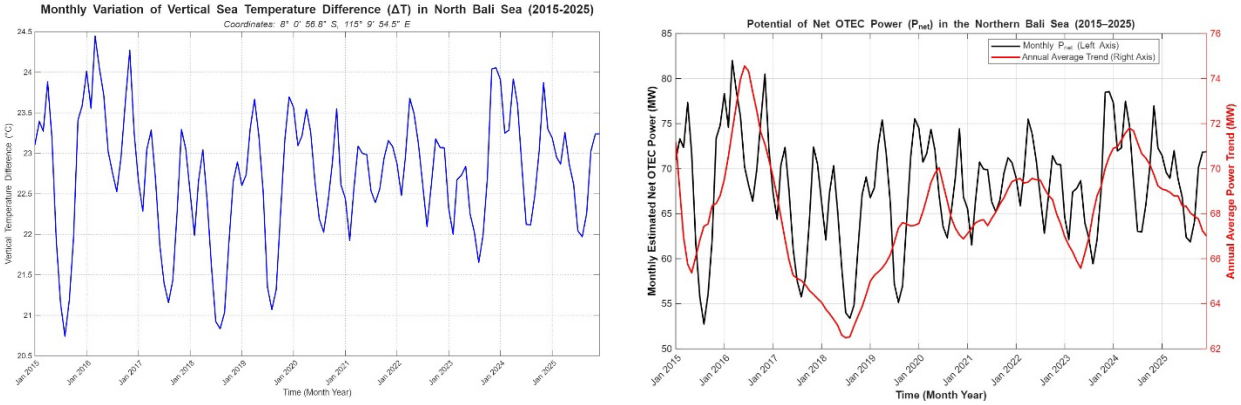

Figure 2 Monthly Variation of Vertical Sea Temperature Difference (Left) and Potential of Net OTEC Power (Right) in Northern Bali Sea from 2015 to 2025

REFERENCES

Firdaus, A. M., Phady, A., & Adiputra, R. (2026). Techno-Economic Integration of OTEC Thermodynamic Cycles with the Development of Floating Prototype Model in North Bali. Results in Engineering, 111479.

Neill, S. P., & Hashemi, M. R. (2018). Fundamentals of ocean renewable energy: generating electricity from the sea. Academic Press.

Nihous, G. C. (2007). A Preliminary Assessment of Ocean Thermal Energy Conversion Resources. Journal of Energy Resources Technology, 129(1), 10–17. https://doi.org/10.1115/1.2424965

Reducing Greenhouse Gas Emissions through Household Food Waste Composting: A Case Study of Lopburi Province, Thailand

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Background

In Thailand, organic waste accounts for a large proportion of municipal solid waste. Improper disposal of food waste not only increases waste management costs but also contributes significantly to greenhouse gas emissions (Krutprong, n.d.). Composting is considered a sustainable alternative because it converts organic waste into valuable fertilizer while reducing the amount of waste sent to landfills (Krutprong, n.d.). This report summarizes a study conducted in Lopburi Province, Thailand, which investigated household food waste generation and evaluated the potential reduction of greenhouse gas emissions through food waste composting (Krutprong, n.d.).

Methodology

The study was conducted in both urban and rural communities in Lopburi Province. A total of 600 households participated in the research. Data were collected over a four-week period, during which householdswere asked to separate and weigh their food waste daily.

Food waste was measured before and after water removal to obtain accurate estimates of solid organic waste generation. The collected data were analyzed to determine the average food waste generation rate per person per day. In addition, statistical analyses were performed to compare food waste generation between urban and rural households and to examine the relationship between household income and food waste production.

The greenhouse gas reduction potential was estimated using the Thailand Voluntary Emission Reduction Program (T-VER) methodology.

Results

The results indicated that the average food waste generation rate before water removal was 0.431 kilograms per person per day. After water removal, the average generation rate decreased to 0.266 kilograms per person per day (Krutprong, n.d.).

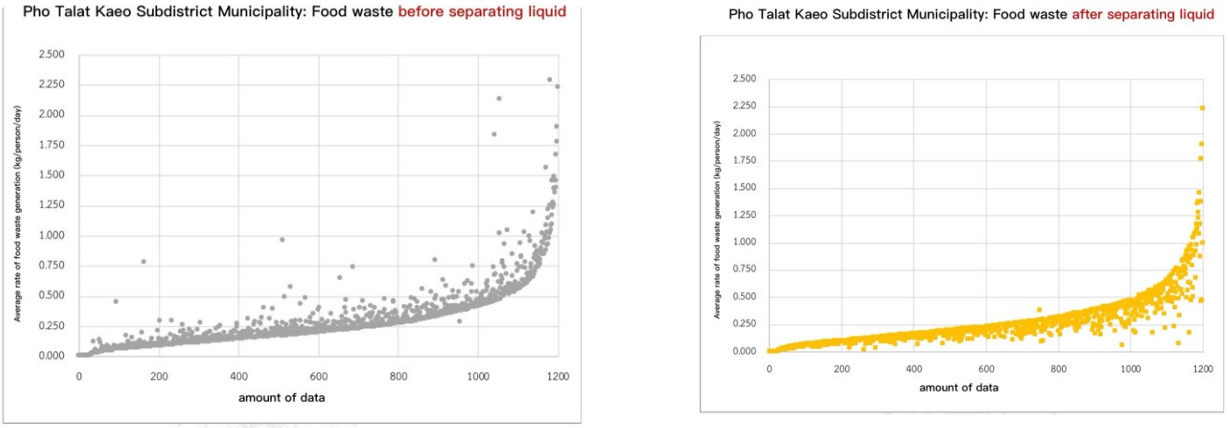

Figure 1. Food waste generation rates in Pho Talat Kaeo Subdistrict Municipality before and after liquid separation, showing a reduction in food waste weight after the removal of excess liquid.

Statistical analysis revealed significant differences in food waste generation between urban and rural households. These findings suggest that lifestyle, consumption patterns, and community characteristics influence the quantity of food waste produced (Krutprong, n.d.). Furthermore, household income was found to be significantly associated with food waste generation, indicating that socioeconomic factors affect food purchasing and disposal behaviors (Krutprong, n.d.).

Using the T-VER methodology, the study estimated that if all households in Lopburi Province separated food waste and converted it into compost rather than disposing of it in landfills, greenhouse gas emissions could be reduced by approximately 6,499 tons of carbon dioxide equivalent (tCO_2e) per year (Krutprong, n.d.).

Discussion

The findings demonstrate that source separation and composting can serve as effective strategies for reducing greenhouse gas emissions from household waste. By diverting food waste from landfills and processing it through composting, methane emissions can be substantially reduced (Krutprong, n.d.). Furthermore, the study revealed that the measured weight of food waste decreased considerably after water removal, indicating that moisture content contributes significantly to the total amount of household food waste. This finding highlights the importance of considering water content when assessing food waste generation and planning waste management strategies. Accurate measurement of food waste can support more effective composting programs and improve estimates of greenhouse gas reduction potential (Krutprong, n.d.).

The study also emphasizes the importance of household participation in waste management programs. Since food waste generation varies according to household income and community characteristics, educational campaigns and public awareness initiatives may help reduce unnecessary food waste and encourage proper waste segregation practices (Krutprong, n.d.). In addition, compost produced from food waste can improve soil quality and reduce dependence on synthetic fertilizers, providing additional environmental benefits (FAO, 2011).

REFERENCES

Food and Agriculture Organization. (2011). *Global food losses and food waste: Extent, causes and prevention*. FAO.

Krutprong, W. (n.d.). *Reducing greenhouse gas emissions from household food waste composting: A case study of Lopburi Province, Thailand*. Department of Environmental Engineering, Chulalongkorn University.

SPATIOTEMPORAL ANALYSIS OF FOREST COVER CHANGE IN JAMBI PROVINCE (2000–2024) USING HANSEN GLOBAL FOREST CHANGE DATA

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Purpose and Background

Deforestation in Indonesia is significantly driven by oil palm plantation expansion, accounting for roughly one-third (3 million hectares) of the country's total old-growth forest loss, while Indonesia remains the world's largest palm oil exporter (Trase, 2024). Jambi Province exemplifies complex land-use conversion dynamics in Sumatra, where oil palm expansion largely occurred on former rubber and fallow land rather than through direct conversion of primary forest (Gatto et al., 2015). Forest loss in this study refers to stand-replacement disturbance at the Landsat pixel scale (Hansen et al., 2013). Although deforestation in Jambi has been studied up to the early 2010s, quantitative documentation for the period 2013–2024 remains scarce. This study therefore aims to (1) calculate the annual deforestation rate in Jambi Province over 2000–2024, and (2) identify its spatiotemporal patterns.

Materials and Methods

This study used Hansen Global Forest Change v1.12 (2024 release) from the University of Maryland (Hansen et al., 2013), comprising three layers: treecover2000, lossyear, and gain, on tile 00N_100E at 30-meter spatial resolution. The administrative boundary was sourced from the Geospatial Information Agency (BIG, 2024). Forest was defined as pixels with canopy cover of 75% or above in 2000. All rasters were cropped and masked to the provincial boundary in R (terra and sf packages), with pixel area converted at 0.09 ha/pixel. The lossyear layer was then tabulated annually to produce a time-series of forest loss from 2001 to 2024, enabling both aggregate area calculation and year-by-year trend analysis across the province. Because the gain layer in Hansen GFC v1.12 only captures regrowth detected through 2012, gain estimates in this study are reported for 2000–2012 only, while loss estimates cover the full 2001–2024 period.

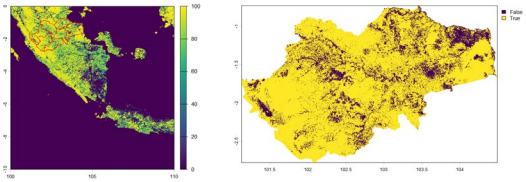

Figure 1. Year-2000 canopy cover at the regional Sumatra scale with the Jambi provincial boundary, and the resulting binary forest/non-forest classification.

Results and Discussion

Jambi Province's forest cover stood at 4,601,872 ha in 2000 and declined to 2,418,827 ha by 2024, a loss of 2,183,046 ha (47.44%) at an average rate of 90,960 ha/year (2.64%/year). The sum of remaining forest and cumulative loss (4,601,873 ha) matches the 2000 baseline to within 1 ha. Forest regrowth (gain) was recorded at 546,474 ha, but only through 2012 per Hansen's gain layer, and is reported here as context rather than netted against loss. This indicates nearly half of Jambi's 2000 forest cover was converted within 24 years, faster than the global average loss of 100 million hectares over 2000–2020 (United Nations, 2025).

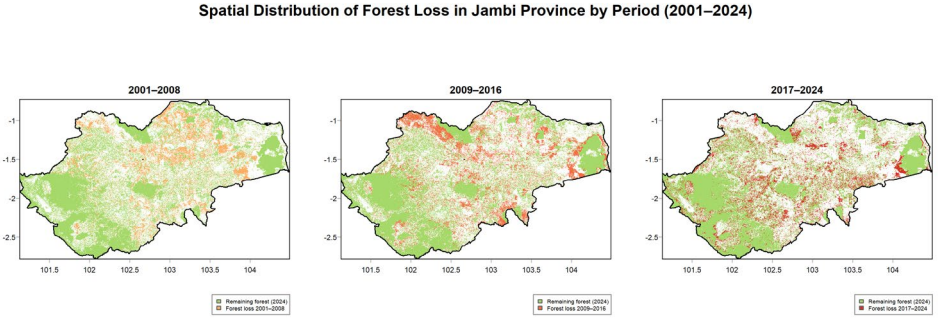

Figure 2. Spatial distribution of forest loss in Jambi Province by period: (a) 2001–2008, (b) 2009–2016, (c) 2017–2024. Green indicates forest remaining as of 2024; colored pixels indicate forest loss occurring within each respective period. Data: Hansen Global Forest Change v1.12 (2024).

Annual trend analysis reveals a non-linear pattern of forest loss. The lowest annual loss was recorded in 2003 (24,025 ha), likely reflecting low commodity prices following the late-1990s economic crisis. Loss then increased through 2006–2009, exceeding 130,000 ha/year, consistent with accelerating oil palm expansion on former rubber and fallow land (Gatto et al., 2015). Two sharp peaks occurred in 2012 (171,998 ha, the highest in the study period) and 2016 (168,412 ha), aligning respectively with record national oil palm expansion (Nusantara Atlas, 2024) and the delayed satellite detection of 2015 El Niño-driven fires (Field et al., 2016). Following 2016, loss declined but remained substantial, fluctuating between 70,000–96,000 ha/year through 2024.

Spatially, the distribution of forest loss across the three sub-periods (Figure 2) reveals a shift in clearing pattern over time. In 2001–2008 (719,162 ha, 32.9% of total loss), loss was concentrated in two dense clusters: a large block across the central part of the province and a second cluster in the east, while the western and southern districts remained largely forested. In 2009–2016 (803,588 ha, 36.8% of total loss, the highest of the three periods), clearing shifted markedly toward the northern boundary of the province, forming a continuous belt of loss along the upper edge, alongside persistent clearing in the east and emerging loss in the southeast. By 2017–2024 (660,296 ha, 30.2% of total loss), the pattern changed again: rather than forming large contiguous blocks, loss became finely dispersed across nearly the entire province, including western districts that had remained largely intact in earlier periods. This progression, from spatially concentrated clearing in the early period to a diffuse, province-wide pattern by 2017–2024, is consistent with frontier deforestation dynamics in which initial large-scale conversion in accessible forest blocks is followed by smaller, more dispersed clearing as remaining forest patches become fragmented and increasingly exposed at their edges.

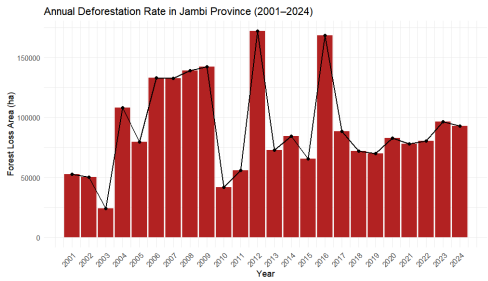

Figure 3. Annual deforestation trend in Jambi Province, 2001–2024.

REFERENCES

Field, R. D., van der Werf, G. R., Fanin, T., Fetzer, E. J., Fuller, R., Jethva, H., Levy, R., Livesey, N. J., Luo, M., Torres, O., & Worden, H. M. (2016). Indonesian fire activity and smoke pollution in 2015 show persistent nonlinear sensitivity to El Niño-induced drought. *Proceedings of the National Academy of Sciences*, 113(33), 9204–9209. https://doi.org/10.1073/pnas.1524888113

Gatto, M., Wollni, M., & Qaim, M. (2015). Oil palm boom and land-use dynamics in Indonesia: The role of policies and socioeconomic factors. *Land Use Policy*, 46, 292–303. https://doi.org/10.1016/j.landusepol.2015.03.001

Geospatial Information Agency [Badan Informasi Geospasial]. (2024). *Administrative boundary of Jambi Province* [Shapefile]. https://tanahair.indonesia.go.id

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. *Science*, 342(6160), 850–853. https://doi.org/10.1126/science.1244693

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., & Townshend, J. R. G. (2024). *Global Forest Change 2000–2024, v1.12* [Data set]. University of Maryland. https://storage.googleapis.com/earthenginepartners-hansen/GFC-2024-v1.12/download.html

Nusantara Atlas. (2024). *2023 marks a surge in palm oil expansion in Indonesia*. https://nusantara-atlas.org/2023-marks-a-surge-in-palm-oil-expansion-in-indonesia/

Trase. (2024). *Indonesian palm oil exports and deforestation*. Stockholm Environment Institute. https://trase.earth/insights/indonesian-palm-oil-exports-and-deforestation

United Nations. (2025). Goal 15: Forests, desertification and biodiversity. United Nations Sustainable Development. https://www.un.org/sustainabledevelopment/biodiversity/

Grade 9 Students' Creativity and Innovation Skills in Motor-based Innovation Design

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Purpose and Background

Creativity is an essential competency in science education because learners are expected to generate ideas, improve ideas, and apply scientific knowledge to unfamiliar real-world situations. It involves divergent thinking, originality, and meaningful knowledge application, while innovation requires transforming creative ideas into concrete products, designs, or solutions (Guilford, 1950; Runco & Acar, 2012; OECD, 2023; Pinar et al., 2025). Student-centered approaches, such as STEM/STEAM education, design-based learning, and engineering design process, can support these skills by engaging students in generating solutions, considering constraints, and developing tangible outcomes (Bozkurt Altan & Tan, 2021; Filipe et al., 2024; Li, 2026; Ozkan & Topsakal, 2021).

In Thai classroom contexts, students may have limited opportunities to express scientific creativity, especially when learning emphasizes content knowledge or when resources for complex projects are limited. Previous Thai studies suggest that creativity and innovation competency requires free thinking, group communication, and the creation of concrete and useful innovations (Hommai et al., 2024). However, less is known about how lower secondary students demonstrate creativity and innovation skills when redesigning familiar everyday objects under a simple scientific constraint, such as incorporating a motor into their design.

To address this gap, this study implemented a motor-based everyday object innovation design activity in a Grade 9 Basic Scientific Innovation course. Students explored everyday objects, proposed additional useful functions, discussed their ideas in groups, and developed an innovation design requiring a motor as a key component. This study aimed to characterize Grade 9 students' creativity and innovation skills in terms of idea fluency and flexibility, originality and usefulness, scientific application, and Elaboration and feasibility.

Materials and Methods

This study was conducted in a Grade 9 Basic Scientific Innovation course. The participants were 48 students working in eight groups of six students. The activity consisted of three stages: (1) exploring familiar everyday objects, , such as umbrellas, trash bins, bags, and water bottles (2) proposing additional useful functions, and (3) developing one selected idea into a motor-based innovation design with science-related concepts, such as motion, electricity, energy transfer, and mechanisms.

Data were collected from students' worksheets, group design sketches, written explanations, classroom observations, and presentations. The data were analyzed qualitatively using four dimensions of creativity and innovation skills adapted from divergent thinking, creative thinking, and design-based learning perspectives. (Bozkurt Altan & Tan, 2021; Guilford, 1950; Li, 2026; OECD, 2023; Runco & Acar, 2012) (1) Idea fluency and flexibility were based on divergent thinking indicators, which focus on the number and variety of ideas, (2) Originality and usefulness were linked to the generation of creative, appropriate, and valuable ideas, as well as the evaluation and improvement of ideas, (3) Scientific/technical application focused on students' use of science-related concepts, and (4) Elaboration and feasibility focused on how students developed their ideas into tangible, useful, and practical innovation designs. To enhance trustworthiness, data from worksheets, sketches, explanations, presentations, and observations were compared.

Results and Discussion

The analysis of students' worksheets, design sketches, written explanations, and presentations revealed four main characteristics of students' creativity and innovation skills, as summarized in Table 1.

Table 1. Summary of students' creativity and innovation skills

Dimension	Evidence from students' work	Interpretation
Idea fluency and flexibility	Students proposed various ideas from everyday objects, such as combs, bottles, umbrellas, tables, bags, trash bins, and lighting devices.	Everyday objects helped students generate diverse ideas across different functional categories.

Dimension	Evidence from students' work	Interpretation
Originality and usefulness	Many ideas added useful functions, such as temperature control, drying, cleaning, automatic opening, safety warning, storage improvement, and user assistance.	Students' creativity was mainly shown through practical functional improvement.
Scientific application	Motors were used for movement, rotation, airflow, drying, cooling, automatic opening, and mechanical operation. Some groups also mentioned electricity, energy transfer, solar cells, sensors, or mechanisms.	The motor constraint encouraged students to connect innovation design with science-related concepts, although some explanations remained general.
Elaboration and feasibility	Some groups produced clear sketches with product names, target users, functions, and operating processes, while others provided limited technical details.	Students showed emerging ability to develop ideas into tangible designs but needed more support in explaining feasibility and mechanisms.

The analysis revealed three main findings. First, students demonstrated creativity by improving familiar objects rather than inventing entirely new products. Their ideas included automatic movement, cleaning, drying, temperature control, warning systems, object tracking, storage improvement, and user assistance. Second, most ideas emphasized practical usefulness, such as reducing effort, saving time, improving safety, supporting hygiene, and increasing convenience, However, the level of originality varied; some ideas extended existing smart devices, while others combined familiar objects with new functions in more creative ways. Third, the motor requirement encouraged students to connect their designs with technical functions, such as rotation, movement, airflow, drying, automatic opening, and mechanical control. Some groups also mentioned electricity, energy transfer, solar cells, sensors, or mechanisms. Nevertheless, several explanations focused more on what the product could do than how the motor or scientific principles made it work.

Overall, the activity helped students begin creative thinking from familiar objects and everyday problems, while the motor constraint linked innovation design with science-related concepts. Students showed stronger evidence of idea generation and usefulness than scientific explanation and feasibility analysis. Therefore, future activities should provide more scaffolding for explaining mechanisms, evaluating feasibility, and testing prototypes.

In conclusion, motor-based everyday object innovation design provided opportunities for Grade 9 students to demonstrate creativity and innovation skills. Students generated diverse and useful ideas, while the motor constraint encouraged connections between design and science-related concepts. Future activities should include scaffolding for mechanism explanation, feasibility evaluation, and prototype testing.

REFERENCES

Bozkurt Altan, E., & Tan, S. (2021). Concepts of creativity in design-based learning in STEM education. *International Journal of Technology and Design Education, 31*, 503–529. https://doi.org/10.1007/s10798-020-09569-y

Guilford, J. P. (1950). Creativity. *American Psychologist, 5*(9), 444–454. https://doi.org/10.1037/h0063487

Hommai, A., Anuworrachai, S., & Pongsophon, P. (2024). Development of grade 10 students' creativity and innovation competency through creating plant hormone comics. *Journal of Research Unit on Science, Technology and Environment for Learning, 15*(2), 194–211.

Li, X. (2026). Effects of engineering design-based science on students' STEM competence and engineering design behaviors. *International Journal of Technology and Design Education, 36*, 663–684. https://doi.org/10.1007/s10798-025-10011-4

Ozkan, G., & Umdu Topsakal, U. (2021). Exploring the effectiveness of STEAM design processes on middle school students' creativity. *International Journal of Technology and Design Education, 31*, 95–116. https://doi.org/10.1007/s10798-019-09547-z

OECD. (2023). *PISA 2022 assessment and analytical framework*. OECD Publishing. https://doi.org/10.1787/dfe0bf9c-en

Pinar, F. I. L., Panergayo, A. A. E., Sagcal, R. R., Acut, D. P., Roleda, L. S., & Prudente, M. S. (2025). Fostering scientific creativity in science education through scientific problem-solving approaches and STEM contexts: A meta-analysis. *Disciplinary and Interdisciplinary Science Education Research, 7*, Article 18. https://doi.org/10.1186/s43031-025-00137-9

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal, 24*(1), 66–75. https://doi.org/10.1080/10400419.2012.652929

Fabricating liquid thermometers from recycled materials and teaching application in Natural Science subject under STEM education orientation

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Purpose and Background

In the context of modern education in Vietnam, the 2018 General Education Program has shifted the focus of the Natural Sciences subject from mere knowledge transmission to a competency- and quality-development approach through practical and experiential activities (Ministry of Education and Training, 2018). STEM education plays a core role in fostering creative thinking and problem-solving skills through the interdisciplinary integration of thematic strands, including *Earth and Space, Matter and Material Changes, Living Organisms, and Energy and Changing Form.*

This study proposes a procedure for fabricating liquid thermometers from recycled materials and its pedagogical application in organizing the instructional topic *"Fabricating a Simple Liquid Thermometer"* for middle school students. The pedagogical process is developed based on David Kolb's (2014) experiential learning theory combined with the orientation of STEM education in Vietnam, aiming to establish an active learning environment. By self-fabricating thermometers, students gain a profound understanding of the principle of thermal expansion of liquids, while simultaneously developing learner competencies, linking lessons to real-world contexts, and fostering an awareness of environmental resource recycling. Through empirical experimentation, the project demonstrates the efficacy of the experiential education model in enhancing learners' competencies and qualities, thereby contributing to the innovation of STEM-oriented instructional methodologies for middle school students.

Materials and Methods

This study employs a pedagogical experimentation approach combined with a mixed-methods research design incorporating both quantitative and qualitative methods. The research framework is organized into three sequential phases: (1) Systematizing the theoretical foundations and proposing the fabrication procedure for liquid thermometers; (2) Implementing the teaching activity on the topic*"Fabricating a Simple Liquid Thermometer"* with two groups of students; and (3) Evaluating post-experimental efficacy through pre- and post-tests, as well as rubric-based assessments evaluating product criteria and learner competencies. The participants comprise 50 eighth-grade students of equivalent academic performance, divided into an experimental group (receiving STEM-oriented instruction) and a control group (receiving traditional instructional methods). The collected data are analyzed using mathematical and statistical tools to visualize results, determine students' development levels, and verify adherence to the research design.

Results and Discussion

The Process of Fabricating liquid thermometers from recycled materials.

A thermometer is a temperature-measuring instrument that operates based on the principle of thermal expansion of liquids, typically utilizing alcohol as the thermometric fluid due to its high sensitivity to temperature fluctuations (d'Alembert, 2017). According to Genovia et al. (2016), thermometers can be constructed from recycled materials or simple laboratory apparatus. On this basis, the present study fabricated a thermometer model using accessible materials, including plastic bottles, water, medical alcohol, color indicators, funnels, clay, and plastic straws. The experimental procedure was standardized through four distinct stages: (1) Preparation of the thermometric indicator solution; (2) Assembly of the thermometer; (3) Testing in hot and cold environments; and (4) Calibration of the liquid level at room temperature.

The Teaching Process based on David Kolb's experiential learning theory, combined with STEM education orientation in Vietnam.

The teaching process is designed based on David Kolb's four-stage experiential learning cycle and the STEM education orientation in Vietnam, including the following five specific activities:

Activity name	Experimental group (EG)	Control group (CG)
Activity 1: *Problem Formulation and Idea Generation*	- Teacher: Poses a real-world problem and open questions - Students: Answers questions; defines liquid thermometer requirements.	- Teacher: Introduces the *"Thermal Expansion"* lesson. - Students: Reviews prior knowledge of thermometers and temperature.
Activity 2: *Studying background knowledge*	- Students: Studies materials on thermal expansion and thermometer principles. - Teacher: Provides reference materials.	- Teacher: Lectures on the mechanism of liquid thermal expansion. - Students: Takes notes and completes

		exercises.
Activity 3: *Product Proposal and Design*	- Students: Proposes fabrication methods and drafts the design. - Teacher: Gives feedback and approves the design	- Teacher: Introduces the thermometer and demonstrates how to read it. - Students: Follows step-by-step instructions.
Activity 4: *Product manufacturing, testing, and refinement*	- Students: Works in groups to build, test, calibrate and optimize products. - Teacher: Observes and guides students.	- Teacher: Conducts a demo experiment on liquid thermal expansion. - Students: Performs hands-on experiment following guidance.
Activity 5: *Reporting, Evaluation, and Extension*	- Students: Showcases products, presents processes and peer-assesses. - Teacher: Gives feedback and delivers a final summary.	- Students: Completes application exercises. - Teacher: Grades assignments, gives feedback and summarizes.

Table 1: Description of Teacher and Student Activities in the Experimental and Control Groups Project-based learning on the topic "Fabricating a Simple Liquid Thermometer".

The topic *"Fabricating a Simple Liquid Thermometer"* enables students to apply knowledge of temperature, the Celsius scale, thermometer structures, thermal expansion, and thermal conduction to self-fabricate learning tools, thereby developing natural science competencies and bridging the gap between theory and practice. The pedagogical experiment was conducted with 50 students of equivalent academic performance, divided into an experimental group (EG) and a control group (CG). The teacher implemented the instruction in accordance with the proposed pedagogical process; the efficacy of the lesson was evaluated through pre- and post-tests, as well as the quality of students' assessment rubrics.

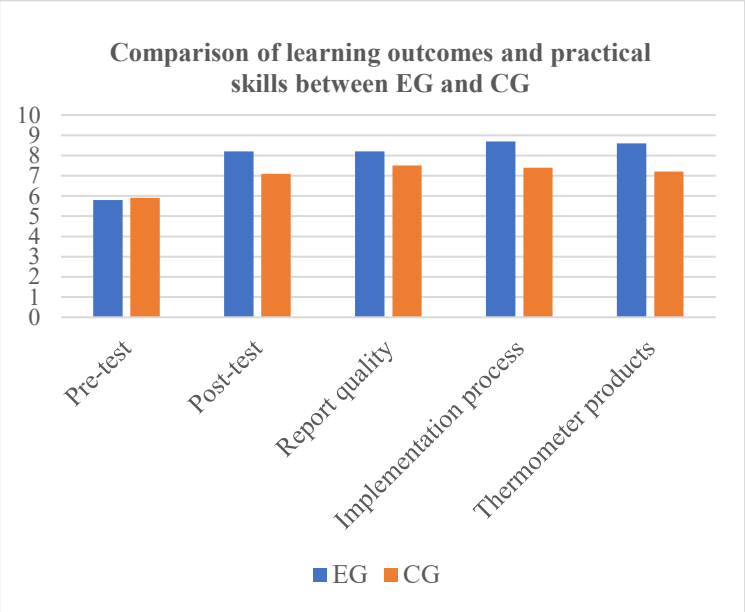

Table 2: Learning Outcomes and Practical Skills of EG, CG

Empirical data show a significant difference in efficacy between the two methods. While pre-test mean scores (EG: 5.8 vs. CG: 5.9) confirm identical baseline cognitive abilities, the post-test reveals a significant shift, with the EG scoring higher (8.2) than the CG (7.1). This statistical evidence indicates that experiential learning enhances foundational knowledge and real-world application skills.

The EG outperformed the CG across all three rubric criteria. Explaining physical product mechanisms fostered students' critical thinking, teamwork, and problem-solving. In contrast, the CG-reliant on teacher-led demos and lectures-only attained an upper-intermediate proficiency level in both behavior indicators and product quality.

Findings confirm that teaching *"Fabricating a Simple Liquid Thermometer"* via a STEM approach integrated with Kolb's theory boosts learning quality and fosters student competencies. Furthermore, upcycling recycled materials into visual learning tools reduces equipment costs while raising environmental awareness. Featuring a clear five-step procedure, this highly scalable model can be readily applied to other integrated theoretical-practical topics within the Natural Sciences curriculum.

REFERENCES

1. Ministry of Education and Training .(2018). *General education program - Master program (Issued under Circular No. 32/2018/TT-BGDĐT dated December 26, 2018, by the Minister of Education and Training)*.
2. Ministry of Education and Training. (2020). *Official Dispatch No. 3089/BGDĐT-GDTrH on the implementation of STEM education in secondary education*.
3. Genovia, J. A., Anto, K. A. M., Mante, D. R. A., Parcutilo, B. C., Pepe, N. S., Malayao Jr, S. O., ... & Capilitan, D. B. (2016). Differential thermoscope. *Researchgate Publication*, *30*(5), 812-992.
4. Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. FT press.
5. le Rond d'Alembert, J. B. (2017). *Thermometer*. Ann Arbor, Michigan: Michigan Publishing, University of Michigan Library.

ANALYSIS OF THE HSR WHOOSH LINE AS A GROWING MOBILITY AREA AND ITS EFFECTS ON SURROUNDING REGIONS

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Purpose and Background:

Indonesia's first high-speed rail line, the Jakarta-Bandung High-Speed Railway (HSR) or Whoosh train, is a critical milestone for the country's transportation sector. The railway aims to improve regional mobility, foster economic integration and development along the corridor, and reduce the travel time from Jakarta to Bandung from more than three hours to a mere 40 minutes. Apart from enhancing the efficiency of transportation, the project also represents Indonesia's aspiration to enhance its national competitiveness and upgrade its infrastructure.

However, while enhanced accessibility provides numerous economic opportunities, high-speed rail development also poses environmental and social issues. The project has raised significant concerns regarding rapid urban expansion, the conversion of agricultural land, unequal access, and ecological degradation. This paper, therefore, utilizes Ullman's Theory of Spatial Interaction and land use interpretations to analyze the Whoosh High-Speed Rail and the understanding of improved mobility in terms of regional development and the implications of this change.

Materials and Methods:

This study employed a qualitative descriptive approach based on literature review and spatial analysis. Information was synthesized from academic publications, government reports, and previous studies discussing the Whoosh HSR and its surrounding regions. The analysis was interpreted using Ullman's Theory of Spatial Interaction, which explains movement between regions through three primary concepts: complementarity, transferability, and intervening opportunities.

Spatial observations of the Jakarta–Bandung HSR corridor were also incorporated to examine land use patterns around station areas, including Halim, Karawang, and Tegalluar. Environmental and socio-economic impacts were analyzed by comparing findings from previous studies regarding land use change, urban expansion, and community responses.

Results and Discussion

The analysis indicates that the Whoosh High-Speed Rail significantly enhances regional interaction by significantly decreasing travel time between Jakarta and Bandung. In the Ullman Framework, complementarity occurs because Jakarta is the main economic center of Indonesia, while Bandung is the source of tourism, creative industries, and higher education. The railway improves transferability by reducing the time cost of travel, thus enabling more frequent commuting, business activities and tourism. While other transport options, such as toll roads and conventional railways, still exist, the reduction in travel time offered by high-speed rail intensifies existing economic interactions, rather than creating entirely new ones.

The encouragement of Transit Oriented Development has been increased to the rise of accessibility between areas, where the project has and is projected to accelerate urbanization around rail and station areas. However, without proper policies and monitoring, these benefits would be unevenly distributed, with development largely concentrated only along the transportation corridor rather than across the wider region, while also failing to prioritize current land use practices and livelihoods.

Environmental impacts continue to be important, whereas construction and the subsequent expansion of urban areas have resulted in the conversion of agricultural land, fragmentation of landscapes and increased pressure on the surrounding ecosystems. Deforestation from construction has led to lower agricultural yields and increased risk of flooding, soil instability and habitat fragmentation in many regions. Social impacts have also emerged through land acquisition, displacement of farming communities, loss of traditional livelihoods and unequal accessibility, as relatively high ticket prices benefit middle- and upper-income users.

Overall, the findings indicate that although the Whoosh High-Speed Rail successfully improves regional mobility and economic connectivity, sustainable development requires balancing infrastructure expansion with transparent environmental protection and inclusive accessibility policies, as current practices by stakeholders still deflect environmental protection and focus solely on economic growth.

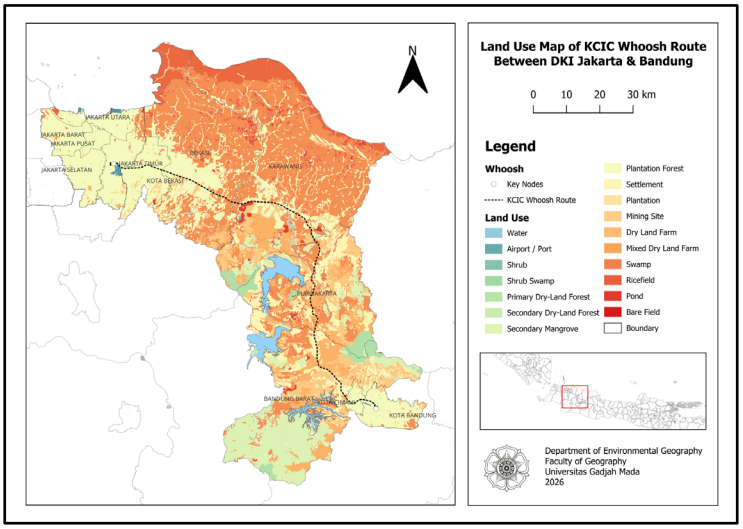

Figure 1
Source: (*Indonesia Geospasial*, 2025) Processed

Impacts of the HSR Whoosh Line on Surrounding Regions	
Positive Impacts	**Negative Impacts**
Significant reduction in travel time	Agricultural land conversion
Increased regional mobility	Environmental degradation
Growth of Transit-Oriented Development	Flood and landslide risks
Economic clustering around stations	Community displacement
Increased tourism and business activities	Unequal accessibility due to ticket prices

Table 1

REFERENCES

Faoziyah, U. (2020). The Effect of Transport Infrastructure on Land-use Change: The Case of Toll Road and High-Speed Railway Development in West Java. Journal of Regional and City Planning.

Huang, L. (2020, July 28). *Bungled Jakarta–Bandung high-speed rail line causes chaos*. Dialogue Earth.https://dialogue.earth/en/pollution/bungled-jakarta-bandung-high-speed-rail-line-causes-chaos/

Nurfhadila, A., Meilawan, A., Maulidina, D., & Pratama, M. (2025). *Indonesia-China Cooperation in Whoosh Infrastructure Development to Improve Indonesia's Economy*.

Sanjaya, F., & Puspitasari, V. (2020). Analisis Mengenai Dampak Lingkungan Pembangunan Kereta Cepat Jakarta-Bandung Dalam Perspektif Kritis Environmentalisme. *Padjadjaran Journal of International Relations*, *2*(2), 170. https://doi.org/10.24198/padjir.v2i2.26044

Ullman, E. L. (1956). *The role of transportation and the bases for interaction.* In W. L. Thomas (Ed.), *Man's Role in Changing the Face of the Earth*. University of Chicago Press.

Wijaya, T. (2021, July 25). *Jakarta–Bandung High-Speed Railway*. The People's Map of Global China. https://thepeoplesmap.net/project/jakarta-bandung-high-speed-railway/

Spatial Order of Road Networks as a Reflection of Regional Geographical Diversity in Coastal Indonesia

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Purpose and Background:

The phenomenon of coastal spatial development has become increasingly intensive across the Indonesian archipelago, encompassing port-based lowlands, rural tourism coasts, island tourism areas, and coastal hilly regions that remain vital for settlement, transportation, and tourism, yet closely connected to terrestrial ecosystems increasingly affected by anthropogenic pressure (Adyasari et al., 2021). In relation to SDG 15 "Life on Land," protecting these ecosystems from degradation and biodiversity loss therefore requires a clear understanding of how such development is spatially structured (United Nations Department of Economic and Social Affairs, 2025). Road networks, in this regard, are among the key infrastructures shaping that structure, since they determine accessibility and human activity while also fragmenting the surrounding landscape (Forman & Alexander, 1998). This spatial structure can in turn be examined through street orientation entropy, a measure of how regular or diverse a road network's spatial order is, ranging from highly directional to highly dispersed (Boeing, 2019). Accordingly, this study aims to compare road network orientation entropy across several selected coastal district scale areas in Indonesia representing different coastal geographical settings, thereby examining how this diversity is reflected in the spatial order of their road networks.

Materials and Methods:

This study utilizes road network datasets obtained through OpenStreetMap, an open and collaboratively maintained mapping platform. To ensure efficiency in processing large-scale spatial data, the entire workflow, from data extraction to analysis, was conducted using Google Colab with the Python programming language. Essentially, OSMnx is a Python package that enables road network data to be retrieved and structured for further analysis (Boeing, 2017). The method employed to address this study is road orientation entropy analysis. It is a technique that measures how uniformly or randomly road segments are oriented within an area, allowing the spatial order of a road network, ranging from highly directional to highly dispersed, to be expressed as a single comparable value. This method was applied to six selected coastal district scale areas representing different coastal geographical settings in Indonesia, namely Tanjung Priok, Semarang Utara, Kretek, Denpasar Selatan, Balikpapan Selatan, and Nusaniwe.

Results and Discussion:

The results show that road network spatial order varies considerably across the six coastal study areas, as summarized in Table 1 and Figure 1. Based on normalized entropy and dominant orientation ratio, the areas fall into three patterns, namely more directional, complex, and highly dispersed, each shaped by a different combination of terrain, settlement history, and land use.

First is the more directional pattern, represented by Semarang Utara and Denpasar Selatan, both recording the lowest normalized entropy at 0.84. This pattern emerges because flat terrain places little constraint on road alignment, so roads follow a regular grid oriented to the shoreline rather than the land contour. Semarang Utara shows strong east to west (90°) dominance, since its straight coastline, port access roads around Pelabuhan Tanjung Emas, and structured urban grid all reinforce one direction, consistent with documented urbanization pressure along the north Java coast (Handayani et al., 2020), giving it the highest dominant ratio at 0.25. Denpasar Selatan shows a similar alignment, driven more by tourism and urban planning along Sanur's corridors than by topography, while the diagonal Ngurah Rai Bypass adds a secondary direction that explains its slightly higher dispersion.

Second is the complex pattern, represented by Tanjung Priok and Nusaniwe, sharing a normalized entropy of 0.89 through different mechanisms. Tanjung Priok's complexity is functional, since port roads align to berth positions, industrial estates impose their own grids, and kampung settlements grew incrementally without central planning, so several orientations coexist instead of one. Nusaniwe's complexity is geographic instead, since its narrow coastal strip along Teluk Ambon forces the main road into a diagonal northeast to

southwest alignment, while surrounding hills block inland continuation, so secondary roads climb at scattered angles.

Lastly is the highly dispersed pattern, represented by Kretek and Balikpapan Selatan, again for different reasons. Kretek's dispersion stems from several independent road forming functions, since agricultural plots, tourism access toward Parangtritis, and rural settlement links each pull roads in different directions, so that no single function dominates. Balikpapan Selatan's dispersion has a more direct physical cause, since the area is built across ridges and valleys with no flat lowland to anchor a grid, so every road instead follows the contour it crosses, leaving the lowest dominant ratio of all areas at 0.12 and the highest normalized entropy at 0.98.

In conclusion, road orientation entropy proves a simple yet effective indicator of how regional geographical character, whether flat and planned, layered and metropolitan, or hilly and fragmented, becomes embedded in a coastal area's physical structure. For Indonesia's coastal regions, this link supports regional development planning by helping anticipate how road growth may affect adjacent terrestrial ecosystems in line with SDG 15.

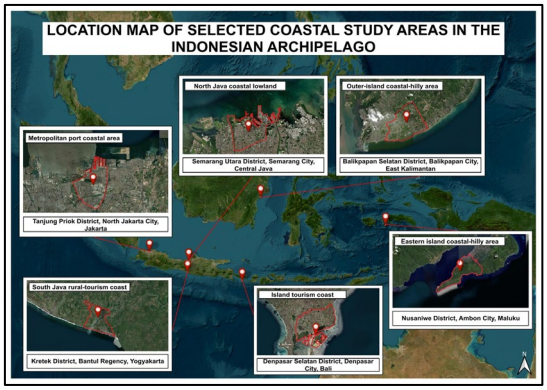

Figure 1. *Location map of selected coastal study areas in Indonesia.*

Table 1. *Road orientation entropy results of selected coastal study areas.*

Study Area	Rose Diagram	Entropy	Norm. Entropy	Dom. Ratio	Pattern
Denpasar Selatan		3.51	0.84	0.18	More directional
Semarang Utara		3.52	0.84	0.25	More directional
Nusaniwe		3.70	0.89	0.21	Complex
Tanjung Priok		3.71	0.89	0.17	Complex
Kretek		3.87	0.93	0.14	Highly dispersed
Balikpapan Selatan		4.08	0.98	0.12	Highly dispersed

REFERENCES

Adyasari, D., Pratama, M.A., Teguh, N.A., Sabdaningsih, A., Kusumaningtyas, M.A., & Dimova, N. (2021). Anthropogenic impact on Indonesian coastal water and ecosystems: Current status and future opportunities. *Marine Pollution Bulletin, 171,* 112689. doi:10.1016/j.marpolbul.2021.112689

Boeing, G. (2017). OSMnx: A Python package to work with graph theoretic OpenStreetMap street networks. *Journal of Open Source Software, 2*(12), 215. doi:10.21105/joss.00215

Boeing, G. (2019). Urban spatial order: Street network orientation, configuration, and entropy. *Applied Network Science, 4,* 67. doi:10.1007/s41109-019-0189-1

Forman, R.T.T., & Alexander, L.E. (1998). Roads and their major ecological effects. *Annual Review of Ecology and Systematics, 29,* 207 to 231. doi:10.1146/annurev.ecolsys.29.1.207

Handayani, W., Rudiarto, I., Setyono, J.S., Chigbu, U.E., & Sukmawati, A.M.A. (2020). Urbanization and increasing flood risk in the northern coast of Central Java, Indonesia: An assessment towards better land use policy and flood management. *Land, 9*(10), 343. doi:10.3390/land9100343

United Nations Department of Economic and Social Affairs. (2025). *The Sustainable Development Goals Report 2025.* New York, NY: United Nations.

A Lesson Study on Teaching Kinetic Molecular Theory in Grade 10

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Purpose and Background

Kinetic Molecular Theory (KMT) is one of the fundamental concepts in science education because it explains the behavior and movement of particles and their relationship to temperature, pressure, and volume. A strong understanding of KMT is important since it serves as the foundation for explaining various scientific concepts and phenomena in chemistry, biology, and earth science. However, despite its significance, many students continue to experience difficulties and misconceptions in learning KMT due to the abstract nature of molecular interactions and the challenge of visualizing microscopic processes. These learning difficulties became more evident among Grade 10 students, especially after the transition from remote learning during the COVID-19 pandemic back to face-to-face classes. The lack of engagement, limited instructional materials, and reliance on conventional lecture methods may further hinder students' understanding of the topic.

To address these concerns, the study explored the use of Lesson Study (LS) as an intervention in teaching KMT among Grade 10 students in Baybay National High School. Lesson Study is a collaborative professional development approach where teachers work together to plan, observe, reflect, and improve classroom instruction. Through repeated lesson cycles and collaborative reflection, teachers are able to identify effective teaching strategies that enhance student learning and classroom engagement. Specifically, this study aimed to determine how Lesson Study affects students' classroom performance and understanding of KMT, how it contributes to the development of teachers' pedagogy, and what teaching strategies are effective in improving instruction in KMT. The study also sought to contribute to the limited literature on the application of Lesson Study in science education, particularly in the teaching of Kinetic Molecular Theory.

Materials and Methods

This study utilized a Lesson Study (LS) design to improve the teaching of Kinetic Molecular Theory (KMT) among Grade 10 students of Baybay National High School. The participants of the study were three Grade 10 Basic Education Curriculum (BEC) sections enrolled in Chemistry during the fourth quarter of the school year. The researchers implemented three Lesson Study cycles, each consisting of the study, plan, teach, and reflect phases. During the study and planning phases, the Lesson Study team collaboratively prepared the lesson plan using the 7E instructional model and identified strategies and instructional materials appropriate for teaching KMT. In the teach phase, one member served as the model lecturer while the other members and the cooperating teacher observed the class using an observation sheet. After every cycle, the team conducted a reflective discussion with the MKO to identify strengths, challenges, and possible modifications to improve the succeeding implementation.

The study employed data triangulation through diagnostic and post-tests, classroom observations, and interviews with selected low-performing students. The diagnostic and post-tests were used to determine students' Class Proficiency Level (CPL) before and after the implementation of the research lesson. Observations, field notes, and video or audio recordings were utilized to identify themes and instructional challenges encountered during the lesson implementation. Interviews were also conducted to gain deeper insights into the students' learning experiences, difficulties, and perceptions regarding the lesson and teaching strategies used. Qualitative data gathered from observations and interviews were analyzed through thematic analysis, while descriptive analysis was used in interpreting assessment results. The findings from the different data sources were compared through triangulation to strengthen the credibility and validity of the results.

Results and Discussion

The implementation of Lesson Study (LS) in teaching Kinetic Molecular Theory (KMT) resulted in noticeable improvements in students' classroom performance and understanding of KMT concepts. Based on the diagnostic test results, all three Grade 10 sections initially demonstrated low Class Proficiency Levels (CPL), with 29.27% for Cycle I, 26.47% for Cycle II, and 42.42% for Cycle III. These results indicated that students had limited prior knowledge and misconceptions regarding KMT concepts and relationships among

variables such as temperature, pressure, and volume. However, after the implementation of the research lesson and the modifications introduced after every LS cycle, the students' post-test scores significantly improved. Cycle I obtained a CPL of 73.1%, Cycle II reached 82.0%, while Cycle III achieved the highest CPL of 87.8%, which falls under the proficient level. The gradual increase in proficiency levels suggests that continuous lesson refinement through collaborative planning, observation, and reflection positively influenced students' understanding and mastery of the lesson.

The study also revealed that hands-on and interactive teaching strategies greatly contributed to student engagement and learning. The use of experiments, visual instructional materials, arrow cards, and computer simulations helped students better visualize molecular movement and the relationships among KMT variables. In particular, the use of PhET simulations became one of the most effective interventions observed in the study. Students showed greater interest and participation when they were allowed to manipulate the simulations themselves during the succeeding cycles. Interviews with students also revealed that the simulations and experiments made the lesson more understandable and enjoyable. Furthermore, the Lesson Study process improved the pedagogy of the teachers by helping them identify weaknesses in instruction, improve classroom management and time management, and modify assessment strategies based on students' needs and responses. Overall, the findings demonstrated that Lesson Study is an effective intervention in improving both KMT instruction and student learning outcomes.

Table 1. Summary of the Class Proficiency Level (CPL) and Key Findings Across the Three Lesson Study Cycles

Cycle	Diagnostic CPL	Post-test CPL	Key Findings
Cycle I	29.27%	73.1%	Identified lack of instructional materials, limited student participation, poor time management, and ineffective grouping strategies.
Cycle II	26.47%	82.0%	Increased use of hands-on activities, visual aids, and computer simulations improved student engagement and comprehension.
Cycle III	42.42%	87.8%	Providing laptops for each group and maximizing interactive simulations resulted in the highest proficiency level and stronger classroom participation.

REFERENCES

Dudley, P. (2015). Lesson Study: Professional Learning for our time. *How lesson study works and why it creates excellent learning and teaching*, New York: Routledge, 2015. 1-5.

Elipane, L. E. (2017). Introducing Lesson Study as a Professional Development Model in the Islands of the Philippines. Journal of Computational and Theoretical Nanoscience, *23* (2), 1126 - 1129.

Erceg, N., Aviani, I., Mešic, V., Gluncic, M., & Žauhar, G. (2016). Development of the Kinetic Molecular Theory of Gases Concept Inventory: Preliminary Results on University Students' Misconceptions *Physical Review Physics Education Research, v12* n2 p020139-1-020139-23

Sanchez, J. M. (2021). Understanding of Kinetic Molecular Theory of Gases in Three Modes of Representation among Tenth-Grade Students in Chemistry. *International Journal of Learning, Teaching and Educational Research Vol. 20,* No. 1, pp. 48-63, January 2021 https://doi.org/10.26803/ijlter.20.1.3

ZERO-WASTE CONSUMPTION BEHAVIOR OF GENERATION Z: AN EMPIRICAL STUDY IN HANOI, VIETNAM

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Purpose and Background

The global environmental crisis, compounded by post-pandemic challenges, has underscored the necessity of transitioning toward a circular economy. In the urban landscape of Hanoi, the rapid expansion of platform-based e-commerce and online food delivery services has significantly increased plastic waste, creating substantial pressure on urban waste management systems. Generation Z, defined by its high cognitive agility and technological proficiency, serves as a pivotal agent in this transition. Despite existing literature on green purchase intentions, a notable academic gap persists regarding the structural determinants of long-term zero-waste behavior in Hanoi. This study addresses this void by examining the intersection of microplastic risk perception, social pressure, and digital media influence, providing a scientific foundation for sustainable urban policy.

Materials and Methods

Zero-waste consumption is conceptualized here as a proactive individual commitment to resource conservation, intervening at the initial stage of the consumption cycle to bypass traditional waste disposal. This research integrates traditional behavioral antecedents, such as social norms and altruistic motivation, with modern contextual variables, including microplastic health risk perception and digital media exposure. Employing a quantitative methodology, the study utilizes a Structural Equation Modeling (SEM) framework to map causal relationships between these latent variables and three core behaviors: reduction, reuse, and recycling. Data were collected via an online survey of Generation Z residents in Hanoi, using a validated 5-point Likert scale to ensure empirical rigor.

Results and Discussion

The predictive model reveals that microplastic risk perception is a primary driver for rejecting single-use plastics, with an impact coefficient (β) of 0.15–0.20, suggesting that environmental concern is deeply linked to personal health security. Furthermore, digital media acts as a critical channel for social norm dissemination; with a predictive coefficient ($\beta>0.30$), online interactions within "green" communities normalize sustainable practices as ethical values. However, a paradox exists: high environmental awareness does not consistently lead to daily action due to the convenience of delivery systems and a lack of localized circular infrastructure. This gap indicates that systemic integration of sustainable alternatives is as crucial as individual awareness.

To bridge the persistent gap between pro-environmental awareness and practical daily action in Hanoi, systemic intervention strategies must be prioritized. It is recommended that municipal authorities and regulatory bodies collaborate closely with major e-commerce players and online delivery platforms to establish mandatory sustainable packaging standards. Rather than relying on voluntary corporate actions, these standards should be integrated into the fundamental service supply chain. Furthermore, financial mechanisms such as "green credit" incentives should be directed toward food-service startups and small-to-medium enterprises operating within high-density office clusters to facilitate their transition to reusable and circular container systems.

The role of academic institutions is equally paramount. Universities in Hanoi should systematically incorporate the scientific study of circular economy mechanics and the medical impacts of microplastic exposure into their broader curricula. By translating abstract ecological concern into tangible action-based projects, educational institutions can empower students to act as informed environmental ambassadors. These

individuals, through their significant influence on digital platforms and their capacity for cross-generational communication, can exert collective pressure on suppliers and retailers to accelerate the overall "greening" of the capital city's economy.

The ongoing shift toward zero-waste consumption among Generation Z in Hanoi signifies a structural evolution of the urban economy rather than a transient cultural trend. While this transition faces significant challenges related to economic costs and the entrenched habits of urban convenience, the strategic deployment of digital influence combined with targeted, infrastructure-based policy support can successfully catalyze this change. By harmonizing individual health-conscious motivations with collective environmental sustainability goals, Hanoi is well-positioned to leverage its tech-savvy youth demographic in solving its critical waste management crisis, thereby providing a replicable model for other rapidly urbanizing cities in the region.

Predictor Variable	Impact on Behavior	Impact Coefficient (β)
Microplastic risk perception	Rejecting single-use plastics	0.15–0.20
Digital media exposure	Dissemination of social norms	>0.30

Table 1. Summary of Structural Equation Modeling (SEM) Impact Coefficients

REFERENCES

Binnemans, K., Jones, P. T., Blanpain, B., Van Gerven, T., & Pontikes, Y. (2015). Towards zero-waste valorisation of rare-earth-containing industrial process residues: A critical review. *Journal of Cleaner Production*, 99, 17-38.

Nguyễn Thị Thu Hương, Trần Văn Bách, & Lê Hồng Ngọc. (2023). Antecedents of Gen Z's green purchase intention in Vietnam's fashion industry with the moderating role of greenwash perception. *Sustainability*, 15(10), 4319.

A Needs Assessment of Argument-Driven Inquiry with Simulation for Promoting Climate Literacy in Lower Secondary Science Education

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Purpose and Background

NASA has reported unequivocal evidence that Earth is warming at an unprecedented rate and that human activity is the principal cause. This global situation makes climate literacy an essential goal of science education. According to the U.S. Global Change Research Program (USGCRP), climate literacy involves understanding how the climate system works, how human actions influence climate, and how climate affects people and other parts of the Earth system. A climate-literate person should also be able to recognize credible information, communicate about climate change, and make informed decisions. Similarly, the PISA 2025 Science Framework highlights environmental science competencies under "Agency in the Anthropocene," including explaining human interactions with Earth's systems and making decisions based on evidence, creative thinking, and systems thinking.

These expectations indicate that climate change education should not be limited to delivering factual knowledge. Students need opportunities to interpret data, evaluate evidence, construct explanations, discuss different perspectives, and consider possible actions. Argument-Driven Inquiry (ADI) is therefore relevant because it engages students in inquiry, claim construction, evidence use, reasoning, and argumentation. Simulation can further support this process by allowing students to manipulate variables, observe outcomes, and use model-based data as evidence for explanation and discussion.

Therefore, this preliminary study aimed to investigate lower secondary science teachers' current practices and needs in teaching climate change, as well as their perspectives on using ADI with simulation to promote students' climate literacy.

Materials and Methods

This study used a needs assessment survey design to investigate teachers' current practices and instructional needs in teaching climate change. The target sample consisted of 80 lower secondary science teachers from schools under the Office of the Basic Education Commission (OBEC) in Bangkok, Thailand, selected through purposive sampling. Data were collected using a questionnaire consisting of three sections: general information, current climate change instruction, and teachers' perspectives on using ADI with simulation to promote climate literacy. The data were analyzed using frequency, percentage, and content analysis. Due to the limited period of data collection, this proceeding reports preliminary findings from eight respondents, while further data collection is ongoing.

Results and Discussion

The preliminary data were collected through a questionnaire from eight lower secondary science teachers. The high-frequency responses related to current climate change instruction, students' climate literacy-related difficulties, and teachers' perspectives on ADI with simulation are presented in Table 1.

Table 1. Preliminary findings on current climate change instruction and teachers' perspectives on ADI with simulation for promoting climate literacy (n = 8)

Section	Issue	High-frequency response	f	%
Current climate change instruction	Teaching approach	Lecture-based instruction	7	87.50
		Information searching from learning resources	5	62.50
	Teaching challenge	Students' skills in reading, analyzing, and using scientific evidence	5	62.50
		Time and curriculum constraints	4	50.00
	Learning media	Videos or video clips	7	87.50
	Purpose of using media	To motivate students or introduce the lesson	7	87.50
		To support learning activities	7	87.50
Students' climate	Learning difficulty	Connecting causes, impacts, and solutions	4	50.00

literacy-related difficulties		systematically		
		Interest, motivation, or perceiving climate change as relevant to daily life	4	50.00
ADI, simulation, and climate literacy	Perceived contribution of ADI	Promoting conceptual understanding of climate systems, causes, impacts, mitigation, and adaptation	6	75.00
		Promoting thinking processes and evidence use	6	75.00
	Perceived contribution of simulation	Promoting thinking processes and evidence use	7	87.50
	Required component of ADI with simulation	Simulation allowing students to manipulate variables and observe outcomes	7	87.50
		Driving questions or situations to stimulate analysis and argumentation	6	75.00
		Evidence-based discussion or argumentation	6	75.00
		Climate change situations related to students' lives	6	75.00
	Suitability for lower secondary students	Level 3 or higher: Moderately to highly appropriate	7	87.50

Note. Respondents could select more than one option. The findings are preliminary because data collection is still ongoing.

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The preliminary findings from eight teachers showed that current climate change instruction was mainly lecture-based (n = 7, 87.50%) and commonly supported by videos or video clips (n = 7, 87.50%) to motivate students or introduce the lesson (n = 7, 87.50%) and support learning activities (n = 7, 87.50%). Some teachers also used information searching from learning resources (n = 5, 62.50%). These findings indicate that current instruction still relies largely on teacher explanation and media-based presentation.

Regarding instructional needs, teachers reported students' skills in reading, analyzing, and using scientific evidence as a major challenge (n = 5, 62.50%), followed by time and curriculum constraints (n = 4, 50.00%). Teachers also identified students' difficulties in connecting causes, impacts, and solutions systematically, and in perceiving climate change as relevant to daily life (n = 4, 50.00% each). These results suggest that students need more opportunities to engage with evidence, systems thinking, and personally meaningful climate change issues.

Teachers perceived ADI as supporting both conceptual understanding and evidence use (n = 6, 75.00% each), while simulation was most frequently perceived as promoting thinking processes and evidence use (n = 7, 87.50%). The key required component was simulation that allows students to manipulate variables and observe outcomes (n = 7, 87.50%). Teachers also emphasized driving questions, evidence-based discussion or argumentation, and climate change situations related to students' lives (n = 6, 75.00% each). Most teachers rated ADI with simulation at Level 3 or higher, indicating moderate to high appropriateness for lower secondary students (n = 7, 87.50%).

Overall, the findings respond to the purpose of this needs assessment by showing that teachers' current practices are still largely lecture- and media-based, while their reported challenges point to students' needs for evidence use, systems thinking, and real-world relevance. Teachers' perspectives also suggest that ADI with simulation is a promising instructional approach for promoting climate literacy because it can connect climate concepts with evidence-based reasoning, argumentation, variable manipulation, and meaningful climate change contexts. However, these findings should be interpreted as preliminary because data collection is still ongoing.

REFERENCES

Erenler, S., Cetin, P. S., & Eymur, G. (2024). Impact of argument-driven inquiry activities on pre-service science teachers' views of the nature of scientific inquiry in the context of climate change education. Science & Education. https://doi.org/10.1007/s11191-024-00512-4

NASA. (n.d.). Evidence: How do we know climate change is real?. NASA Science. https://science.nasa.gov/climate-change/evidence/

OECD. (2023). PISA 2025 science framework. OECD Publishing.

U.S. Global Change Research Program. (2009). Climate literacy: The essential principles of climate science. U.S. Global Change Research Program.

Wise, S. B. (2010). Climate change in the classroom: Patterns, motivations, and barriers to instruction among Colorado science teachers. Journal of Geoscience Education, 58(5), 297–309.

Exploring the Behavior of TDP43: A Protein Linked to Dementia

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Purpose and Background

TDP43 (TAR DNA-binding protein of 43 kDa) is a protein that works in the brain, and its aggregates are found from more than 90% of patients with amyotrophic lateral sclerosis (ALS), a disease similar to dementia. Therefore, TDP-43 is a key target for ALS treatment. ALS is caused by the loss of the muscle cells, and patients with ALS gradually lose the ability to breath and speak. Because no fundamental treatment for ALS currently exists, understanding the mechanism of ALS will play a significant roll in treating ALS.

TDP43 can be divided into four functional regions : three sphere-like regions and one string-like region (Fig1). Previous studies have suggested that string-like region is crucial in aggregate formation. However, most of them have focused on only string-like region, and how sphere-like regions contribute to aggregation remains unknown. Therefore, we aim to purify a fragment that includes both of sphere-like and string-like region: we call this connected region, clarifying the mechanism of aggregation fundamentally.

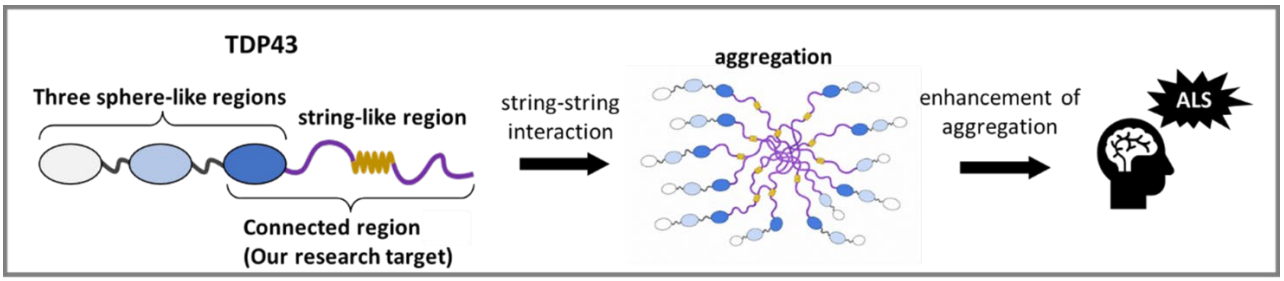

Fig1. TDP43 structure and its aggregation model

Materials and Methods

As a protein analysis method, we chose NMR (nuclear magnetic resonance) because we can see how proteins interact with each other at the level of atoms.

As a protein-producting method, we also chose *E. coli*, gut bacteria, because we can produce large amount of protein and it is inexpensive. After *E. coli* bacteria produced the TDP43 protein inside their cells, we broke the bacteria using ultrasound waves. Then, we separated and remove heavy waste by spinning the mixture at high speed. Finally, we used a technique called affinity chromatography, which catches only TDP43 from the mixture with a variety of small molecules, to isolate and collect the pure TDP43 (Fig2).

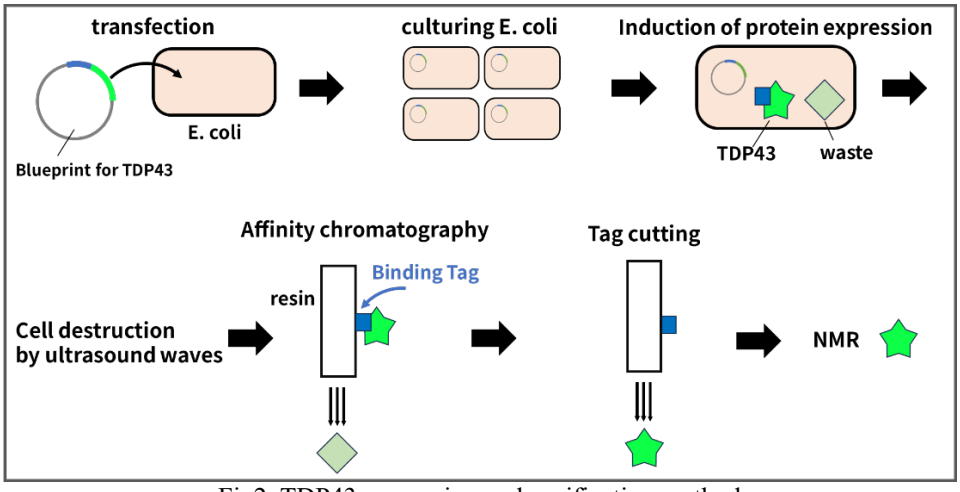

Fig2. TDP43 expression and purification method

Results and Discussion

We have two main results. The first is finding the best conditions for purifying TDP43. During the purification process, string of connected region is always broken, which was a problem. To fix this, we attached

a small protective piece called SUMO to the end of the protein. Thanks to this, we were able to successfully collect TDP43 without break.

To check whether TDP43 was breaking apart, we used a technique called SDS-PAGE, which separates proteins by molecular size and shows them as bands on a gel. Our target protein should appear at a size of 17 kDa. Without the SUMO, we saw a smaller band, which told us the protein was breaking apart. After adding the SUMO tag, we got a band at the right size.

The second result is the discovery of a new interaction that may be linked to how ALS occurs. Using NMR, we studied three things separately: the string-like region alone (Fig3. red), the sphere region alone (Fig3.black), and a version that the two were connected (Fig3. blue). When we compared the results, we noticed that the signals shifted depending on whether the two regions were connected or not. In our experiment, this kind of shift means that the two regions are interacting with each other inside the same protein.

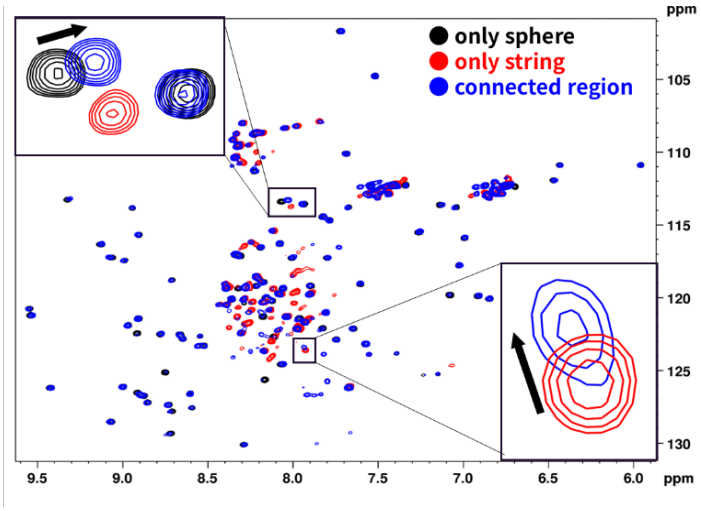

Fig3. NMR spectra of TDP43

Now, let's discuss what these results mean. As mentioned above, ALS is thought to develop when multiple TDP43 proteins accummulate. We believe that the sphere-string interaction in a single TDP43 protein controls this accumulation. How does the interaction control the accumulation? The key idea is folding. When the sphere-like region and the string-like region interact and fold in a TDP43, less surface area is exposed, making it harder for one TDP43 to stick to other TDP43 (Fig4. left). On the other hand, when the two regions are stretched open, more surface area is exposed, making it much easier for the proteins to interact with each other (Fig4. right). This interaction can be the trigger of ALS. Therefore, we may treat ALS fundamentally if we can prevent this interaction. We believe that our findings could contribute to the development of new treatments for ALS.

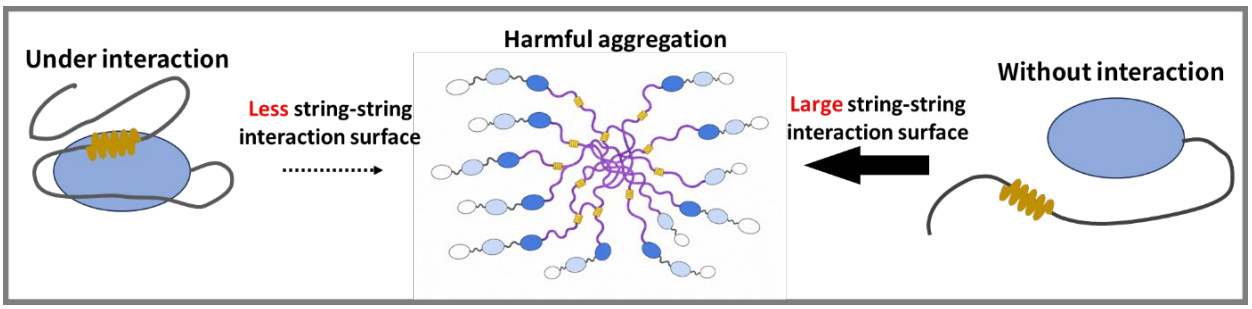

Fig4. Aggregation model of TDP43

REFERENCES

Wei, Y., Lim, L., Wang, L., & Song, J. (2016). Inter-domain interactions of TDP-43 as decoded by NMR. *Biochemical and Biophysical Research Communications, 473*(2), 614–619.

Dang, M., Wu, L., & Zhang, X. (2025). Structural insights and milestones in TDP-43 research: A comprehensive review of its pathological and therapeutic advances. *International Journal of Biological Macromolecules, 306*(Part 3), Article 141677.

L. Yang, Y. Jasiqi, A. Zettor, O. Vadas, J. Chiaravalli, F. Agou, H. A. Lashuel, *Angew. Chem. Int. Ed.*2024, 63, e202314587.

Fostering Students' Understanding of the Nature of Science through the Family Resemblance Approach: Developing Learning Guidelines within a STEM-BCG Context

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Purpose and Background

Developing an understanding of the Nature of Science (NOS) is a foundational pillar of scientific literacy, empowering citizens to make informed decisions in an increasingly complex society. For decades, NOS instruction has been heavily dominated by the "Consensus View" (CV), which characterizes science through a generalized, checklist-like set of tenets (e.g., science is tentative, empirical, and socially embedded). While CV has been pedagogically functional, it faces critical limitations: it portrays science as a monolithic enterprise, neglects the unique methodological diversity across different scientific disciplines, and largely marginalizes the complex socio-political, economic, and institutional dimensions of scientific practices. To overcome these shortcomings, the Family Resemblance Approach (FRA) offers a more robust and holistic alternative. Unlike the rigid nature of CV, FRA conceptualizes science as a dynamic, polycentric network of interconnected features, systematically categorized into two major domains: the *Cognitive-Epistemic System* (aims, values, practices, and methods) and the *Social-Institutional System* (professional activities, social certification, ethos, and socio-political-economic influences). Consequently, FRA captures the authentic, multifaceted, and evolving nature of modern science far more comprehensively than CV.

Despite its theoretical advantages, translating the FRA framework into classroom practice remains highly abstract and challenging for educators, particularly in making the social-institutional dimensions visible to students. This pedagogical gap necessitates a concrete and powerful learning vehicle, which this study addresses through the integration of the STEM-BCG (Bio-Circular-Green Economy) approach. The STEM-BCG framework serves as a strategic dual-mechanism to operationalize FRA in a classroom setting. First, the *Engineering Design Process (EDP)* provides an active, hands-on space where students engage in scientific practices, technological optimization, and collaborative problem-solving, thereby materializing the *Cognitive-Epistemic System*. Second, the *BCG economic model* shifts classroom activities toward real-world, open-ended *Socio-Scientific Issues (SSI)* regarding sustainability, green technology, and resource management. These issues naturally compel students to navigate the *Social-Institutional System*, as they must negotiate ethical dilemmas, governmental regulations, financial constraints, and public policies that influence scientific developments.

Consequently, exploring how FRA-NOS dimensions manifest within a STEM-BCG context presents a critical and timely research opportunity. Currently, there is a distinct paucity of empirical evidence examining the dynamic emergence of FRA-NOS components during STEM-BCG activities and how instructional designs can systematically support them. To bridge this critical gap, this study systematically links theory to practice. By investigating students' baseline understandings and tracking the real-time, dynamic emergence of FRA-NOS components within this integrated context, the researchers can identify key instructional factors. This foundational exploration directly leads to the formulation of robust learning guidelines, thereby transforming FRA-NOS from an abstract theoretical framework into an actionable, powerful pedagogical reality.

Materials and Methods

This study employs an Educational Design Research (EDR) approach integrated with a mixed-methods exploratory design to investigate how students conceptualize the Nature of Science (NOS) through the Family Resemblance Approach (FRA) within a STEM-BCG context. The participants will be purposively sampled upper secondary science students in Thailand, selected for their foundational knowledge necessary to engage with complex Socio-Scientific Issues (SSI) and the Engineering Design Process (EDP). Data collection will occur across three sequential phases—pre-implementation, implementation, and post-implementation—utilizing specially designed STEM-BCG learning modules embedded with "NOS Triggers" and "Reflection Nodes." To capture comprehensive data, the study will use FRA-NOS pre- and post-questionnaires, semi-structured interviews, student reflective journals, and classroom audio/video observations.

The collected data will be systematically analyzed to address the research questions: quantitative survey data will be evaluated using descriptive statistics and radar charts to track conceptual shifts, while qualitative data will undergo thematic and classroom discourse analysis to chronologically map emergent FRA-NOS patterns and isolate key pedagogical drivers. Ultimately, these integrated findings will be synthesized to construct the final evidence-based curriculum guide, "The STEM-BCG FRA Pedagogical Model."

Results and Discussion

The empirical findings of this study are anticipated to reveal a comprehensive picture of student learning and pedagogical design across four interconnected areas, beginning with an expected shift in students' understanding of the Nature of Science as framed by the Family Resemblance Approach (FRA-NOS). Quantitatively, mixed-methods data visualized through radar charts are projected to demonstrate significant improvements, particularly within the traditionally neglected social-institutional system of science. Qualitatively, thematic analyses of student interviews and journals are anticipated to show a profound conceptual transition, where students move away from viewing science as a rigid, linear checklist and begin to recognize its pluralistic nature as well as its deep entanglement with real-world economic models, government policies, and community ethics. This conceptual growth is expected to be mirrored in the real-time dynamics of the classroom, where a process flow map will likely illustrate distinct emergent patterns of FRA-NOS components. Specifically, initial exposure to open-ended Bio-Circular-Green (BCG) economy and socio-scientific issues (SSI) is projected to immediately activate discourse surrounding the social values and ethos of science, whereas the subsequent hands-on engineering design process (EDP) phase will likely trigger the cognitive-epistemic system as students actively build and test green innovations. In terms of pedagogical execution, the research anticipates isolating two primary drivers of this successful learning experience, namely the teacher's deliberate explicit-reflective prompting at critical junctures and the inherent multi-perspective complexity of authentic BCG dilemmas. These insights will ultimately be synthesized into the primary practical output of the study, which is projected to be "The STEM-BCG FRA Pedagogical Model"—a comprehensive curriculum guide that operationalizes the integration of EDP and SSI, defines classroom roles, and embeds explicit reflection nodes.

When discussing these anticipated findings in relation to established international literature, the study will frame the expected conceptual shifts as a successful paradigm change that validates the holistic FRA framework proposed by Erduran and Dagher (2014) and Irzik and Nola (2011). By demonstrating that high school students can successfully navigate the socio-political and economic infrastructures of science, these outcomes will argue against the restrictive limitations of the traditional consensus view outlined by Lederman (2007), positioning FRA as a far more dynamic tool for interpreting modern, high-stakes "post-normal science" where scientific consensus is entangled with societal uncertainties. Furthermore, the study expects to address a critical gap in science education literature by demonstrating that the abstract and complex nature of FRA theory can be practically operationalized through the STEM-BCG approach. In this dual-mechanism model, the EDP is anticipated to serve as a vital cognitive scaffold that materializes technical knowledge-building, while the BCG model acts as an essential socio-contextual catalyst that brings the institutional dimensions of science directly into the student experience. Finally, corroborating the seminal work of Khishfe and Abd-El-Khalick (2002), the theoretical discussion will emphasize that mere hands-on immersion in green technology activities is insufficient for developing epistemological sophistication. Instead, the study will argue that the curriculum's embedded reflection nodes and teacher-led dialogues represent the true, indispensable engine driving students' conceptual change, transforming implicit classroom practices into explicit, lifelong understandings of the Nature of Science.

REFERENCES

Erduran, S., & Dagher, Z. R. (2014). *Reconceptualizing the nature of science for science education: Scientific knowledge, practices and other family categories*. Springer.

Irzik, G., & Nola, R. (2011). A family resemblance approach to the nature of science for science education. *Science & Education, 20*(7-8), 591–607. https://doi.org/10.1007/s11191-010-9293-4

Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching, 39*(7), 551–578. https://doi.org/10.1002/tea.10036

Lederman, N. G. (2007). Nature of science: Past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 831–879). Lawrence Erlbaum Associates.

SCREENING AND PRELIMINARY CHARACTERIZATION OF TRANSGENIC RICE CALLUS LINE EXPRESSING VP1 PROTEIN OF ENTEROVIRUS A71

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Purpose and Background

Hand, Foot, and Mouth Disease (HFMD) represents a major public health threat that drives severe neurological complications and fatalities in children under five years of age[1]. This disease is primarily caused by Enterovirus A71 (EV-A71). Although current inactivated commercial vaccines possess high clinical efficacy reaching 97.3%, their widespread implementation is heavily restricted by high production costs and market prices (ranging from 2,700 to 3,400 Baht per dose), making them capital-intensive and less accessible for broad public distribution [1,2]. Furthermore, these conventional vaccines strictly require a continuous refrigeration cold chain throughout storage and transportation, which severely limits vaccine deployment in remote or resource-limited areas [1]. Plant-based molecular farming offers an innovative solution to these logistics and financial limitations by utilizing host plant cells as all-in-one bioreactors and oral delivery vehicles[3]. This strategy leverages bio-encapsulation within the plant cell wall to provide gastric protection against acidic degradation, enabling target recombinant antigens to pass safely into the small intestine where they are selectively digested to trigger a protective immune response [3]. The primary objective of this research is to screen and identify a promising lead cell line (lead clone) from multiple transgenic rice callus lines (*Oryza sativa* L. cv. Nipponbare) engineered to express the EV-A71 VP1 structural recombinant protein under a sugar-starvation inducible RAmy3D promoter system [4]. This study focuses on a multi-stage characterization process to verify stable transgene integration and evaluate the consistency of VP1 protein expression across different candidate lines. Additionally, cell growth kinetics, specific growth rates, sugar consumption profiles, and overall recombinant protein productivity are investigated in controlled cell suspension cultures to determine the most efficient lead cell line [5]. The critical bioprocess engineering data obtained from this selection will lay the foundation for optimizing a scalable, cost-effective, and cold-chain-independent edible vaccine platform to combat HFMD [3].

Materials and Methods

Transgenic rice callus lines (Oryza sativa L. cv. Nipponbare) transformed with the pCAMBIA2300-VP1 vector containing the sugar-starvation inducible RAmy3D promoter were maintained on NB solid medium supplemented with sucrose and G418 antibiotic selection agent. Cell suspension cultures were initiated by inoculating friable callus into liquid NB medium, scaled up to larger shake flasks, and incubated on an orbital shaker under continuous dark conditions. A dual-phase cultivation strategy was applied: a biomass proliferation phase to accumulate cells in nutrient-rich medium, followed by a complete media exchange into sugar-free NB medium to activate the inducible promoter system and trigger recombinant VP1 protein expression under sugar starvation. Cell growth kinetics were evaluated by monitoring fresh weight (FW) and dry weight (DW) from harvested samples. Sugar consumption profiles (sucrose, glucose, and fructose) in the spent culture media were quantified via UPLC-ELSD using an Asahipak NH2P-50 4E column. Stable integration of the transgene was validated through genomic DNA extraction and PCR genotyping. Qualitative expression and target molecular weight integrity of the recombinant VP1 protein were analyzed via SDS-PAGE and Western blot using a primary rabbit anti-EV71 VP1 antibody and ECL detection.

Results and Discussion

Based on the previous multi-stage screening framework established by the laboratory, a total of 12 candidate cell lines (comprising T1–T6 and S1–S6) were originally generated. Building upon these preliminary trials, the current study systematically evaluated a focused pool of 10 transgenic rice callus lines comprising the T-candidate group (T1-T6) and S-candidate lines (S1-S4) to identify high-performing lead clones. However, due to poor cell growth rates observed in the T-candidate group, these lines were not selected for further screening analysis. Consequently, the initial screening phase focused on the S-candidate lines, which were subjected to a 24 hour induction period in sugar-free NB-S liquid medium following semi-solid maintenance culture. Western blot analysis successfully verified the specific target band of the recombinant VP1 protein at approximately 37 kDa, leading to the narrow selection of lines S1 through S4 for deeper

characterization. Subsequent extensive validation utilizing an extended 72 hour sugar-starvation protocol paired with parallel immunodetection confirmed that candidate lines S1, S3, and S4 tested strongly positive for target antigen expression, justifying their advancement into liquid shake flask subcultures.

To evaluate long-term translational potential and expression stability across successive generations, passage trials (Passages 1 & 2) were carried out. Immunoblots confirmed that lines S1 and S3 maintained prominent, highly reproducible VP1 expression levels matching the positive antigen standards. Meanwhile, candidate line S4 exhibited a distinct decline in both expression intensity and cell growth rates over continuous passage. However, because target VP1 expression remained clearly detectable in line S4 despite its slower kinetic profile, it has not been discontinued from the study. Consequently, lines S1, S3, and S4 continue to be monitored, with S1 and S3 demonstrating the most robust and stable characteristics as primary lead cell lines.

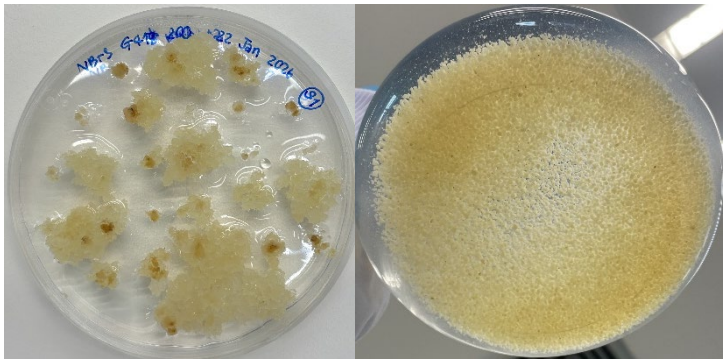

Fig. 1. Morphology and cultivation of transgenic rice callus expressing EV-A71 VP1 protein on NB semi-solid selection medium and subsequent cell suspension culture in liquid NB medium.

Following this screening and identification phase, these selected candidate lines are being subjected to detailed bioprocess monitoring in continuous flask cultivation [5]. Crucial post-screening evaluation is currently underway to systematically analyze cell growth rates, sugar consumption profiles, and cell metabolic viability during the starvation stress period. These subsequent experimental steps will provide critical kinetic parameters and quantitative data necessary to determine the optimal harvest window and finalize the selection of the ultimate lead cell line for high-yield bioproduction.

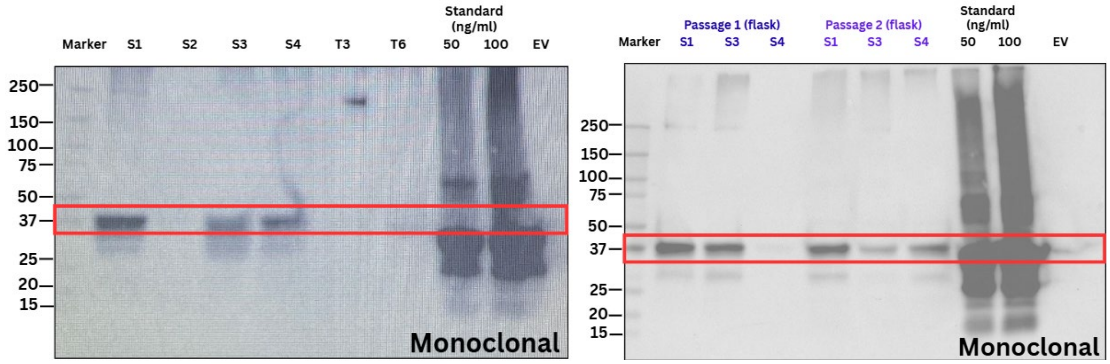

Fig. 2. Western blot analysis of recombinant VP1 protein expression (approx. 37 kDa) in transgenic rice callus candidate lines across successive passages (P1 and P2).

REFERENCES

[1] Kung, Y. H., Huang, S. W., & Wang, J. R. (2023). Recent advances in the development of vaccines and therapeutics against Enterovirus A71. Journal of Biomedical Science, 30(1), 18. https://doi.org/10.1186/s12929-023-00908-4

[2] Golden Jubilee Medical Center, Faculty of Medicine Siriraj Hospital, Mahidol University. (n.d.). Enterovirus 71 Vaccine. https://www.gj.mahidol.ac.th/main/entrovac/

[3] Rosales-Mendoza, S. (2025). Molecular farming: A reinvented platform for vaccine production. Vaccines, 13(2), 191. https://doi.org/10.3390/vaccines13020191

[4] Ho, S. L., Tong, W. F., & Yu, S. M. (2009). Multiple cis-elements in the rice Amy3D sugar response complex are involved in sugar and starvation regulation. Plant Cell Reports, 28(1), 67–76. https://doi.org/10.1007/s00299-008-0514-0

[5] Shuler, M. L., & Kargi, F. (2002). Bioprocess engineering: Basic concepts (2nd ed.). Prentice Hall.

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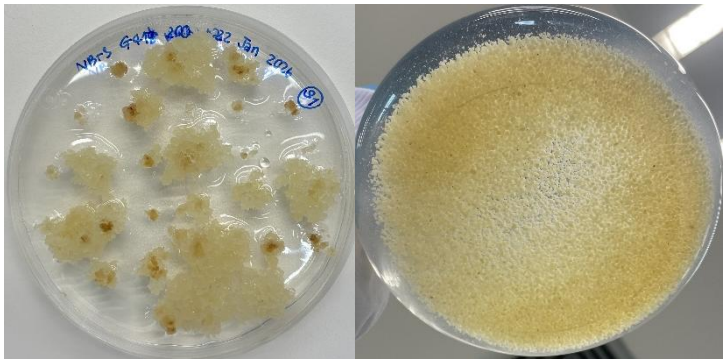

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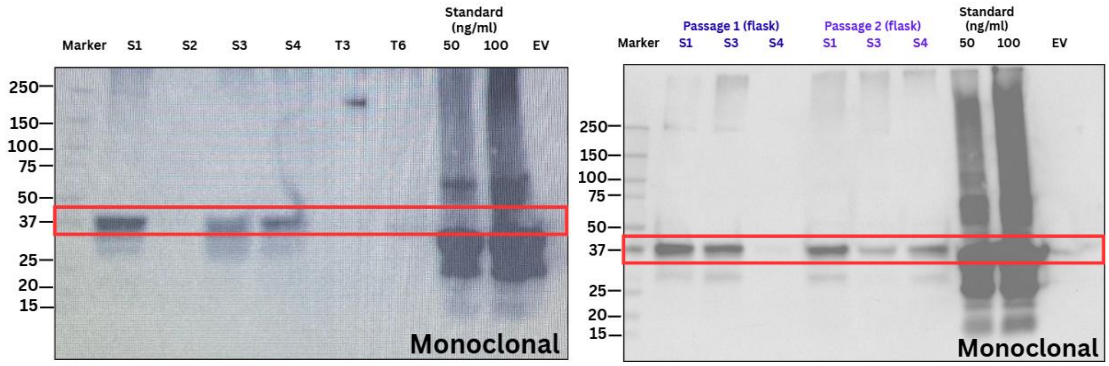

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INSTANCE SEGMENTATION OF RICE PANICLES FOR PLOT-LEVEL YIELD PREDICTION

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Purpose and Background

Rice is a regularly eaten food that feeds more than half the world's population and about 28% of it grows in China. Jilin, where our study area is located, is one of the provinces in China where a lot of premium japonica rice is cultivated, and an early read on the harvest helps with grain reserves and price planning. Satellites are usually helpful for gathering data on a whole region, but they cannot resolve a single panicle, the part of the plant that sets how much grain it carries. They can only read yield from canopy color and density rather than from the panicles themselves.

Some of the research tries applying deep learning to solve this problem. Semantic segmentation depicts every panicle pixel with one label, which works until two panicles touch, and it can no longer tell them apart; Bak et al. (2025) reached an R^2 of 0.89 this way but found that overlapping panicles blur together in their masks. What we get is object detectors instead of drawing a box around each panicle, yet a box records only its location, not its area, outline, or elongation shapes. The shape of the individual panicle is still nowhere to be acquired, which is what correlates with grain number and final yield. The RiceSEG benchmark used here was released with semantic labels only. Instance segmentation will give each panicle some features, and then we can measure and pass to a Random Forest that estimates plot-level yield.

Materials and Methods

Training data came from five sub-regions of the RiceSEG benchmark: Tanzania, Guangdong, Jilin, Jiangsu, and Hunan. RiceSEG ships six-class semantic masks. The panicle class was converted to per-instance polygons with Connected Components Analysis and the Segment Anything Model, and tiling the source images into quadrants gave 976 training and 220 validation images.

The detector is a customized YOLOv11l-seg model. Two changes target the shape of rice panicles, which are long, curved, and often overlapping. Dynamic Snake Convolution takes over the normal convolution in backbone layers 4 and 6, where the receptive field bends along the panicle spine. Large Selective Kernel Attention is placed at the end of the backbone and picks a kernel size per pixel to separate overlapping panicles.

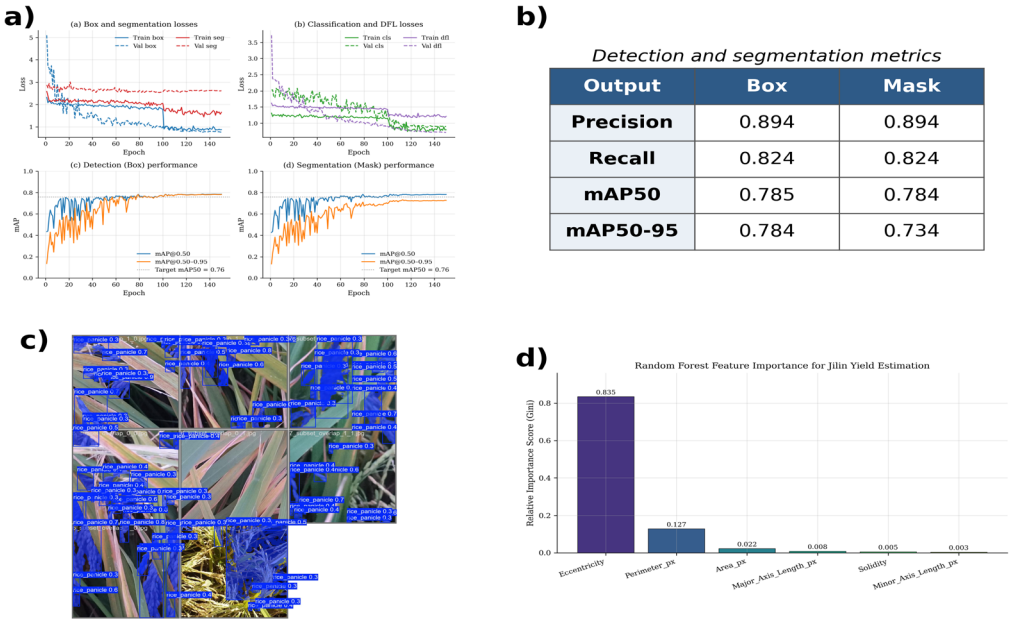
For yield, six shape features were measured from every predicted mask: area, perimeter, major axis length, minor axis length, eccentricity, and solidity. The Random Forest model mapped all of these features to a per-panicle yield value in tonnes per hectare. The yield targets were not measured in the field but assigned from the 7.28 to 8.50 t/ha range reported in the Jilin Statistical Yearbook, and the model was evaluated with 5-fold cross-validation. The plot-level estimate is the mean of the per-panicle predictions.

Results and Discussion

On the 220-image validation set (239 panicle instances), the model reached a Box precision of 0.894, a recall of 0.824, and a Box mAP50 of 0.785 (Figure 1a, 1b). Box mAP50-95 is valued at 0.784, and it is almost identical to mAP50, which means that it's a tight-bounding box even at strict overlap thresholds. The masks were less precise at those thresholds, with mAP50-95 falling to 0.734. Most errors were missed panicles (42 false negatives) rather than false detections (25 false positives). A missed panicle was mainly because of the shrinking sample, whereas a false detection would add an invalid row to the feature table. If the missed panicles are systematically smaller or more closed off, they could also bias the feature distribution (Figure 1c).

The Random Forest explained most of the yield variation, with an R^2 of 0.8537 and an RMSE of

0.1564 t/ha, about 1.9% of the mean yield. This R^2 is near to the 0.89 claimed by Bak et al. (2025), even though the two are not directly comparable: that study used a multi-week time series, whereas this pipeline uses a single image per plot. Feature importance was concentrated in eccentricity (83.5%) and perimeter (12.7%) (Figure 1d). Because panicle size varied little across the Jilin plots, the model relied on shape descriptors. Eccentricity could also act as a representative for spikelet configuration, which is a relationship that was not measured here.



Detection and segmentation metrics

Output	Box	Mask
Precision	0.894	0.894
Recall	0.824	0.824
mAP50	0.785	0.784
mAP50-95	0.784	0.734

Figure 1. Model results: (a) training and validation losses with Box and Mask performance over 150 epochs; (b) detection and segmentation metrics on the validation set; (c) predicted panicle instances on a validation batch; (d) Random Forest feature importance for yield estimation.

REFERENCES

Bak, H.-J., Kim, E.-J., Lee, J.-H., Chang, S., Kwon, D., Im, W.-J., Hwang, W.-H., Chang, J.-K., Chung, N.-J., & Sang, W.-G. (2025). Deep learning-based semantic segmentation for rice yield estimation by analyzing the dynamic change of panicle coverage. *Frontiers in Plant Science, 16*, 1611653.

Qi, Y., He, Y., Qi, X., Zhang, Y., & Yang, G. (2023). Dynamic snake convolution based on topological geometric constraints for tubular structure segmentation. *Proceedings of the IEEE/CVF International Conference on Computer Vision*, 6070-6079.

Wei, J., Tian, X., Ren, W., Gao, R., Ji, Z., Kong, Q., & Su, Z. (2024). A precise plot-level rice yield prediction method based on panicle detection. *Agronomy, 14*(8), 1618.

Zhou, J., Wang, H., Kato, Y., et al. (2025). RiceSEG: A global multi-class rice segmentation dataset. *Plant Phenomics, 7*, 100099. https://doi.org/10.1016/j.plaphe.2025.100099

NAVIGATING THE AI-DRIVEN EDUCATIONAL LANDSCAPE: A GROUNDED THEORY APPROACH TO DEVELOPING AN ADAPTIVE LEADERSHIP FRAMEWORK

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Purpose and Background

The rapid development of generative artificial intelligence, starting with ChatGPT and expanding to large language models, has placed education leaders at the forefront of transformative institutional change. In China this urgency is encoded in policy: the 2025 Education Power Construction Plan (2024–2035) enshrines AI-enabled transformation as a national strategy, and school principals as the key bottleneck for its implementation (Luo, 2025). Yet a review of 168 peer-reviewed papers on AI and educational leadership reveals that the area is fundamentally conceptual rather than empirical (Renta-Davids et al., 2025), and that middle leaders' participation in AI is contingent upon their level of personal confidence as well as organizational support (Berkovich & Eyal, 2025). However, this research gap is addressed in this study by asking: *What leadership capabilities are defined by real-life experiences of educational leaders navigating through AI-driven transformation?*

Materials and Methods

Grounded theory was applied to develop theory from data rather than fitting data to existing frameworks. Semi-structured interviews were conducted in April 2026 with three purposively selected educational leaders in China via Tencent Meeting: Participant A, a subject chair at a new public school in Hangzhou; Participant B, the founder of a graduate admissions consultancy based in Beijing; and Participant C, the founder of a K-12 tutoring company based in Shanghai. These three participants, drawn from distinct educational sectors, were selected to collect diverse leadership experiences across different AI adoption contexts. The analysis employed three coding levels: open coding, axial coding, and selective coding. The analysis generated 47 initial open codes, and continuous cross-level comparisons were performed. Due to the sample size, theoretical saturation was not reached; the findings are therefore exploratory and tentative.

Results and Discussion

Open Coding. Line-by-line analysis produced 47 initial codes. Table 1 presents a representative selection.

Table 1 Selected Open Codes with Representative Quotations

Open Code	Representative Quotation
Teacher anxiety about AI displacement	"The biggest challenge is that teachers feel AI will 'take their jobs'—things like automatic question generation." (A)
AI as low-end substitute	"We treat AI as a 'low-end substitute': we do what AI cannot do—deep digging and emotional connection." (B)
Resistance from algorithmic teachers	"The biggest resistance comes from those who rely on test-taking strategies—they feel AI has taken away their control." (C)
Pilot before scale	"I would first run a pilot with one or two young teachers, then hold sharing sessions." (A)
Small-step quick iteration	"My principle is small steps, fast iteration, quick trial and error." (B)
Data challenging intuition	"Data told me a class's Geography scores suddenly dropped, but intuitively that class had good discipline." (A)

Axial Coding. The 47 codes were grouped into six overarching categories of leader competencies: (1) Situational calibration, focusing on followers' readiness and emotional response to AI implementation, combining the identity threat process with Hersey and Blanchard's framework; (2) Employee centred Transformation, motivating change through role modeling and project ownership rather than unilateral

commands; (3) Proactive risk navigation, anticipating policy and market changes before official confirmation and developing multi-layered contingency plans; (4) Balanced empowerment, granting process autonomy and intervening only when results exceed expectations; (5) Data-driven intuition, using analytics to guide focus but interpreting contexts using human judgment based on Wang's (2021) symbiotic decision-making framework; and (6) Ethical boundary setting, maintaining professional ethics under the influence of AI, including taking responsibility for decisions made with AI assistance . These six capabilities define the leadership skills that education leaders can develop from real-life experiences in addressing AI-driven transformation.

Selective Coding. Synthesizing the six axial categories leads to the core concept: Adaptive Fusion Leadership (AFL), which is the ability to flexibly integrate situational, transformational, and data-driven leadership approaches while maintaining ethical principles within a context of high uncertainty. AFL is enacted via three meta-competencies: style flexibility (shifting between directive and supportive actions as the situation requires), source flexibility (processing data, intuition, and policy signals without becoming over-dependent on one source), and speed flexibility (adjusting the speed of decision-making according to specific changes, rapid cycles and long deliberations).

In the era of AI-driven educational transformation, educational leaders need to possess the six leadership traits identified through axial coding analysis to succeed. These interwoven traits enable leaders to employ a range of leadership styles and strategies to address technological and organizational uncertainties. The combination of these traits forms the foundation of Adaptive Convergent Leadership (AFL), representing an intuitive fusion of human rational judgment, ethical responsibility, and the support provided by AI in decision-making.

This finding aligns with the tenets of situational leadership theory, which emphasizes leader behavior adaptation to followers' readiness. However, contrasting with conventional situational leadership, the results of this study show that leaders need to continuously interpret AI-generated data, signals and question politics and ethics, thus moving leadership adaptation beyond human-to-human interactions. This finding also aligns with transformational leadership theory, particularly with the proposed employee-oriented style of change. However, participants in this study emphasized that experimentation and iterative learning were more important than vision, suggesting that AI-driven leadership in educational change may be more flexible than traditional transformational leadership models.

China's centralized, policy-driven education system means that leadership needs to strike a balance between innovation, policy compliance, and organizational stability. This context may explain why proactive risk aversion and ethical boundary setting are important leadership capabilities, as educational leaders not only need to drive innovation but also ensure its responsible implementation, aligning it with national education priorities.

REFERENCES

Berkovich, I., & Eyal, O. (2025). Support for generative artificial intelligence as a predictor of middle leaders' generative artificial intelligence self-efficacy, valuing, and integration in school leadership work. *Educational Management Administration & Leadership.* https://doi.org/10.1177/17411432251361251

Luo, L. (2025, May 27). *Generative artificial intelligence era principal leadership reconstruction: International experience and China's approach.* Primary and Secondary School Management. https://www.cnaes.edu.cn/post/30588

Renta-Davids, A., Camarero-Figuerola, M., & Camacho, M. (2025). Navigating the challenges and opportunities of artificial intelligence in educational leadership: A scoping review. *Review of Education, 13*(2). https://doi.org/10.1002/rev3.70101

Wang, Y. (2021). Artificial intelligence in educational leadership: A symbiotic role of human-artificial intelligence decision-making. *Journal of Educational Administration, 59*(3), 256–270. https://doi.org/10.1108/jea-10-2020-0216

SOCRATIC AI-MEDIATED INQUIRY (SAMI) TO ADDRESS SECONDARY STUDENTS' MISCONCEPTIONS ABOUT THE SIMPLE PENDULUM

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Purpose and Background

Conceptual understanding of simple harmonic motion (SHM) and the simple pendulum is undermined by persistent misconceptions for example, that a heavier bob or a wider swing lengthens the period, that the period is proportional to length, and that kinetic energy is greatest at the top of the swing (Tumanggor et al., 2020; Somroob & Wattanakasiwich, 2017). Conceptual change occurs when students become dissatisfied with a prior idea and find a better one intelligible and plausible (Posner et al., 1982); such instruction yields large average gains (Pacaci et al., 2024), yet conventional lessons rarely surface and refute these stable, partly productive prior conceptions (Smith, diSessa, & Roschelle, 1993). Large language models can sustain Socratic dialogue at scale and have rivalled active learning (Kestin et al., 2025), but they can also assert confident errors and slip into answer-giving (Gregorcic & Pendrill, 2023), and few studies measure AI-supported conceptual change with validated diagnostics. This study introduces SAMI (Socratic AI-Mediated Inquiry): a single chatbot that elicits a student's idea, questions it, openly states and refutes the common misconception, and runs a predict–observe–explain (POE) cycle with a purpose-built simulation. We ask: (RQ1) Does SAMI improve conceptual understanding more than conventional teaching? (RQ2) How is the dialogue related to learning gains?

Materials and Methods

This was a nonequivalent control-group pretest–posttest quasi-experiment in a Thai secondary school. Two intact Grade-11 classes were assigned to a treatment group (SAMI; n = 32) or a control group (conventional lecture–demonstration–practice; n = 31). Both groups covered the same three concepts A (period vs. mass/amplitude), B (period vs. length and g, and frequency), and D (energy and graph reading) across two 90-minute sessions over two weeks. A fourth concept, C (restoring force and the SHM condition), was assessed but not taught, serving as an untreated within-test comparison. Understanding was measured with a 12-item four-tier diagnostic (answer, confidence, reason, confidence), which classifies each response as secure understanding (SU), false positive/negative, misconception (MIS), or lack of knowledge (LK) (Kaltakci-Gurel et al., 2017). SAMI was implemented in a custom EdCafe chatbot combining Socratic questioning, refutational moves, and POE with the simulation; all dialogues were logged. Data were analysed with within-group Wilcoxon signed-rank tests, class normalized gain $\langle g \rangle$ (Hake, 1998), a between-group ANCOVA with the pre-test as covariate, and Spearman correlations linking dialogue features to gains.

Results and Discussion

The groups were equivalent at pre-test (Mann–Whitney U, $p = .20$). Both improved, but the treatment group improved more (treatment 45% → 72%, $\langle g \rangle = 0.48$; control 38% → 58%, $\langle g \rangle = 0.31$). Adjusting for the pre-test, the post-test advantage was significant with a large effect (ANCOVA $F(1, 60) = 10.27$, $p = .002$, partial $\eta^2 = 0.15$; adjusted means 8.52 vs. 6.98 out of 12). The effect was concentrated on the most-targeted misconception: on concept A the treatment gain far exceeded the control ($\langle g \rangle = 0.68$ vs. 0.33; between-group $d = 1.09$, $p < .001$), whereas the untreated concept C showed no group difference ($\langle g \rangle = 0.34$ vs. 0.36; $d = 0.06$). Because A diverged sharply while C did not and baseline was equal the advantage is attributable to the SAMI sessions rather than to testing or maturation (Figure 1). Concepts B and D favoured the treatment but not significantly (D was taught last and reached by fewer students Secure understanding in the treatment group rose from 7% to 33%, while the control group stayed flat (about 12%); lack-of-knowledge roughly halved (49%→24%).

Linking process to outcome (RQ2), students whose dialogues contained more conceptual-change talk and more turns achieved larger normalized gains (Spearman $\rho = 0.66$, $p = .003$, and $\rho = 0.51$, $p = .030$; $n = 18$; Figure 2), whereas dialogue duration and the bot's questioning rate did not ($\rho = 0.22$ and 0.10, both n.s.) consistent with active-engagement accounts of learning, in which constructive and interactive engagement outperforms passive exposure (Chi & Wylie, 2014). Limitations: SAMI was evaluated as an integrated package (dialogue + refutation + simulation) against conventional teaching, so the unique contribution of the AI is not

isolated from the simulation; the study used intact classes in a single school with modest samples, and the overall advantage was carried mainly by concept A.

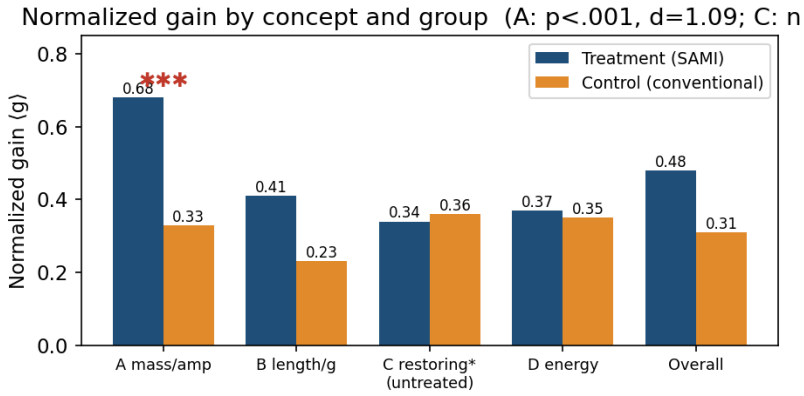

Figure 1. Normalized gain ⟨g⟩ by concept and group. Concept A (most-targeted) shows a large treatment advantage; the untreated concept C shows none.

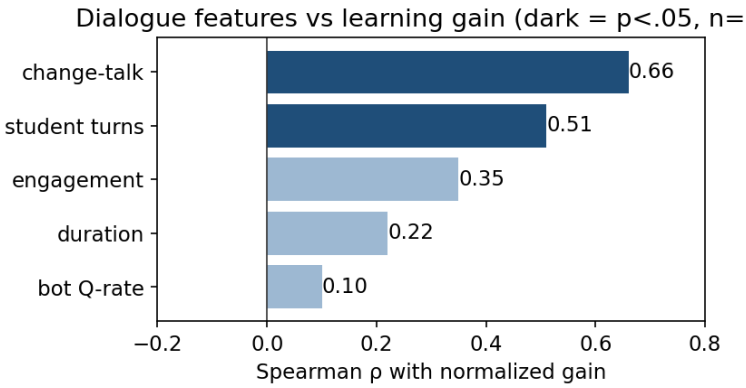

Figure 2. Association between Session-1 dialogue features and normalized gain (Spearman ρ; dark bars $p < .05$, $n = 18$). Engagement quality, not time-on-task or the bot's questioning rate, tracks learning.

REFERENCES

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243.

Gregorcic, B., & Pendrill, A.-M. (2023). ChatGPT and the frustrated Socrates. *Physics Education, 58*(3), 035021.

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.

Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, L. C. (2017). Development and application of a four-tier test to assess pre-service physics teachers' misconceptions about geometrical optics. *Research in Science & Technological Education, 35*(2), 238–260.

Kestin, G., Miller, K., Klales, A., Milbourne, T., & Ponti, G. (2025). AI tutoring outperforms in-class active learning: An RCT. *Scientific Reports, 15*, 17458.

Pacaci, C., Ustun, U., & Ozdemir, O. F. (2024). Effectiveness of conceptual change strategies in science education: A meta-analysis. *Journal of Research in Science Teaching, 61*(6), 1263–1325.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211–227.

Smith, J. P., diSessa, A. A., & Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *Journal of the Learning Sciences, 3*(2), 115–163.

Somroob, S., & Wattanakasiwich, P. (2017). Investigating student understanding of simple harmonic motion. *Journal of Physics: Conference Series, 901*, 012123.

Tumanggor, A. M. R., Supahar, Ringo, E. S., & Harliadi, M. D. (2020). Detecting students' misconception in simple harmonic motion concepts using four-tier diagnostic test. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni, 9*(1), 21–31.

Filler Frequency and Functional Development Across CEFR Levels in the Oxford Test of English: A Corpus-Based Comparison with Native-Speaker Benchmarks

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Purpose and Background

In spoken communication, fluency has always been regarded as one of the major factors influencing skill assessment, and the fillers are considered markers of hesitation and disfluency traditionally (Council of Europe, 2001; Levelt, 1989). In a classic behaviorist and early psycholinguistic literature, filled pauses were identified as symptoms of poor speech planning and signs of low verbal skill (Mahl, 1956). However, in later studies of language fluency, it has been shown that disfluencies, including, fillers, vary depending on speaking context, and they can reflect both spoken language production difficulty and communicative strategy (Bortfeld et al., 2001). Although fillers are considered planning difficulty indicators in process marking (Clark & Fox Tree, 2002), a different perspective has introduced that the fillers can exist in natural speech and support listener comprehension by signaling upcoming delays or complex information (Fraundorf & Watson, 2011). As language is not only delivering the information but also used to manage interaction, features such as fillers can function as interpersonal communication management tools in strategic communication (Hyland, 2005a). According to a prior study, lexical and non-lexical fillers can be categorized according to their semantic status and discourse functions (Muller, 2005). Additionally, it is found that non-lexical fillers like "uh" can lead the listeners to active interpretation as a processing signal and predict the upcoming information (Arnold et al., 2007). In speaking assessment, fluency is a key criterion and the use of fillers can influence how the speaker's performance is considered (De Jong et al., 2015). Moreover, in speaking skill assessment tests, the observable performance features like fluency have a substantial impact on raters' judgements of communication skill level (Bachman & Palmer, 1996). Nevertheless, the role of fillers in test performance, how their functional roles are perceived, and how they align with proficient native use have yet to be investigated – especially in corpus-based studies with spoken test data. The Oxford Test of English (OTE) spoken proficiency assessment is well-aligned with the Common European Framework of Reference (CEFR) and it provides reliable defined proficiency levels of learner performance. According to the OTE official test specifications, fluency is mentioned as one of the key elements of the speaking criteria. Additionally, coherence and cohesion are also indicated under the fluency which increase the suitability of Oxford Test of English Learner Corpora (OTELC) for this study. OTELC is a unique database of spoken and written corpora collected from the candidates who took the Oxford University Press OTE. The database is organized according to CEFR-aligned proficiency classifications and to support corpus-based investigations in standardized assessment contexts.

Materials and Methods

This study uses a corpus-based mixed-method design where quantitative frequency analysis and qualitative concordance-based functional analysis are combined. Using multi-theoretical framework, the study is designed to be carried out under two complementary theoretical lenses: Levelt's Model of Speech Production (1989) as cognitive processing lens and Hyland's (2005b) Metadiscourse Framework as functional discourse lens. With this combination, the hypothesis of shift from hesitation markers to strategic discourse tools as language proficiency increases is identified (Functional Shift Hypothesis). For quantitative analysis, the frequency of the use of filler across the CEFR levels (Below A2 to B2) will be identified and compared. The primary data source of this study is the spoken test part of the Oxford Test of English Learner Corpus (OTELC), which is a systematic collection of learner corpora from Oxford Test of English candidates. The database is classified with CEFR alignment and can provide authentic learner performance in a standardized speaking assessment context. The data groups of Below A2, A2, B1 and B2 speaking test data will be used, and the equal-sized CEFR sub corpora will be created (sample size may vary depending on corpus accessibility). Throughout the study, Sketch Engine will be used as the primary software for corpus analysis. By concordance-based contextual analysis, lexical and non-lexical fillers will be identified from the transcribed spoken responses of real test tasks. The lexical fillers will be operationally defined as real lexical items used pragmatically rather than semantically (e.g., like, well, you know, I mean) and the non-lexical fillers as non-word vocals such as "uh", "um", or "er". For data analytical procedures, the following steps will be carried out.

1. Calculate the frequency per 100 words of each filler type across CEFR levels (Normalized frequency) by using the wordlist function.

2. Run a chi-square test in order to determine whether the frequency differences between CEFR levels are statistically significant (Raw frequency).
3. Extract 1000 instances per CEFR level by using concordance (KWIC – Key Word in Context) to assure the manual coding is manageable and representative. (Extraction of lexical and non-lexical fillers will base on their original ratio at each CEFR level in the database)
4. Conduct functional coding of the extracts, and based on the contextual analysis, the fillers' discourse functions will be interpreted (e.g., hesitation, planning, interactional use). For this interpretation, complementary theoretical lens, derived from Levelt's Model of Speech Production (1989) and Hyland's Metadiscourse Framework (2005), will be used.
5. Identify patterns of development across CEFR levels by cross-level comparison of the frequency and functions of fillers.
6. Additionally, the study will advance to native benchmark concordance comparison to see learner filler functions and native-speaker benchmark patterns' functional alignment. For this functional alignment analysis, the native-benchmark patterns will be identified and divided from the database itself, as it includes the data of candidates from native countries.
This study proposes the Functional Shift Hypothesis to explain the variation of filler functions across CEFR proficiency levels. The hypothesis suggests that the function of the fillers used will shift from hesitation-based production to strategic discourse-management as the learners' proficiency level increases. At lower levels, the functions are expected to be speech planning difficulty, lexical retrieval, and hesitation. As the level gets higher, the functions may shift into strategic use of organizing speech, expressing stance, and managing listener interaction. This development is further expected to show alignment with native-speaker pragmatic usage patterns.

Results and Discussion (Implications)

This study aims to extend filler research into examining strategic discourse roles, pragmatic development and functional sophistication across proficiency levels. Moreover, by introducing a developmental perspective across CEFR levels, the study contributes by adding developmental evidence to learner corpus research as it will show how filler usage develops systematically with speaking proficiency. Additionally, the proposed Functional Shift Hypothesis offers a new systematic explanatory framework for filler development interpretation across CEFR levels, and it can guide future learner fluency studies. In practical contribution, the study will provide insight into how fillers should be perceived in contemporary language assessment by considering their functions in addition to frequency. Secondly, the study aims to support fluency descriptor interpretation by differentiating between disruptive hesitation fillers and communicatively effective fillers, especially in CEFR-based assessment scoring interpretation. Additionally, such a move in perspective may help speaking teachers in teaching learners about strategic use of fillers for many different purposes based on the evidence. Moreover, the study may also provide clear insight into how speaking strategically determines pragmatic fluency rather than faster speech production.

REFERENCES

Arnold, J. E., Hudson Kam, C. L., & Tanenhaus, M. K. (2007). If you say thee uh you probably mean this one: Expectancies created by disfluencies influence spoken word recognition. Psychological Science, 18(10), 915–922.
Bachman, L. F., & Palmer, A. S. (1996). Language testing in practice. Oxford University Press.
Bortfeld, H., Leon, S. D., Bloom, J. E., Schober, M. F., & Brennan, S. E. (2001). Disfluency rates in conversation: Effects of age, relationship, topic, role, and gender. Language and Speech, 44(2), 123–147.
Clark, H. H., & Fox Tree, J. E. (2002). Using uh and um in spontaneous speaking. Cognition, 84(1), 73–111.
Council of Europe. (2001). Common European framework of reference for languages: Learning, teaching, assessment. Cambridge University Press.
De Jong, N. H., Steinel, M. P., Florijn, A. F., Schoonen, R., & Hulstijn, J. H. (2015). Facets of speaking proficiency: Fluency contributes strongly to listener judgments. The Modern Language Journal, 99(2), 223–243.
Fraundorf, S. H., & Watson, D. G. (2011). The um advantage: Disfluency facilitates listeners' memory for speech. Psychonomic Bulletin & Review, 18(1), 151–158.
Hyland, K. (2005a). Metadiscourse: Exploring interaction in writing. Continuum.
Hyland, K. (2005b). Stance and engagement: A model of interaction in academic discourse. Discourse Studies, 7(2), 173–192.
Levelt, W. J. M. (1989). Speaking: From intention to articulation. MIT Press.
Mahl, G. F. (1956). Disturbances and silences in the patient's speech in psychotherapy. Journal of Abnormal and Social Psychology, 53(1), 1–15.
Müller, R. (2005). A corpus study of verbal and nonverbal fillers in spoken discourse. John Benjamins.

JUNIOR HIGH SCHOOL STUDENTS' VIEWS OF NATURE OF SCIENCE: EVIDENCE FROM A PRIVATE SCHOOL IN DAVAO REGION, PHILIPPINES

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Purpose and Background

Understanding the Nature of Science (NOS) is an essential component of scientific literacy because it helps learners understand how scientific knowledge is developed, validated, and applied in society. Despite the increasing number of international studies about NOS, limited research has been conducted in the Philippine context, particularly among junior high school students. This study aimed to examine the views of Filipino junior high school students regarding the different aspects of NOS and determine whether significant differences existed when grouped according to gender and grade level.

The study was anchored on the "consensus view" of NOS, which includes the understanding that scientific knowledge is tentative, empirical, subjective, imaginative and creative, socially and culturally embedded, and influenced by observations and inferences. It also includes understanding the distinction between scientific theories and scientific laws. Previous international studies revealed that many secondary students possess inadequate or transitional understandings of NOS concepts. However, no study prior to this had explicitly investigated NOS views among Filipino junior high school learners.

Scientific literacy remains a major concern in the Philippines, especially after the country's low performance in international assessments such as PISA 2018. Since understanding NOS is strongly connected to scientific literacy, investigating students' NOS conceptions may provide valuable insights for improving science instruction and curriculum implementation in the country. This study therefore contributes to the growing body of NOS research and highlights the need for explicit NOS instruction within Philippine science education.

Materials and Methods

This study utilized a convergent parallel mixed-methods research design wherein quantitative and qualitative data were collected and analyzed simultaneously. The respondents were 173 junior high school students enrolled in Grades 7 to 10 in a private school in Davao Region, Philippines during the academic year 2021–2022. The participants were selected through convenience sampling due to movement restrictions during the COVID-19 pandemic.

The primary instrument used in the study was the Student Understanding of Science and Scientific Inquiry (SUSSI) questionnaire. The instrument assessed students' views regarding seven aspects of NOS: tentativeness, empirical nature of science, social and cultural embeddedness, imagination and creativity, methods of scientific investigation, observation and inference, and scientific theories and laws. The questionnaire consisted of 28 Likert-scale items and seven open-ended questions.

Data collection was conducted online using Google Forms. Necessary permissions and approvals were obtained from the institution and school authorities prior to data gathering. Students voluntarily participated in the study after accomplishing the informed consent form.

Quantitative data from the Likert-scale responses were analyzed using descriptive statistics such as frequency, percentage, mean, and standard deviation. Inferential statistics including t-test, analysis of variance (ANOVA), and chi-square test of independence were also used to determine significant differences according to gender and grade level. Qualitative responses from the open-ended questions were analyzed using a rubric adapted from previous NOS studies and categorized into naïve, transitional, or informed views.

Results and Discussion

The findings revealed that most junior high school students possessed transitional views regarding the different aspects of Nature of Science (NOS), as shown in Table 1. Quantitative data indicated that a large

percentage of respondents demonstrated transitional understandings in aspects such as tentativeness, empirical nature, observation and inference, imagination and creativity, and methods of scientific investigation. However, many students still exhibited naïve views, particularly regarding scientific theories and laws.

As presented in Table 1, one of the most notable findings was students' misunderstanding of the relationship between scientific theories and laws. Many respondents believed that scientific theories become laws once they are proven correct. Others viewed laws as absolute truths while theories were considered unverified ideas. These misconceptions indicate that students had difficulty understanding the distinct roles and functions of scientific theories and laws within science.

Results further showed that students struggled with understanding the empirical nature of science and the role of creativity and imagination in scientific work. Several students believed that imagination could lead to mistakes in scientific investigations rather than contribute to scientific discovery and innovation. Furthermore, some respondents believed that scientists always follow a single universal scientific method, indicating limited understanding of how scientific investigations vary depending on context and purpose.

In terms of demographic differences, significant gender-based differences were only found in the imagination and creativity aspect of NOS, where female students demonstrated more informed views than male students. Significant grade-level differences were also observed in the tentative and observation-and-inference aspects, although these differences were relatively small. Overall, the findings suggest that exposure to science classes alone does not automatically develop students' informed views of NOS.

The study emphasizes the importance of integrating explicit NOS instruction into science teaching. The researchers recommended that Philippine science curricula, textbooks, and instructional practices should more clearly incorporate NOS concepts and reflective discussions to improve students' scientific literacy and understanding of how science works.

Table 1. Summary of Junior High School Students' Views of Nature of Science (NOS)

NOS Aspect	Dominant View	Key Finding
Tentativeness	Transitional	Most students understood that scientific knowledge may change over time
Empirical Nature	Transitional	Students partially recognized the importance of evidence and experimentation
Social and Cultural Embeddedness	Transitional	Students showed limited understanding of how society and culture influence science
Imagination and Creativity	Transitional	Some students believed creativity is not important in scientific work
Methods of Scientific Investigation	Transitional	Many students believed scientists follow one universal scientific method
Observation and Inference	Transitional	Students had difficulty distinguishing observation from inference
Scientific Theories and Laws	Naïve	Many students believed theories become laws once proven

Source: Adapted from Gerondio et al. (2023).

REFERENCES

Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education, 82*(4), 417–436.

Das, P. M., Faikhamta, C., & Punsuvon, V. (2019). Bhutanese students' views of nature of science: A case study of culturally rich country. *Research in Science Education, 49*(2), 391–412.

Gerondio, L. B., Unabia, W. A. R., Mayang, Z. M., & Alimbon, J. A. (2023). *Junior high school students' views of nature of science: evidence from a private school in Davao Region, Philippines*. International Journal of Science Education. https://doi.org/10.1080/09500693.2023.2260522

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331–359.

Pro-social Attitude-Behavior Gap Among Private Secondary School Students

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Purpose and Background

The primary objective of the United Nations' Sustainable Development Goal 4 (SDG4), specifically target 4.7, by 2030, is to foster global citizenship with a sense of social responsibility and empathy, as well as to develop learners' knowledge and skills to promote sustainable development. To accomplish this, the educational system of China has implemented mandatory curricula for secondary school. These include the Integrated Practical Activity Curriculum (IPA) and the Labor Course, which was formally designated as an independent compulsory subject in 2022. Both courses are regarded as instruments for cultivating prosocial conduct. These courses are advantageous in that they facilitate students' engagement in social practice and foster an understanding of social responsibility (Hu et al., 2025; Zhao & Tuo, 2024).

Nevertheless, a substantial disparity has been demonstrated between the pro-social attitudes and participation of students in China (Xiao et al., 2022). Private schools are also updating their educational management policies in response to the revision of the "Regulations on the Implementation of the Private Education Promotion Law (2021)." Therefore, it is imperative to investigate private schools. The majority of extant research has concentrated on quantitative descriptions but lacks comprehension of the "attitude-behavior gap" from the student's perspective.

Consequently, the purpose of this investigation is to examine the attitudes of private secondary school students toward pro-social behavior, actual participation, and obstacles from their perspective.

Materials and Methods

A mixed-methods approach was employed, which included quantitative data collected through a survey and qualitative data collected through an interview. Initially, a paper-based, self-administered questionnaire was distributed to three private institutions in Fuzhou city from April 2025 to May 2025. From a total of 150 individuals, a straightforward random sample of 116 was selected. The participants were between the ages of 13 and 16, with 47% being male and 53% being female. The response rate was 77.5%. There are a total of 15 questions distributed across three themes. Theme 1 (Q1-4): demographic characteristics, which displayed the age, gender, province, school name, and study level of the students' qualifications. Theme 2 (Q5-10) focused on students' pro-social attitudes, indicating their willingness to engage in pro-social activities and their attitudes toward these activities; Theme 3 (Q11-15) addressed the actual frequency of participation, illustrating how often students participated. Theme 2 employed a five-point Likert scale ranging from 1 to 5 (strongly disagree, disagree, neutral, agree, and strongly agree); theme 3 ranged from 1 to 5 (never, rarely, sometimes, often, and always).

Subsequently, 12 candidates participated in semi-structured interviews from May 2025 to June 2025, contingent upon their responses to the survey themes in their respective districts. The duration of each interview ranged from 15 to 23 minutes. The interview is designed to facilitate the exchange of experiences between students regarding pro-social activities. The interview content was categorized into two themes: a) the influence of prosocial behavior on individuals and b) the obstacles that impede participation. Regarding theme b, we further classified the obstacles into "external factors" and "psychological risk perception." Interviews were recorded and transcribed with the consent of the students.

Results and Discussion

The survey indicates that there is a discrepancy between "attitude" and "participation" among secondary school students. Figure 1 illustrates that most students show a strong willingness to do pro-social activities. More than 73% of students are willing to protect the river from pollution, nearly 80% of students prefer to help strangers, and around 90% of students show mercy on homeless animals (T2: Q5-Q6-Q7). Questions related to willingness to participate in volunteer services: almost all students indicate great interest, while a few students do not want to participate in volunteer activities (T2: Q8-Q9-Q10). These findings illustrate that students have a positive attitude toward pro-social values.

However, as shown in Figure 2, students' actual participation is not high. There are no students who often participate in service activities, and only approximately 12% of students participated as volunteers (T3:Q11-Q12). Around 22% of students often help strangers outside of school (T3: Q14). Contrarily, when it refers to actual pro-social activity on campus, more than 65% of students often help others in school, and a notable minority of students (T3: Q15) offer suggestions to school development.

The findings show two major factors: First, students hold a positive attitude towards prosocial behavior and look forward to participating in prosocial activities. However, the frequency of actual participation in prosocial activities is low, which indicates that some obstacles influence the consistency of students' thoughts and actions. Secondly, students' behavior is different between on and off campus. On campus, students actively help others. However, off campus, students do not actively participate in prosocial activities. It indicates that social factors limit students' enthusiasm for participation. Third, only a few students are willing to make suggestions to the school, which indicates that internal factors within the school hinder students' enthusiasm for participation.

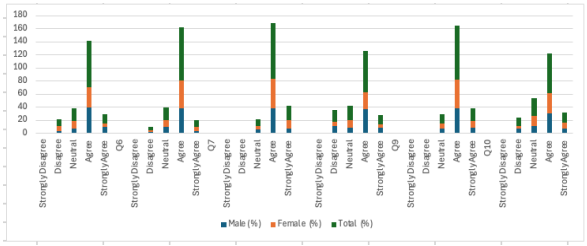

Figure 1- Students' pro-social attitude

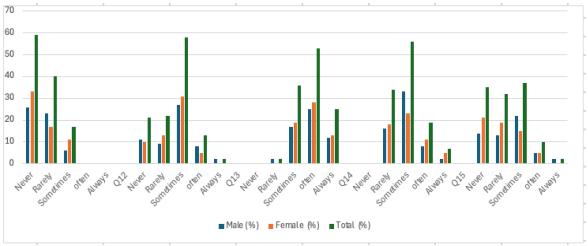

Figure 2- Students' actual frequency of participation

To obtain a profound understanding of the students' perspective, an interview was conducted and divided into three factors: Firstly, academic pressure is an obstacle. A second-year student stated, "I frequently assist my peers on campus but not in society." In terms of safety, we are prohibited from leaving the campus for an extended period, particularly in the private sector. Some students also said, "Parents don't encourage us to do it because of safety and study issues." A third-year student stated that private schools have a greater academic workload, despite the presence of some specialized courses that are considered a means of obtaining academic credentials. Secondly, a student expressed a lack of motivation when social activities were required by the school: "I prefer to participate in pro-social activities, such as volunteering, but when the school requires us to do so, I feel it is a form of homework." Third, media influence has been perceived as a psychological impediment. Students raised that "negative news, such as instances of 'false accidents,' causes them to be apprehensive about assisting strangers." However, before helping others, I can take particular steps. "It suggests that students are more likely to engage in social responsibility when they are provided with a secure and equitable social environment and positive media guidance." Schools must provide positive feedback to engage students in school management.

This empirical evidence for the principle of self-determination theory (SDT) suggests that students' motivation is influenced by autonomous fulfillment, relatedness, and competence. Consequently, a second-year student expressed, "I am interested in composing a letter to the school; however, I have not observed any improvements, and as a result, I will not be writing again." Students' insights reveal that academic burden, insufficient school and parent support, and social values drive the attitude-behavior gap. We categorize them into two factors (Figure 3).

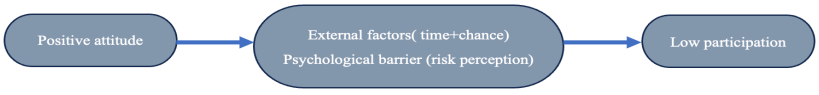

Figure 3. Framework of the attitude-behavior gap in pro-social behavior

REFERENCES

Hu, L., Cheng, J., Wu, C., Liu, Z., & Zheng, L. (2025). Influencing factors for sustainable high-quality implementation of comprehensive practical activity courses in rural areas. *Humanities and Social Sciences Communications*, *12*(1), 1937. https://doi.org/10.1057/s41599-025-06226-4

Xiao, G., Xie, Y., & Lin, R. (2022). Towards Differentiated Labor Education: Family Background, School Location, and Adolescents' Housework Participation. *Research in Educational Development*, *42*(Z2). https://doi.org/10.14121/j.cnki.1008-3855.2022.z2.018

Zhao, J., & Tuo, H. (2024). The impact of housework participation on prosocial behavior development among junior high school students in China. *Scientific Reports*, *14*(1), 32092. https://doi.org/10.1038/s41598-024-83717-5

SUSTAINING AGRICULTURAL INNOVATION: EVIDENCE FROM HEALTHY RICE SEED AND CROP MANAGEMENT AMONG RICE FARMERS IN INDONESIA

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Purpose and Background

Rice is a strategic commodity that plays a vital role in Indonesia's food security. However, rice productivity in Bogor Regency remained between 4.9 and 5.9 t ha^{-1} during 2018–2024, considerably below its potential yield of approximately 7.2 t ha^{-1} achievable through improved crop management (Asnawi, 2017; BPS, 2024). These conditions highlight the need for agricultural innovations to improve rice productivity and strengthen food security. Nevertheless, increasing productivity alone is insufficient if innovation benefits cannot be sustained over time, making the long-term sustainability of agricultural innovation a major challenge for sustainable agricultural development (Klerkx et al., 2012; Rogers, 2003).

Healthy Rice Seed and Crop Management (HRSCM), implemented through the Farmer Field Schools (FFS) approach, is an integrated agricultural innovation that promotes improved rice cultivation practices while enhancing productivity and resource-use efficiency (Alamsyah et al., 2022). Although previous studies have identified farmer characteristics, innovation characteristics, extension performance, and environmental support as important determinants of agricultural innovation adoption (Bakker et al., 2022; Gunawan et al., 2019; Putra & Sadono, 2024), evidence regarding whether innovation adoption contributes to business sustainability remains inconclusive (Ekawati et al., 2025; Hasan et al., 2025). Therefore, this study aims to examine the factors influencing business sustainability among rice farmers participating in FFS in Bogor Regency, Indonesia. Business sustainability was evaluated through social, economic, and environmental dimensions. The proposed relationships among constructs were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS).

Materials and Methods

This study was conducted in Bogor Regency, West Java, Indonesia, where HRSCM program has been implemented using the FFS approach. The research was carried out from October 2025 to February 2026 using a quantitative survey involving 105 rice farmers selected through proportional random sampling from farmer groups in Jonggol and Tanjungsari Districts. Primary data were collected using structured questionnaires. The proposed model examined the effects of farmer characteristics, FFS effectiveness, perceived innovation characteristics, environmental support, extension support, and innovation adoption on business sustainability, which was measured through social, economic, and environmental dimensions. The relationships among variables were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) with SmartPLS 4. Model evaluation included the assessment of path coefficients, coefficient of determination (R^2), predictive relevance (Q^2), and multicollinearity (VIF).

Results and Discussion

The structural model demonstrated satisfactory explanatory and predictive capability, explaining 65.3% of the variance in innovation adoption and 30.4% of the variance in business sustainability. In addition, the model showed acceptable predictive relevance ($Q^2 = 0.198$) without multicollinearity issues (VIF = 1.015–3.481). The structural relationships between the proposed constructs and business sustainability are presented in Table 1.

As shown in Table 1, Farmer Field School effectiveness ($\beta = 0.341$, $p = 0.003$) and environmental support ($\beta = 0.440$, $p = 0.017$) positively influenced business sustainability. These findings demonstrate that business sustainability is primarily driven by participatory learning and enabling environments rather than by technology dissemination alone. Farmer Field Schools enhance experiential learning, improve farmers' problem-solving capacity, and encourage continuous knowledge exchange, while favorable environmental conditions enable farmers to sustain innovation benefits over time. These findings are consistent with the Agricultural Innovation Systems perspective, which emphasizes that sustainable innovation depends on interactions among farmers, institutions, and supporting environments rather than on technology alone (Klerkx et al., 2012).

Table 1. Structural model results for business sustainability

Structural Relationship	β	T-statistics	p-values	Significance
Farmer Characteristics → Business Sustainability	0.137	1.568	0.117	Not Significant
Farmer Field School Effectiveness → Business Sustainability	0.341	2.955	0.003	Significant
Innovation Characteristics → Business Sustainability	-0.326	2.546	0.011	Significant
Environmental Support → Business Sustainability	0.440	2.397	0.017	Significant
Extension Support → Business Sustainability	-0.070	0.558	0.577	Not Significant
Innovation Adoption → Business Sustainability	-0.012	0.073	0.942	Not Significant

Notes: significant at $p < 0.05$

Table 1 shows that farmer characteristics, extension support, and innovation adoption did not significantly influence business sustainability. These findings suggest that business sustainability cannot be explained solely by farmers' resource endowment, external assistance, or technology adoption. Instead, business sustainability appears to depend on the interaction between participatory learning through Farmer Field Schools and enabling production environments. Furthermore, perceived innovation characteristics had a significant negative effect on business sustainability, indicating that farmers become more critical in evaluating innovation after implementation as they balance the expected benefits of innovation against production costs, labor requirements, and compatibility with local farming conditions. The findings highlight that sustaining agricultural innovation depends on participatory learning, enabling farming environments, and continuous institutional support beyond the initial implementation stage. These findings extend the understanding of agricultural innovation by demonstrating that long-term business sustainability is driven more by learning processes and enabling environments than by technology adoption alone. Therefore, strengthening Farmer Field Schools and supportive institutional and farming environments should become strategic priorities for enhancing the long-term sustainability of agricultural innovation and rice farming businesses.

REFERENCES

Alamsyah, A. A., Anggarawati, S., & Suwarnata, E. A. A. (2022). Feasibility of rice farming jajar legowo planting system in Dramaga, Ciomas, and Tamansari Sub-District, Bogor Regency. *E3S Web of Conferences*, *361*, 1–7. https://doi.org/10.1051/e3sconf/202236102019

Asnawi, R. (2017). Peningkatan Produktivitas dan Pendapatan Petani Melalui Penerapan Model Pengelolaan Tanaman Terpadu Padi Sawah di Kabupaten Pesawaran, Lampung. *Jurnal Penelitian Pertanian Terapan*, *14*(1), 44–52. https://doi.org/10.25181/jppt.v14i1.141

Bakker, T., Poisot, A.-S., & Roesch, K. (2022). Farmer Field Schools: Building Capacities to Achieve a Successful Agroecological Transition. *Perspective CIRAD*, *57*(1). https://doi.org/10.19182/per

BPS. (2024). *Kabupaten Bogor dalam Angka 2024* (Vol. 41). BPS Kabupaten Bogor.

Ekawati, Rizieq, R., Ellyta, Bancin, H. D., Aini, F., & Satria, R. (2025). Sustainability index of new improved rice varieties adoption: An ecological perspective. *IOP Conference Series: Earth and Environmental Science*, *1535*(1). https://doi.org/10.1088/1755-1315/1535/1/012018

Gunawan, G., Hubeis, A. V. S., Fatchiya, A., & Susanto, D. (2019). Dukungan Penyuluhan dan Lingkungan Ekternal terhadap Adopsi Inovasi dan Keberlanjutan Usaha Pertanian Padi Organik. *Agriekonomika*, *8*(1), 70–80. https://doi.org/10.21107/agriekonomika.v8i1.4951

Hasan, A. K. M. M., Afrad, Md. S. I., Hasan, S., Kimti, H. R., & Tazkia, Z. (2025). Good Agricultural Practices in Sustainable Crop Production: Drivers, Profitability, Impacts and Challenges. *Asian Journal of Agricultural and Horticultural Research*, *12*(4), 193–207. https://doi.org/10.9734/ajahr/2025/v12i4428

Klerkx, L., Van Mierlo, B., & Leeuwis, C. (2012). Evolution of systems approaches to agricultural innovation: Concepts, analysis and interventions. In *Farming Systems Research into the 21st Century: The New Dynamic* (pp. 457–483). Springer Netherlands. https://doi.org/10.1007/978-94-007-4503-2_20

Putra, R. A., & Sadono, D. (2024). Examining the Relationship Between Innovation Characteristics and Extension Support When Using Jajar Legowo as an Agricultural Innovation. *Jurnal AGRISEP: Kajian Masalah Sosial Ekonomi Pertanian Dan Agribisnis*, *23*(1), 93–110. https://doi.org/10.31186/jagrisep.23.01.93-110

Rogers, E. M. (2003). *Diffusion of Innovations 5th Edition* (5th ed.). Simon and Schuster.

CONSUMER-BASED SENSORY PROFILING OF COMMERCIAL PASTEURIZED RTE SAUSAGES IN THE INDONESIAN MARKET

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Purpose and Background:

Ready-to-eat (RTE) pasteurized sausage have become widely favored in the Indonesian market due to its convenience, high nutritional value, and appealing taste. As the market becomes increasingly competitive, sensory quality has become an important factor influencing consumer preference and product differentiation. Therefore, understanding consumer perception and the ideal sensory characteristics of an product is essential, as sensory quality is closely associated with consumer satisfaction, perception, and acceptance (O'Sullivan *et al.* 2011).

Sensory profiling is widely used to characterize sensory attributes, support product development, and compare products with similar characteristics (Lawless dan Heymann 2010). Compared with traditional descriptive analysis, consumer-based sensory profiling eliminates the need for extensive panelist training while providing direct feedback from the target consumers (Ares *et al.* 2011).

However, comprehensive studies combining consumer-based sensory profiling with consumer preference evaluation of commercial pasteurized meat sausages in the Indonesian market remain limited. Therefore, this study aimed to characterize the sensory profiles and identify sensory attributes associated with the ideal product and consumer liking of commercial pasteurized RTE sausages available in the Indonesian market.

Materials and Methods:

The study was conducted between August and October 2024 at the Sensory Evaluation Laboratory, Division of Food Science and Technology, IPB University, Bogor, Indonesia. Five commercially available RTE pasteurized sausages from different brands were selected as samples. All products were purchased from the same retail outlet one day before testing, stored under refrigerated conditions, cut into approximately 4 cm pieces, and served at room temperature. Each sample was assigned a random three-digit code before evaluation.

A total of 144 consumer panelists were recruited based on the screening criteria described in ISO 8586:2023. Sensory evaluation was performed individually in sensory booths using an online questionnaire. Consumer-based sensory profiling was conducted using the Check-All-That-Apply (CATA) method with 15 predefined sensory attributes covering texture, aroma, taste, flavor and aftertaste. Panelists first identified the sensory attributes expected in an imaginary ideal product, followed by the evaluation of each coded sample by selecting applicable attributes. Consumer acceptance was assessed using a 6-point hedonic scale (1 = dislike very much; 6 = like very much). Water was provided as a palate cleanser between samples.

Data were collected with Microsoft Excel and analyzed with XLSTAT 2021 add-ins. CATA and hedonic responses were analyzed using the CATA Data Analysis module ((correspondence analysis (CA) and Principle Coordinate Analysis (PCoA)), to visualize the sensory profiles of the products and the ideal product, as well as to identify sensory attributes associated with consumer preference.

Results and Discussion

A total of 124 valid responses were obtained from 144 consumer panelists after data screening. Correspondence Analysis (CA) was performed to visualize the sensory profiles of the five commercial pasteurized meat sausage products and the ideal product based on CATA responses (Figure 1). In the CA symmetric plot, the proximity between products and sensory attributes reflects the frequency with which attributes were selected by consumers, while the relative positions of the commercial products and the ideal product indicate how closely each product matches the sensory characteristics expected by consumers.

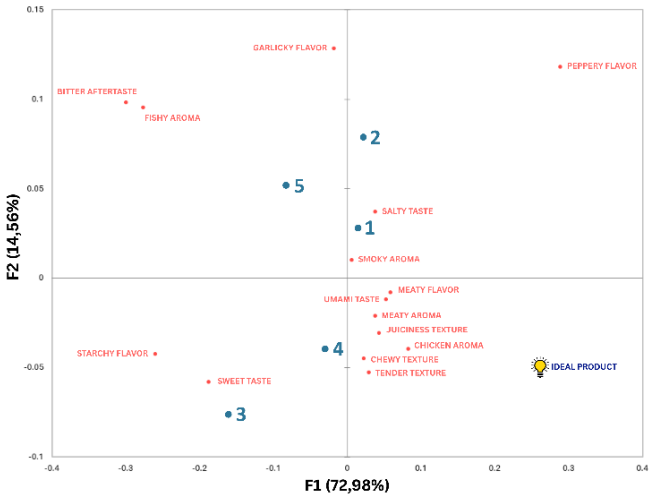

Figure 1. *Sensory profiles of commercial pasteurized RTE sausages and the ideal product*

To further investigate the relationship between sensory attributes and consumer acceptance, CATA and overall liking data were analyzed using Principal Coordinates Analysis (PCoA) (Figure 2). Attributes located closer to the liking point were considered more positively associated with consumer preference. The PCoA revealed that meaty flavor, meaty aroma, tender, and juiciness were positioned nearest to the liking vector, suggesting that consumers who assigned higher liking scores tended to perceive these attributes more frequently.

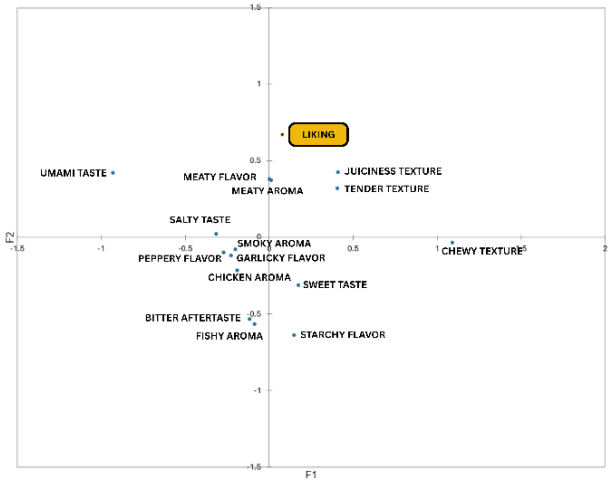

Figure 2. *PcoA diagram showing the relationship between sensory attributes and consumer liking*

The positive association of these attributes with consumer liking may be explained by the concept of oro-sensory exposure, which refers to the sensory stimulation experienced during oral processing. These textural attributes may provide a more satisfying chewing experience and may prolong oral processing, allowing greater release of meat flavor and aroma compounds during mastication. A similar finding was reported by Tian et al. (2023), who demonstrated that prolonged chewing increased the release of meat flavor compounds from sausage bolus before declining near the swallowing point due to saliva dilution and moisture loss.

REFERENCES

Ares, G., Varela, P., Rado, G., & Giménez, A. (2011). Are consumer profiling techniques equivalent for some product categories? The case of orange-flavoured powdered drinks. *International Journal of Food Science & Technology, 46*(8), 1600–1608. https://doi.org/10.1111/j.1365-2621.2011.02657.x

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: Principles and practices* (2nd ed.). Springer.

Tian, X., Li, Z., Li, K., Wu, Z., Ren, R., Wang, H., & Zeng, C. (2023). Flavor release from traditional dry-cured pork during oral processing. *Food Science and Human Wellness, 12*(1), 102–110. https://doi.org/10.1016/j.fshw.2022.07.028

Supplement

A Contextualized Pedagogical Framework for Integrating SDG 15 into STEAM Education: A Student-Centered Approach in Secondary Education

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Abstract

Biodiversity loss poses critical challenges to sustainable development, particularly under SDG 15 (Life on Land), yet its integration into school education remains limited and largely theoretical. This study proposes a contextualized framework for embedding SDG 15 into secondary STEAM education through a four-stage, project-oriented approach: contextualization, inquiry, solution design, and action with reflection. An embedded assessment layer evaluates students' awareness, competencies, and agency, offering a structured and measurable model to connect global sustainability goals with classroom practice.

Keywords: SDG 15, STEAM education, sustainability education, pedagogical framework, student agency

1. Introduction

Biodiversity loss and ecosystem degradation, highlighted in SDG 15 (Life on Land), pose critical challenges to sustainable development. However, its integration into school education remains limited and largely theoretical, with fragmented approaches that disconnect learning from real-world contexts. While STEAM offers an interdisciplinary pathway, a more contextualized and structured approach is needed to support meaningful learning and students' active engagement in sustainability challenges.

2. Problem & Research Gap

Despite growing interest in integrating STEAM with the Sustainable Development Goals, most approaches remain general and fragmented, often treating SDGs as broad themes rather than specific targets. Few studies focus explicitly on SDG 15 or provide structured pedagogical frameworks for systematic implementation in classroom practice. In addition, assessment in sustainability education remains limited, primarily emphasizing awareness rather than competencies and student agency. Consequently, a clear gap exists in developing a contextualized and structured framework for integrating SDG 15 into STEAM education with an embedded, holistic assessment approach.

3. Research Objective

This study proposes a structured and contextualized pedagogical framework for integrating SDG 15 into STEAM education. The framework aims to:

- support teachers in translating sustainability goals into meaningful learning activities,
- foster students' competencies and agency,
- incorporate an assessment approach for evaluating learning outcomes.

4. Proposed Framework

This study proposes a Contextualized SDG-STEAM Pedagogical Framework to integrate SDG 15 into secondary education through a structured and student-centered approach. The framework consists of four interconnected stages:

(1) **Contextualization**, where global sustainability goals are translated into locally relevant issues;
(2) **Inquiry**, in which students engage in interdisciplinary STEAM-based investigation;
(3) **Solution Design**, where students develop feasible and context-sensitive responses;
(4) **Action and Reflection**, enabling students to implement solutions and reflect on their learning, forming a continuous learning–action cycle.

In addition, the framework incorporates an assessment layer to evaluate learning outcomes. This integrated model not only provides a structured approach for implementing SDG 15 in classroom practice but also enables a more comprehensive and measurable evaluation of sustainability-oriented learning.

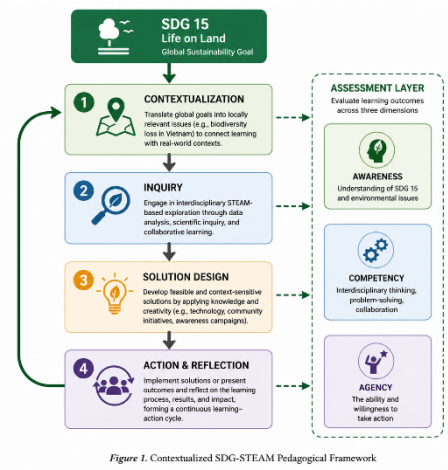

Figure 1. Contextualized SDG-STEAM Pedagogical Framework

5. Illustrative Example

An illustrative example is a STEAM-based project on conserving endangered primates in Vietnam, such as critically endangered langur species—animals often unfamiliar to students, who may not distinguish them from common monkeys or recognize their ecological significance. This highlights the importance of grounding learning in local biodiversity contexts. Students investigate ecological factors, analyze population decline, and apply interdisciplinary knowledge to design feasible conservation solutions. Outputs may include presentations or digital products. This example demonstrates how contextualized learning enhances understanding of SDG 15 while fostering problem-solving competencies and student agency.

6. Significance

This study contributes to education for sustainable development by proposing a contextualized framework specifically for SDG 15, addressing the lack of structured implementation in current approaches. It further integrates an assessment layer that evaluates not only awareness but also competencies and student agency, offering both theoretical and practical value for implementing and assessing sustainability-oriented learning.
The proposed framework demonstrates the potential of contextualized STEAM education to connect SDG 15 with classroom practice while fostering students' capacity for meaningful action.

REFERENCES

1. UNESCO (2017). *Education for Sustainable Development Goals: Learning Objectives.*
2. United Nations (2015). *Transforming our world: The 2030 Agenda for Sustainable Development.*
3. Ferguson, R. (2012). *Learning analytics: Drivers, developments and challenges.*

SDGs Workshop

Purpose of the SDGs workshop

SDGs (Sustainable Development Goals) are important actions to improve and set up a sustainable world. All the seventeen goals raised in the SDGs are critical and urgent issues. We should collaborate to find the direction to solve those issues, especially since their causes are diverse even in the local areas. Therefore, mutual understanding of the causes of the SDGs matters is vital to reach a starting point for cooperation. This workshop is one way to establish comprehension of SDGs among people in Asia.

We hope you, the workshop attendants, will discuss with students from other countries, and make friends with each other. Human network is essential to solving global issues, and this is the opportunity to start building the network.

SDGs Workshop

Room 2207 (MATSUI Satoshi, Chiba University)

Group A		Name	University / School	Country/ Region
1	Facilitator	Claudia Rebeca Nolasco Rodriguez	Chiba University	El Salvador
2	Learner	MARIA GABRIELIN	Universitas Gadjah Mada	Indonesia
3	Learner	JIN XINXIN	Mahidol University	China
4	Learner	KANAZAWA Takuro	Chiba University	Japan
5	Learner	NEMOTO Sota	Chiba University	Japan
6	Learner	AMEMIYA Kazuha	Tokyo Metropolitan Tama High School of Science and Technology	Japan
7	Learner	AIBARA Miho	Chiba Municipal Chiba High School	Japan

Group B		Name	University / School	Country/ Region
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3	Learner	ALONICA MAE BATHAN DONAYRE	University of San Carlos	Philippines
4	Learner	INOUE Ryoichi	Chiba University	Japan
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SDGs Workshop

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6	Learner	KUSHIBE Tomoka	Chiba University	Japan
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4	Learner	FUKUDO Kazuki	Chiba University	Japan
5	Learner	SHOJI Yuya	Chiba University	Japan
6	Learner	HOSOMI Sena	Chiba University	Japan
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6	Learner	OMORI Misaki	Chiba University	Japan
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3	Learner	TAHARA Runa	Chiba University	Japan
4	Learner	YOKOGAWA Manami	Chiba University	Japan
5	Learner	WAKITA Haruki	Chiba University	Japan
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SDGs Workshop

Room 2208 (WATANABE Kohei, Chiba University)

Group J		Name	University / School	Country/ Region
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3	Learner	VONG BUNHIENG	Royal University of Phnom Penh	Cambodia
4	Learner	KINOSHITA Yusuke	Chiba University	Japan
5	Learner	HACHIYA Kanami	Chiba University	Japan
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Group K		Name	University / School	Country/ Region
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5	Learner	EGAMI Hiroto	Chiba University	Japan
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3	Learner	FELDY KHALID	Bogor Agricultural University	Indonesia
4	Learner	IWADATE Rika	Chiba University	Japan
5	Learner	AIKAWA Kazune	Chiba University	Japan
6	Learner	KIMURA Gaku	Chiba Municipal Chiba High School	Japan
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5	Learner	HAGIEDA Taisei	Chiba University	Japan
6	Learner	KUNIYASU Ema	Chiba Municipal Chiba High School	Japan

SDGs Workshop

Room 2208 (WATANABE Kohei, Chiba University)

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4	Learner	HIRATA Mahori	Chiba University	Japan
5	Learner	SAWADA Ruka	Chiba University	Japan
6	Learner	TAMAGAWA Ryoutaro	Chiba Municipal Chiba High School	Japan

Group O		Name	University / School	Country/ Region
1	Facilitator	Sarah Craveiro Martins	Chiba University	Brasil
2	Learner	THANASARN WANNALANGKA	King Mongkut's University of Technology Thonburi	Thailand
3	Learner	SHASKI GHINA NURFAUZIYAH	Bogor Agricultural University	Indonesia
4	Learner	YOSHIKAWA Naoki	Chiba University	Japan
5	Learner	SHOJI Yu	Chiba University	Japan
6	Learner	SASAKURA Hinako	Chiba Municipal Chiba High School	Japan
7	Learner	SAKUMA Hinako	Chiba Prefectural Funabashi High School	Japan

Group P		Name	University / School	Country/ Region
1	Facilitator	Yen-Yu Chang	Chiba University	Taiwan
2	Learner	TRIWIT PINKHEAW	Kasetsart university	Thailand
3	Learner	WHELYN AURA RAVELO UNABIA	University of San Carlos	Philippines
4	Learner	MORIMOTO Riku	Chiba University	Japan
5	Learner	HANADA Tomo	Chiba University	Japan
6	Learner	YAMAMOTO Rieko	Chiba Municipal Chiba High School	Japan
7	Learner	KURONUMA Fumika	Chiba Prefectural Funabashi High School	Japan

Group Q		Name	University / School	Country/ Region
1	Facilitator	Rizvon Suleimanov	Chiba University	Tajikistan
2	Learner	DO HUYEN LINH	Vietnam National University of Education	Vietnam
3	Learner	NABILAH SHAFIRA MILENNIANTI	Bandung Institute of Technology	Indonesia
4	Learner	TODA Taiga	Chiba University	Japan
5	Learner	KAMATA Maaya	Chiba University	Japan
6	Learner	IWAHASHI Hana	Chiba Municipal Chiba High School	Japan
7	Learner	KANG Jun	Hiroo Gakuen Senior High School	Japan

Group R		Name	University / School	Country/ Region
1	Facilitator	Savira Aristi	Chiba University	Indonesia
2	Learner	ACHITA MALULIM	Chulalongkorn University	Thailand
3	Learner	NGUYEN THI THUY LINH	Vietnam National University of Education	Vietnam
4	Learner	MORI Akane	Chiba University	Japan
5	Learner	TOMITA Rento	Chiba University	Japan
6	Learner	NISHIWAKI Koma	Chiba University	Japan

Poster

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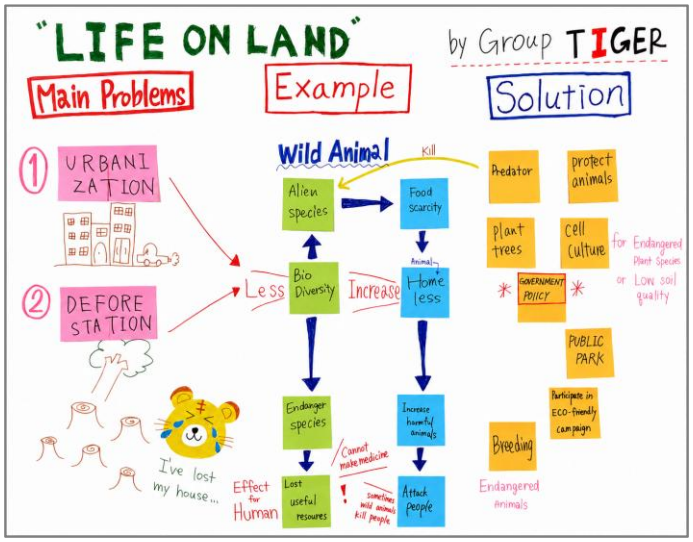

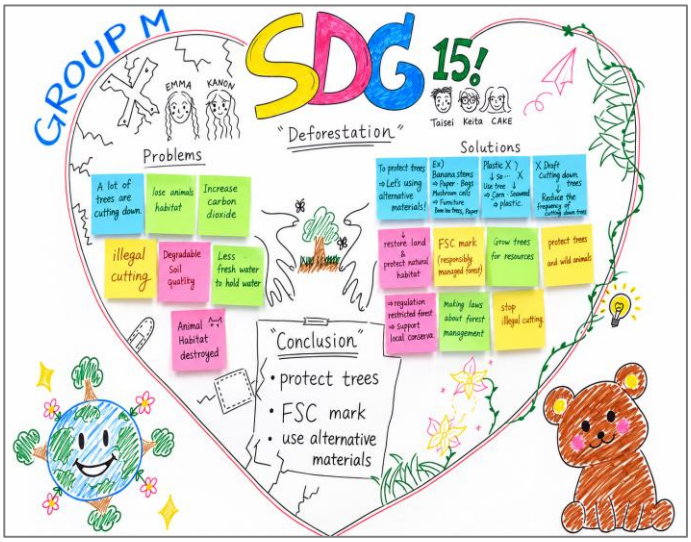

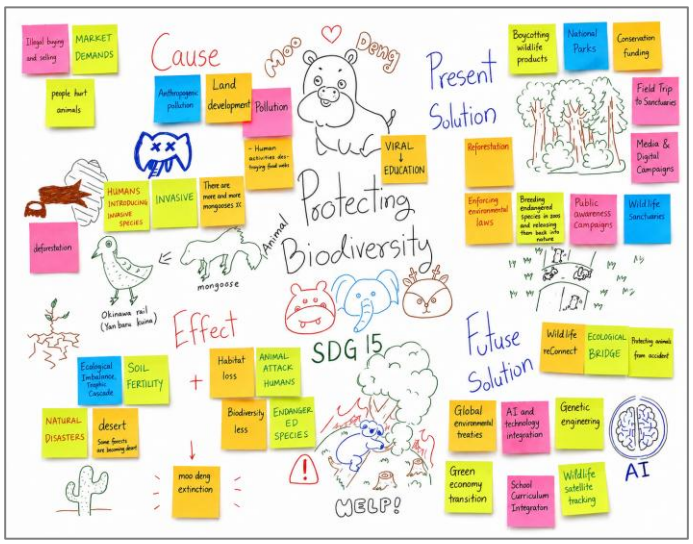

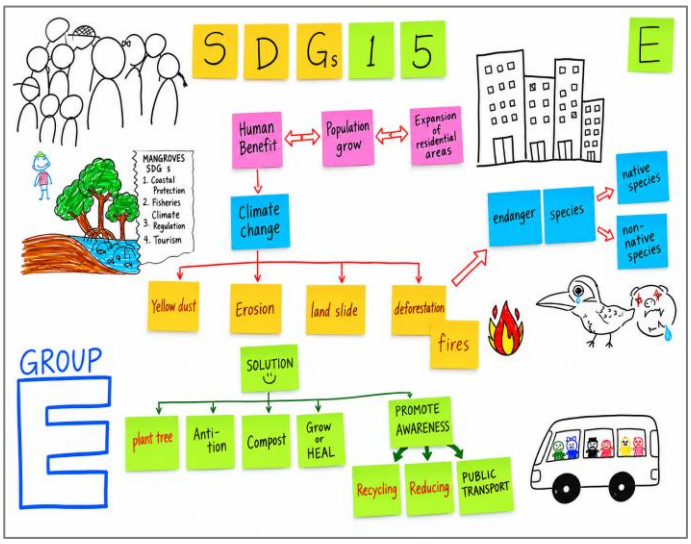

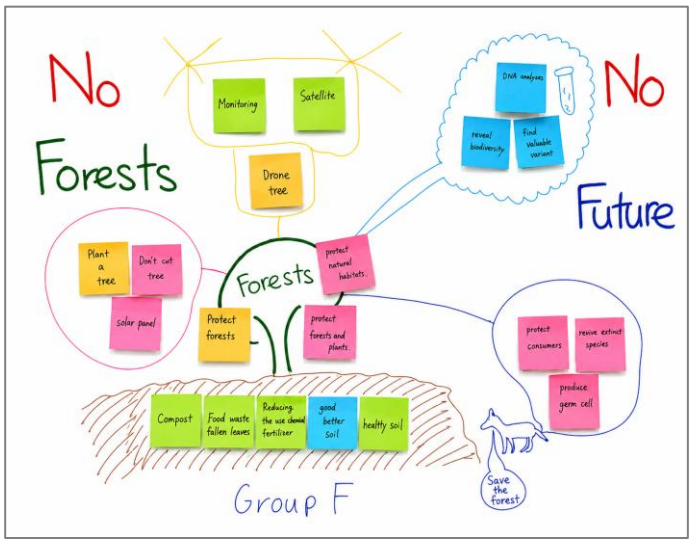

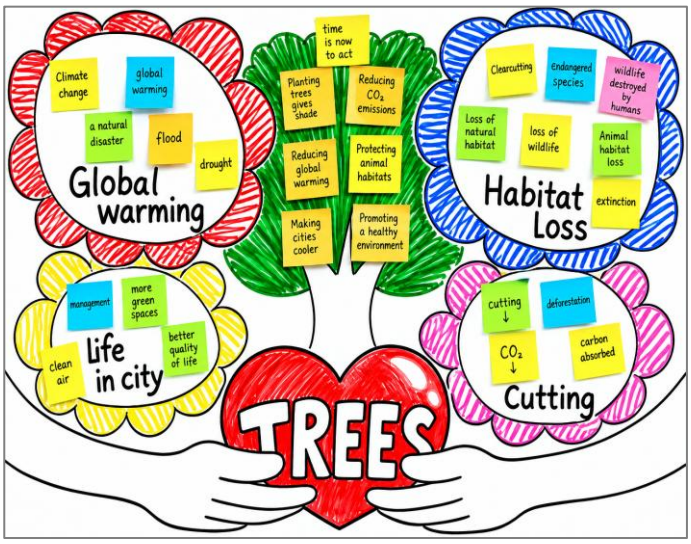

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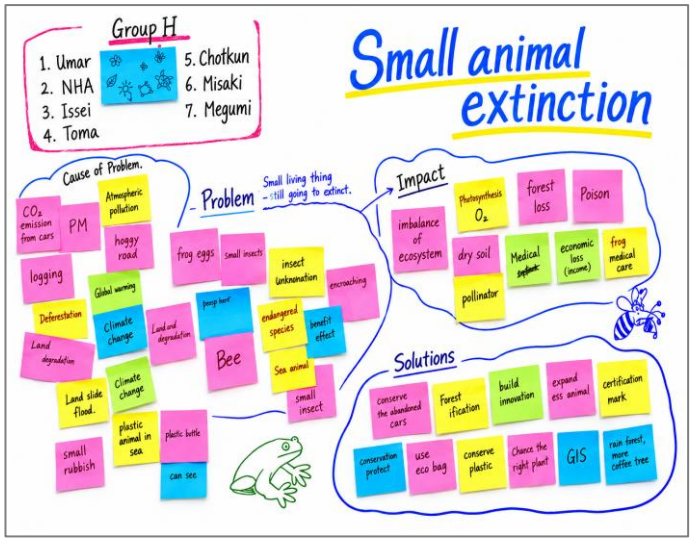

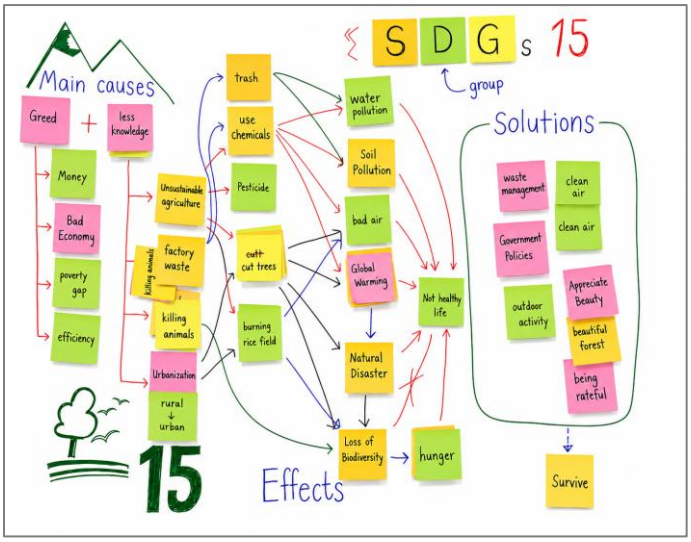

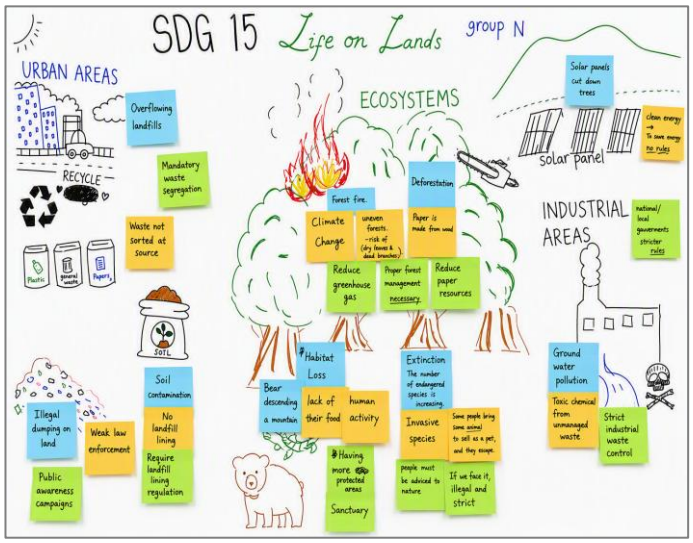



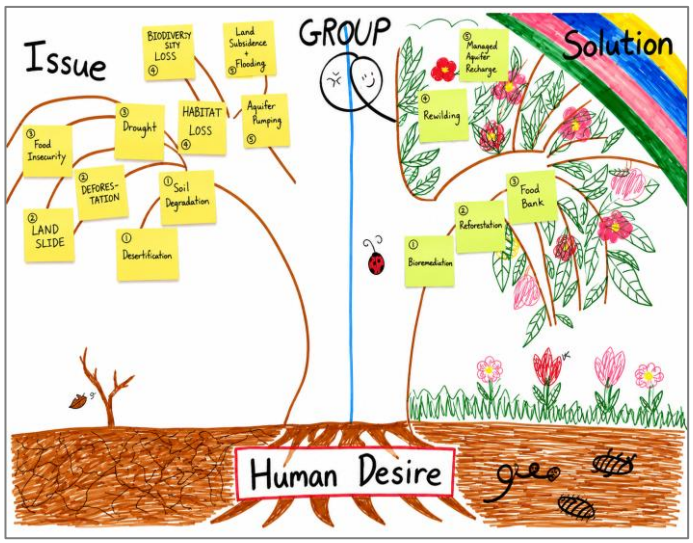

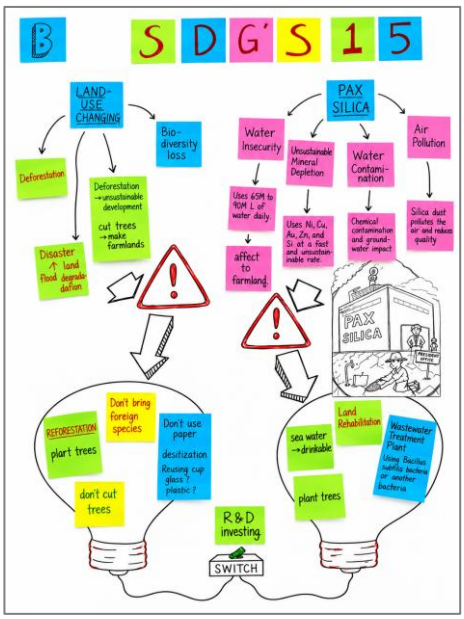

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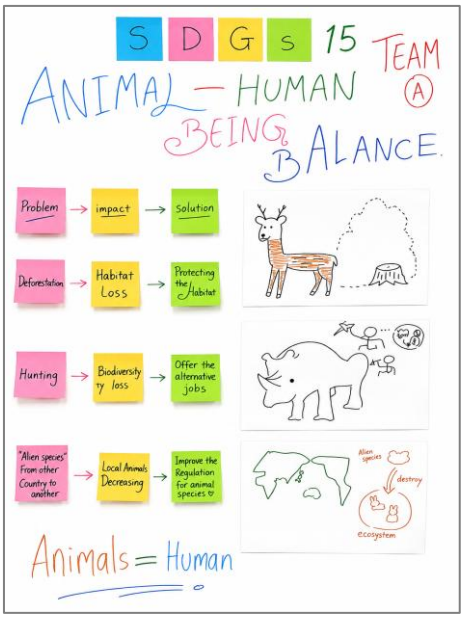

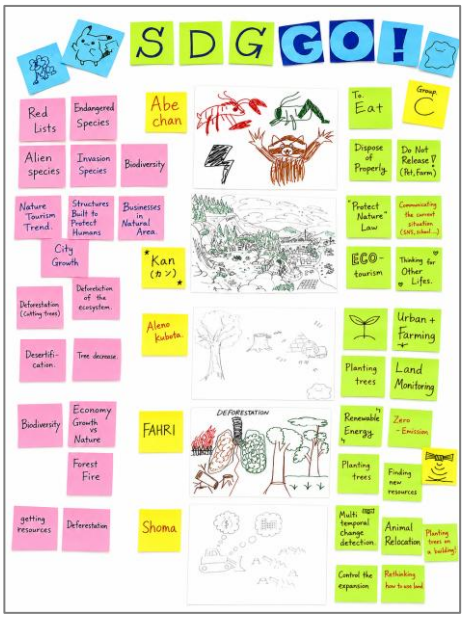

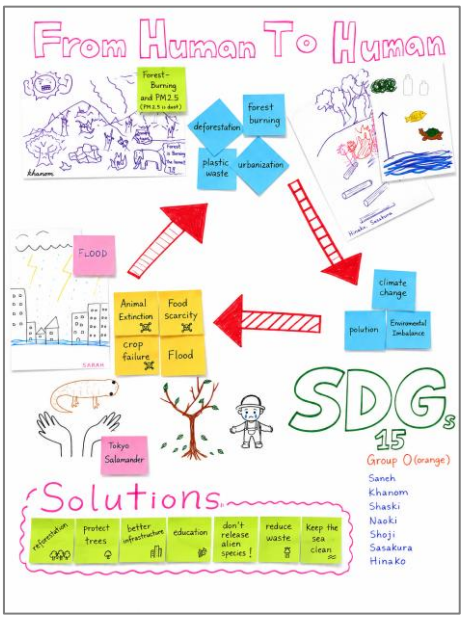

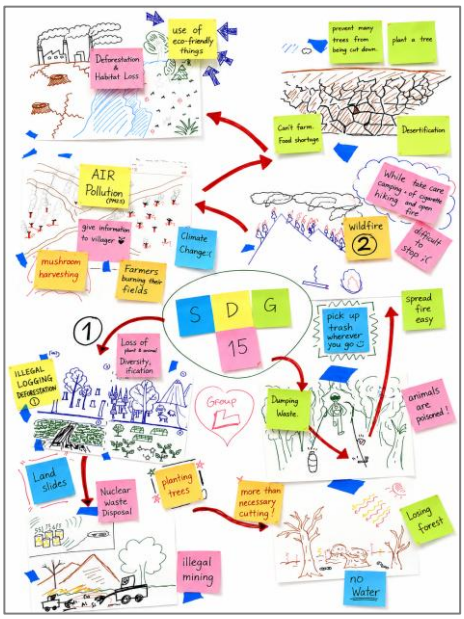

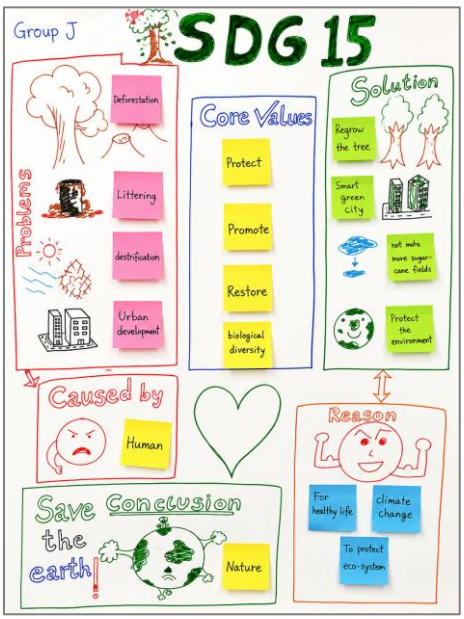

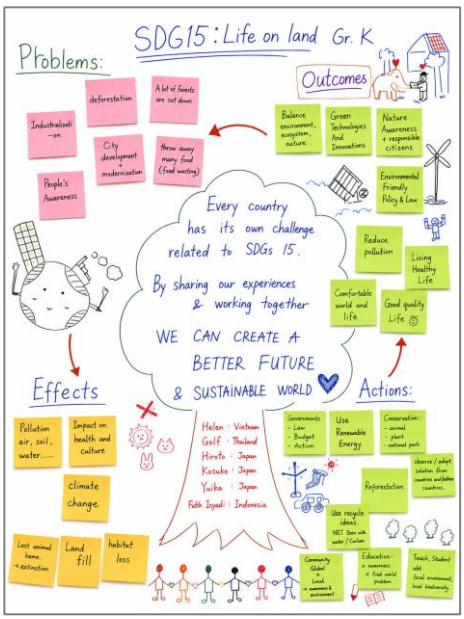

Name & Room List

■ASEAN Students

Name	University	Research Session		Workshop	
ACHITA MALULIM	Chulalongkorn University	2204	Presenter	2208-R	Learner
ALONICA MAE BATHAN DONAYRE	University of San Carlos	2203	Presenter	2207-B	Learner
ARIQ ZAIDAN	Universitas Gadjah Mada	2203	Presenter	2208-J	Learner
DO DIEU LY	Vietnam National University of Education	2203	Presenter	2207-F	Learner
DO HUYEN LINH	Vietnam National University of Education	2204	Presenter	2208-Q	Learner
FELDY KHALID	Bogor Agricultural University	2205	Presenter	2208-L	Learner
HEIN HTET AUNG	King Mongkut's University of Technology Thonburi	2205	Presenter	2207-G	Learner
INGKARAT YIMLAMAI	Chulalongkorn University	2202	Presenter	2208-M	Learner
JIN XINXIN	Mahidol University	2205	Presenter	2207-A	Learner
KANTAPON SANGRUANG	Chulalongkorn University	2201	Presenter	2207-C	Learner
KESINI PHUETPHIAN	Kasetsart University	2203	Presenter	2207-D	Learner
M FAHRI ALFARIZI RASWEN	Universitas Gadjah Mada	2202	Presenter	2207-C	Learner
MA. NIGEL KUIZON YNIESTA	University of San Carlos	2202	Audience	2207-D	Learner
MARIA GABRIELIN	Universitas Gadjah Mada	2203	Presenter	2207-A	Learner
MUHAMMAD WILDAN RAMADHAN	Bandung Institute of Technology	2202	Presenter	2207-E	Learner
NABILAH SHAFIRA MILENNIANTI	Bandung Institute of Technology	2202	Presenter	2208-Q	Learner
NASHRIYYAH NUR IMANI	Universitas Gadjah Mada	2203	Presenter	2207-B	Learner
NATTAPORN TONGPUN	Kasetsart University	2202	Presenter	2207-E	Learner
NGUYEN THI HUYEN	Vietnam National University of Education	2205	Presenter	2208-K	Learner
NGUYEN THI THUY LINH	Vietnam National University of Education	2201	Presenter	2208-R	Learner
PHON PANHA	Royal University of Phnom Penh	2201	Presenter	2207-H	Learner
PLOYCHOMPOO SRESAKULWIWAT	King Mongkut's University of Technology Thonburi	2204	Presenter	2207-I	Learner
REN NI	Mahidol University	2204	Presenter	2207-G	Learner
SARUN SALADTUK	Chulalongkorn University	2205	Presenter	2208-K	Learner
SATHIDA BUNGOED	Kasetsart University	2201	Presenter	2208-L	Learner
SHASKI GHINA NURFAUZIYAH	Bogor Agricultural University	2205	Presenter	2208-O	Learner
SUPAPORN BARRAMEESANGPET	Chulalongkorn University	2203	Presenter	2208-N	Learner
TANAWAT SOMYAPORNJARERNCHAI	Chulalongkorn University	2202	Presenter	2207-H	Learner
THANASARN WANNALANGKA	King Mongkut's University of Technology Thonburi	2201	Presenter	2208-O	Learner
TRIWIT PINKHEAW	Kasetsart university	2204	Presenter	2208-P	Learner
VONG BUNHIENG	Royal University of Phnom Penh	2201	Presenter	2208-J	Learner
WHELYN AURA RAVELO UNABIA	University of San Carlos	2205	Presenter	2208-P	Learner
WILLY WIDYATMAKA ARDI	Institut Teknologi Bandung	2204	Presenter	2207-F	Learner

■High School Students

Name	University/School	Research Session		Workshop	
AIBARA Miho	Chiba Municipal Chiba High School	-	-	2207-A	Learner
AMEMIYA Kazuha	Tokyo Metropolitan Tama High School of Science and Technology	2201	Presenter	2207-A	Learner
HAMADA Morihiro	Chiba Municipal Chiba High School	-	-	2207-B	Learner
HANEISHI Reo	Chiba Municipal Chiba High School	-	-	2207-I	Learner
HATANO Megumi	Chiba Municipal Chiba High School	-	-	2207-H	Learner
HAYASHI Mihee	Chiba Prefectural Funabashi High School	-	Audience	-	-
IWAHASHI Hana	Chiba Municipal Chiba High School	-	-	2208-Q	Learner
KADOWAKI Nia	Chiba Municipal Chiba High School	-	-	2207-C	Learner
KAWAMURA Miyu	Chiba Municipal Chiba High School	-	-	2208-J	Learner
KIMURA Gaku	Chiba Municipal Chiba High School	-	-	2208-L	Learner
KUBOTA Yuya	Chiba Municipal Chiba High School	-	-	2207-E	Learner
KUNIYASU Ema	Chiba Municipal Chiba High School	-	-	2208-M	Learner
KURONUMA Fumika	Chiba Prefectural Funabashi High School	-	-	2208-P	Learner
MORIYA Misaki	Tokyo Metropolitan Tama High School of Science and Technology	2201	Presenter	2207-B	Learner
SAKUMA Hinako	Chiba Prefectural Funabashi High School	-	-	2208-O	Learner
SASAKURA Hinako	Chiba Municipal Chiba High School	-	-	2208-O	Learner
SATO Masumi	Chiba Municipal Chiba High School	-	-	2207-F	Learner
SATO Yuika	Chiba Municipal Chiba High School	-	-	2208-K	Learner
TAKASE Kazuyoshi	Chiba Prefectural Funabashi High School	-	Audience	-	-
TAMAGAWA Ryoutaro	Chiba Municipal Chiba High School	-	-	2208-N	Learner
TSUJI Arisa	Chiba Prefectural Funabashi High School	-	Audience	2208-J	Learner
TSURISHIMA Wakana	Tokyo Metropolitan Tama High School of Science and Technology	2202	Presenter	2207-D	Learner
YAMAMOTO Rieko	Chiba Municipal Chiba High School	-	-	2208-P	Learner

■ASCENT-6E Student

Name	University/School	Research Session		Workshop	
KANG Jun	Hiroo Gakuen Senior High School	2203	Presenter	2208-Q	Learner
KUBOTA Akane	Chiba Meitoku High School	2204	Presenter	2207-C	Learner
MATOBA Ema	Shibaura Institute of Technology Kashiwa High School	-	Audience	2207-G	Learner
TSUKAMOTO Ryunosuke	Shibaura Institute of Technology Kashiwa High School	-	Audience	2208-L	Learner

■TWINCLE Students

Name	University	Research Session		Workshop	
ABE Mikoto	Chiba University	2201	Audience	2207-C	Learner
AIKAWA Kazune	Chiba University	2204	Audience	2208-L	Learner
AIKAWA Kousuke	Chiba University	2202	Audience	2208-K	Learner
EGAMI Hiroto	Chiba University	2203	Audience	2208-K	Learner
FUKUDO Kazuki	Chiba University	2201	Audience	2207-F	Learner
HACHIYA Kanami	Chiba University	2202	Audience	2208-J	Learner
HAGIEDA Taisei	Chiba University	2201	Audience	2208-M	Learner
HAGIWARA Keito	Chiba University	2202	Audience	2208-M	Learner
HANADA Tomo	Chiba University	2201	Audience	2208-P	Learner
HIRATA Mahori	Chiba University	2205	Audience	2208-N	Learner
HOSOMI Sena	Chiba University	2205	Audience	2207-F	Learner
ICHIKAWA Toma	Chiba University	2204	Audience	2207-H	Learner
INAMI Yui	Chiba University	2201	Audience	2207-B	Learner
INOUE Ryoichi	Chiba University	2202	Audience	2207-B	Learner
IWADATE Rika	Chiba University	2204	Audience	2208-L	Learner
KAMATA Maaya	Chiba University	2202	Audience	2208-Q	Learner
KANAZAWA Takuro	Chiba University	2201	Audience	2207-A	Learner
KATO Hiroto	Chiba University	2201	Audience	2207-D	Learner
KINOSHITA Yusuke	Chiba University	2203	Audience	2208-J	Learner
KUSHIBE Tomoka	Chiba University	2204	Audience	2207-E	Learner
MA Jingyu	Chiba University	2204	Audience	2208-M	Learner
MAEDA Hana	Chiba University	2205	Audience	2207-G	Learner
MATSUZAKI Risa	Chiba University	2203	Audience	2207-G	Learner
MORI Akane	Chiba University	2204	Audience	2208-R	Learner
MORIMOTO Riku	Chiba University	2204	Presenter	2208-P	Learner
NAKANO Sumika	Chiba University	2203	Audience	2207-E	Learner
NEMOTO Sota	Chiba University	2203	Audience	2207-A	Learner
NISHIWAKI Koma	Chiba University	2202	Audience	2208-R	Learner
OMORI Misaki	Chiba University	2204	Audience	2207-H	Learner
ONO Shoma	Chiba University	2205	Audience	2207-C	Learner
SAWADA Ruka	Chiba University	2202	Audience	2208-N	Learner
SHIMIYA Manata	Chiba University	2204	Audience	2207-D	Learner
SHOJI Yu	Chiba University	2205	Audience	2208-O	Learner
SHOJI Yuya	Chiba University	2201	Audience	2207-F	Learner
TABUCHI Ryota	Chiba University	2202	Audience	2208-N	Learner
TAHARA Runa	Chiba University	2203	Audience	2207-I	Learner
TAKAGI Isssei	Chiba University	2205	Audience	2207-H	Learner
TAKAHASHI Hazuki	Chiba University	2203	Audience	2207-D	Learner
TODA Taiga	Chiba University	2205	Audience	2208-Q	Learner
TOMITA Rento	Chiba University	2202	Audience	2208-R	Learner
TOYAMA Shuhei	Chiba University	2201	Audience	2207-E	Learner
UCHIYAMA Hikaru	Chiba University	2203	Audience	2207-G	Learner
WAKITA Haruki	Chiba University	2203	Audience	2207-I	Learner
YOKOGAWA Manami	Chiba University	2205	Audience	2207-I	Learner
YOSHIKAWA Naoki	Chiba University	2204	Audience	2208-O	Learner

■Chiba University (International Students)

Name	Faculty	Research Session		Workshop	
Armelia Ramandha	Graduate School of Science and Engineering	2202	Panelist	2207-D	Facilitator
Claudia Rebeca Nolasco Rodriguez	Faculty of Education	2205	Panelist	2207-A	Facilitator
Dinar Pratiwi Aulia	Graduate School of Science and Engineering	2204	Panelist	2207-H	Facilitator
Dorcas Fredua Asimeng	Graduate School of Horticulture	2202	Panelist	2208-J	Facilitator
Fakih Irsyadi	Graduate School of Science and Engineering	2201	Panelist	2208-K	Facilitator
Hanna Putri Devita	Graduate School of Science and Engineering	2203	Panelist	2207-I	Facilitator
Jazmín Videla Heim	Faculty of Education	2203	Panelist	2207-E	Facilitator
Joceline Theda Kadarman	Graduate School of Medical and Pharmaceutical Sciences	2203	Panelist	2207-G	Facilitator
Kunti Khoirunnisaa	Graduate School of Science and Engineering	2204	Panelist	2208-N	Facilitator
Marella Zahra Olala	Graduate School of Science and Engineering	2202	Panelist	2208-M	Facilitator
Rizvon Suleimanov	Graduate School of Humanities and Studies on Public Affairs	2205	Panelist	2208-Q	Facilitator
Sarah Craveiro Martins	Graduate School of Medical and Pharmaceutical Sciences	2204	Panelist	2208-O	Facilitator
Sarleen Castro	Graduate School of Medical and Pharmaceutical Sciences	2203	Panelist	2208-L	Facilitator
Savira Aristi	Graduate School of Science and Engineering	2201	Panelist	2208-R	Facilitator
Thanyaporn Channamom	Graduate School of Medical and Pharmaceutical Sciences	2204	Panelist	2207-B	Facilitator
Yen-Yu Chang	Graduate School of Science and Engineering	2201	Panelist	2208-P	Facilitator
Yuhui Liao	Graduate School of Horticulture	2202	Panelist	2207-C	Facilitator
Yunchen Xu	Graduate School of Horticulture	2205	Panelist	2207-F	Facilitator

■Chiba University

Name	Faculty	Research Session		Workshop	
NOMURA Jun	Graduate School of Education	2203	Chairperson	-	-
TSUJI Koji	Graduate School of Education	2202	Chairperson	-	-
KATO Tetsuya	Graduate School of Education	2201	Chairperson	-	-
SHIMONAGATA Shuji	Graduate School of Education	2205	Chairperson	-	-
MATSUI Satoshi	Graduate School of Education	-	-	2207	Coordinator
WATANABE Kohei	Graduate School of Education	-	-	2208	Coordinator
WANG Qian	Institute for Excellence in Educational Innovation	-	-	-	-
MORISHIGE Hina	Institute for Excellence in Educational Innovation	2204	Chairperson	-	-

ASCENT Student Research Forum 2026 (Online Presentation Session)

■Faculty and Graduate Students from Partner Universities

Name	Faculty	Research Session		Workshop	
Warunee Suphon	Chiang Mai University	S2-R5	Chairperson	-	-
Suphawit Suwanjun	Chiang Mai University	-	-	WR-1	Supervisor
Sarawan Pomsuk	Chiang Mai University	S2-R5	Panelist	WR-1	Facilitator
Saat Mubarrok	Institut Teknologi Bandung	S1-R4	Chairperson	-	-
Alif Shidqie Al Bani	Institut Teknologi Bandung	-	-	WR-2	Supervisor
Daniel Bonifasius Sipayung	Institut Teknologi Bandung	S1-R4	Panelist	WR-2	Facilitator
Arunee Eambaipreuk	Kasetsart University	S1-R2	Chairperson	-	-
Nattaporn Tongpun	Kasetsart University	S1-R2	Panelist	WR-3	Facilitator
Sathida Bungoed	Kasetsart University	S1-R2	Panelist	WR-3	Facilitator
Poschanan Niramitchainont	Mahidol University	S1-R1	Chairperson	-	-
Panchit Longpradit	Mahidol University	-	-	WR-4	Supervisor
Suthiporn Sajjapanroj	Mahidol University	-	-	WR-4	Supervisor
Yangxiangjun Xiong	Mahidol University	S1-R1	Panelist	WR-4	Facilitator
Linxing Li	Mahidol University	S1-R1	Panelist	WR-4	Facilitator
Ni Wayan Wahyuni	Universitas Udayana	S2-R8	Chairperson	WR-5	Supervisor
Shiva Putri Zakkyah	Universitas Udayana	S2-R8	Panelist	WR-5	Facilitator
Naomi Haverim	Universitas Udayana	S2-R8	Panelist	WR-5	Facilitator
Dodi Sudiana	Universitas Indonesia	S2-R7	Chairperson	-	-
Vemby Somadias	Universitas Indonesia	S2-R7	Panelist	WR-6	Supervisor
Anindya Afina Carmelya	Universitas Indonesia	S2-R7	Panelist	WR-6	Facilitator
Rita May Tagalog	University of San Carlos	S2-R6	Chairperson	-	-
Argie Anthony C. Inciso	University of San Carlos	S2-R6	Panelist	-	-
Cristobal A. Rabuya Jr.	University of San Carlos	S2-R6	Panelist	-	-
Mariter T. Malonjao	University of San Carlos	-	-	WR-7	Supervisor
Whelyn Aura R. Unabia	University of San Carlos	-	-	WR-7	Facilitator
Alonica Mae B. Donayre	University of San Carlos	-	-	WR-7	Facilitator
Nguyen Chi Thanh	Vietnam National University	S1-R3	Chairperson	WR-8	Supervisor
Duong Ngoc Anh	Vietnam National University	S1-R3	Panelist	WR-8	Facilitator

■ High School Students

Name	High School	Research Session		Workshop	
Amir Yadzka Razan	Kornita Senior High School	S2-R6	Presenter	WR-2	Learner
Azkia Sausan Hidayat	Kornita Senior High School	S2-R8	Presenter	WR-10	Learner
Muhammad Faturahman Putra Suwarto	SMA Negeri 2 Cirebon	S1-R4	Presenter	WR-12	Learner
Khaira Salmaa Haura	SMA Negeri 2 Cirebon	S1-R4	Presenter	WR-6	Learner
Aisha Athifa Yuwono	SMA Negeri 2 Cirebon	S1-R4	Presenter	WR-3	Learner
Zyvanna Aurelya Wijaya	SMA Negeri 2 Cirebon	S1-R4	Presenter	WR-8	Learner
Khanza Anindya Yasmine	SMA Negeri 3 Depok	S1-R3	Presenter	WR-12	Learner
Anindita Shalsabila Nur Rahman	SMA Negeri 3 Depok	S1-R3	Presenter	WR-6	Learner
Maria Kirana Artanti Hamung	SMA Negeri 3 Depok	S1-R3	Presenter	WR-7	Learner
Sherene Putri Mulya	SMA Negeri 3 Depok	S1-R3	Presenter	WR-5	Learner
Rommy Aksa Jova	SMA Negeri 3 Depok	S1-R3	Presenter	WR-10	Learner
Alvino Tamma Hartadi	SMA Negeri 3 Depok	S1-R2	Presenter	WR-9	Learner
Rakan Dhani Kalani	SMA Negeri 3 Depok	S1-R2	Presenter	WR-3	Learner
Arka Prabaswara Balapradana Setiawan	SMA Negeri 3 Depok	S1-R2	Presenter	WR-2	Learner
Jovan Lemuel Nathanael Sitohang	SMA Negeri 3 Depok	S1-R2	Presenter	WR-1	Learner
Fitri Humairah Dahla	SMA Negeri 3 Depok	S1-R2	Presenter	WR-8	Learner
Kalyca Estiningtyas	SMA Negeri 3 Depok	S1-R2	Presenter	WR-10	Learner
Nayla Khansa Aulia	SMA Negeri 3 Depok	S1-R2	Presenter	WR-9	Learner
Razhaula Mirokeishe	SMA Negeri 3 Depok	S1-R2	Presenter	WR-1	Learner
Kezia Putri Ayunda	SMA Negeri 3 Depok	S1-R2	Presenter	WR-8	Learner
Ashra Delisha Sana Hasmi	SMA Negeri 3 Depok	S1-R1	Presenter	WR-11	Learner
Carissa Kenzie Putri Wahyudi	SMA Negeri 3 Depok	S1-R1	Presenter	WR-2	Learner
Faiza Azkia Ashabi	SMA Negeri 3 Depok	S1-R1	Presenter	WR-4	Learner
Haura Ainun Mahya	SMA Negeri 3 Depok	S1-R1	Presenter	WR-5	Learner
Kirsten Bianca Livinlove	SMA Negeri 3 Depok	S1-R1	Presenter	WR-3	Learner
Nyoman Ashyuka Premaswari	Regents School Bali	S1-R1	Presenter	WR-4	Learner
Roslyn Eleanor Wiguna	Regents School Bali	S1-R1	Presenter	WR-11	Learner
Kadek Isyana Nubawa Putri	Regents School Bali	S1-R1	Presenter	WR-9	Learner
Ni Putu Vinka Anindiaswari Waishanti	Regents School Bali	S1-R1	Presenter	WR-5	Learner
Vinza Al Qathani	SMA Labschool UPI	S1-R3	Presenter	WR-12	Learner
Hanif Muhammad Hamzah	SMA Labschool UPI	S1-R3	Presenter	WR-7	Learner
Satria Aji Mulya Kusuma	SMA Labschool UPI	S1-R3	Presenter	WR-5	Learner
Kimi Feazka	SMA Labschool UPI	S1-R3	Presenter	WR-6	Learner
Raden Arkadhiya Achmad Danendra	Alfa Centauri High School	S1-R4	Presenter	WR-8	Learner
Azka Sabiq Arfa	SMAN 3 Bandung	S2-R7	Presenter	WR-10	Learner
Billy Rayendra Nugraha	SMAN 3 Bandung	S2-R7	Presenter	WR-3	Learner
Chalice Nailasekar Daradjat	SMAN 3 Bandung	S2-R7	Presenter	WR-2	Learner
Nadim Prasetya Regazzoni	SMAN 3 Bandung	S2-R7	Presenter	WR-1	Learner
Ramon Ernest C. Kimhoko	San Carlos School of Cebu, Inc.	S2-R5	Presenter	WR-12	Learner
Clare Therese E. Owacan	San Carlos School of Cebu, Inc.	S2-R5	Presenter	WR-4	Learner
Dmitri Finn D. Lungay	San Carlos School of Cebu, Inc.	S2-R5	Presenter	WR-11	Learner
Seith Christian R. Vanzuela	San Carlos School of Cebu, Inc.	S2-R5	Presenter	WR-7	Learner
Athalia Corazon Magaspi Angot	San Carlos School of Cebu, Inc.	S1-R3	Presenter	WR-10	Learner
Ashtynne Chloe Ejes	San Carlos School of Cebu, Inc.	S1-R3	Presenter	WR-5	Learner
Nyte Rama Flowers	San Carlos School of Cebu, Inc.	S1-R3	Presenter	WR-12	Learner
Jairus Corbin Yau Tiu	San Carlos School of Cebu, Inc.	S1-R3	Presenter	WR-7	Learner
Hanna Kristina Bandiala Andam	San Carlos School of Cebu, Inc.	S1-R2	Presenter	WR-6	Learner
Jainah Louise Ortaliz Galvan	San Carlos School of Cebu, Inc.	S1-R2	Presenter	WR-8	Learner
Jairus Jude Gaviola Genegobis	San Carlos School of Cebu, Inc.	S1-R2	Presenter	WR-9	Learner
Alan Dominic Pineda Tan	San Carlos School of Cebu, Inc.	S1-R2	Presenter	WR-3	Learner
John Carl Niedo Torres	San Carlos School of Cebu, Inc.	S1-R2	Presenter	WR-1	Learner
Nutatcha Yowcharoensuk	Chiang Mai University Demonstration School	S2-R6	Presenter	WR-6	Learner
Kueaangkul Chanpo	Chiang Mai University Demonstration School	S2-R6	Presenter	WR-4	Learner
Kanwara Laopanichkul	Chiang Mai University Demonstration School	S2-R6	Presenter	WR-11	Learner
Natchaya Sirisutham	Chiang Mai University Demonstration School	S2-R5	Presenter	WR-1	Learner
Thee Nophaket	Chiang Mai University Demonstration School	S2-R5	Presenter	WR-9	Learner
Sirawich Pichitpantapong	Chiang Mai University Demonstration School	S2-R5	Presenter	WR-7	Learner
Angkul Utane	Chiang Mai University Demonstration School	S2-R5	Presenter	WR-12	Learner
Supanat Wongpia	Chiang Mai University Demonstration School	S2-R5	Presenter	WR-5	Learner
Chonchanok Suwannatup	Ongkharak Demonstration School	S2-R7	Presenter	WR-1	Learner
Jareeyaporn Wongnuam	Ongkharak Demonstration School	S2-R7	Presenter	WR-3	Learner
Saruda Wangrakwong	Ongkharak Demonstration School	S2-R7	Presenter	WR-2	Learner
Tawit Choowongkomo	Kasetsart University Laboratory School Center for Education Research and Development	S2-R6	Presenter	WR-4	Learner
Peerawich Phookduang	Kasetsart University Laboratory School Center for Education Research and Development	S2-R6	Presenter	WR-11	Learner

■ High School Students

Name	High School	Research Session		Workshop	
Chanyaneut Rattanachoksakul	Wat Rai Khing Wittaya School	S2-R8	Presenter	WR-12	Learner
Thanyapat Sandee	Wat Rai Khing Wittaya School	S2-R8	Presenter	WR-6	Learner
Nampech Chantakun	Wat Rai Khing Wittaya School	S2-R8	Presenter	WR-10	Learner
Phunyawee Sirathatanareey	Wat Rai Khing Wittaya School	S1-R4	Presenter	WR-3	Learner
Kanrawi Rungcharoeyphatthanakit	Wat Rai Khing Wittaya School	S1-R4	Presenter	WR-4	Learner
Sirikan Payongsak	Wat Rai Khing Wittaya School	S1-R4	Presenter	WR-8	Learner
Supawida Khunpithak	Wat Rai Khing Wittaya School	S1-R2	Presenter	WR-9	Learner
Tharchagorn Mod-on	Wat Rai Khing Wittaya School	S1-R2	Presenter	WR-1	Learner
Hoang Minh Quang	High School of Educational Science	S2-R7	Presenter	WR-2	Learner
Vuong Tri Dung	High School of Educational Science	S2-R5	Presenter	WR-7	Learner
Do Minh Dang	High School of Educational Science	S2-R5	Presenter	WR-5	Learner
Nguyen Do Quyen	High School of Educational Science	S2-R5	Presenter	WR-11	Learner
Nguyen Chau Anh	High School of Educational Science	S1-R1	Presenter	WR-4	Learner
HSU, WEN HSIN	National Keelung Girls' Senior High School	S1-R2	Presenter	-	-
HUANG, SHANG YU	National Keelung Girls' Senior High School	S1-R2	Presenter	-	-
CHUANG, YA-CHI	National Keelung Girls' Senior High School	S1-R2	Presenter	-	-
LIN, YU-LE	National Keelung Girls' Senior High School	S1-R2	Presenter	-	-
Ema Matoba	Shibaura Institute of Technology Kashiwa Senior High School	S1-R1	Presenter	WR-11	Learner
Kensei Iida	Hiroo Gakuen Koishikawa	S1-R4	Presenter	WR-8	Learner
Makoto Ugajin	Shibaura Institute of Technology Kashiwa Senior High School	S1-R1	Presenter	-	-
Sota Sasaki	Toin Gakuen Secondary School	S1-R3	Presenter	-	-
Karin Chiyo	Ichikawa Gakuen Ichikawa Senior High School	S2-R8	Presenter	WR-10	Learner
Nana Tsuchida	Ichikawa Gakuen Ichikawa Senior High School	S2-R7	Presenter	WR-2	Learner
Natsuki Torikoshi	Ichikawa Gakuen Ichikawa Senior High School	S2-R8	Presenter	WR-6	Learner

■ Chiba University (International Students)

Name	Faculty	Research Session		Workshop	
Armelia Ramandha	Graduate School of Science and Engineering	S1-R2 & S2-R8	Panelist	WR-9	Facilitator
Rizvon Suleimanov	Graduate School of Humanities and Studies on Public Affairs	S1-R1 & S2-R5	Panelist	WR-10	Facilitator
Joceline Theda Kadarman	Graduate School of Medical and Pharmaceutical Sciences	S1-R4 & S2-R6	Panelist	WR-11	Facilitator
Hanna Putri Devita	Graduate School of Science and Engineering	S1-R3 & S2-R7	Panelist	WR-12	Facilitator
Punnat Changsalak	Graduate School of Science	S1-R4 & S2-R5	Panelist	WR-12	Facilitator

■ Chiba University

Name	Affiliation
Hiroaki Ozawa	Executive Vice President, Chiba University
Jun Nomura	Graduate School of Education, Chiba University
Koji Tsuji	Graduate School of Education, Chiba University
Kohei Watanabe	Graduate School of Education, Chiba University
Hina Morishige	Institute for Excellence in Educational Innovation, Chiba University
Qian Wang	Institute for Excellence in Educational Innovation, Chiba University

