BOOK OF ABSTRACT

"Deep Learning Approach in the Era of Digitalisation to Strengthen Students' Mathematical Abilities"

Presented in

The 3rd International Conference on Mathematics and Mathematics Education (ICMMEd) 2025

November 25, 2025, Ambon, Maluku, Indonesia

Organized By

Department of Mathematics Education

Faculty of Teacher Training and Education

UNIVERSITAS PATTIMURA

THE BOOK OF ABSTRACTS

THE 3rd INTERNATIONAL CONFERENCE ON MATHEMATICS AND MATHEMATICS EDUCATION

ICMMEd 2025
Deep Learning Approach in the Era of Digitalisation to Strengthen Students' Mathematical Abilities

Department of Mathematics Education, Universitas Pattimura
Ambon, Indonesia
November 25th, 2025

OPENING SPEECH OF THE CHAIRMAN OF THE ORGANIZING COMMITTEE
The 3rd ICMMEd 2025 FKIP Universitas Pattimura

Dear participants,
It is my honour to welcome you all from nationwide and across the globe to take part as presenter or sit in participant in the Third International Conference on Mathematics and Mathematics Education (The 3rd ICMMEd) 2025 FKIP Unpatti. The current implementation of Kurikulum Merdeka, adapted from independent curriculum that applying in most schools and universities around Indonesia, has put major issue to deal with, especially in teaching and learning mathematics. This condition brings our focus to develop theme for the third edition of ICMMEd as **Deep Learning Approach in the Era of Digitalisation to Strengthen Students' Mathematical Abilities.**

Following theme of the 3rd ICMMEd, the papers that presented are covering the topics of the conference which hopefully can enrich innovation for teaching and learning mathematics in terms of implementing methods, strategies, using proper tools, etc that fit to the character of independent curriculum. Participants of this conference are lecturers, scientists, teachers, undergraduate and graduate students which coming from various universities and schools in Indonesia and also overseas.

The committee wishes thank abundantly to Dean of Faculty of Teachers Training and Educational Sciences at Pattimura University for his support in any ways to this event. We also thank and appreciate the distinguished speakers from United States, Singapore, Australia, and Indonesia for their knowledge contribution in making the 3rd ICMMEd 2025 FKIP Unpatti as meaningful mathematics event.

I wish you have a wonderful experience and a lot of benefit through this conference. May God bless all of us.

Best regards,

Darma Andreas Ngilawajan, S.Pd., M.Pd
Chairman of the Organizing Committee

THE RUNDOWN OF THE 3RD ICMMED 2025

Zoom Link:
Time: November 25th, 2025, 08.30 Eastern Indonesia Time

Join Zoom Meeting:
https://us06web.zoom.us/j/88550853640?pwd=i3QDuRRAjJio1lOZViaobgML8YKTht.1
Meeting ID: 885 5085 3640
Passcode: ICMMED25

Opening Ceremony Time:
09.00 AM Eastern Indonesia Time (EIT) 08.00 AM Central Indonesia Time (CIT) 07.00 AM West Indonesia Time (WIT) 10.00 AM AEST 08.00 AM Singapore Time 08.00 PM Central Standard Time (November 24th, 2025)

Eastern IndonesiaTime (GMT+09.00)	Local Times	Event	Information
08.30 am – 09.00 am		**Preparation (Zoom link is opened for speakers and participants) and Registration**	Committee
09.00 am – 10.00 am		**Opening:**	
		National Anthem of Indonesia "Indonesia Raya"	
		Traditional Opening Dance: "Hena Masa Waya"	Kalesang Community
		Report from the Organizing Committee Chair: **D. A. Ngilawajan, S.Pd., M.Pd.**	
		Welcome Remarks by the Dean of the Faculty of Teacher Training and Education, Pattimura University: **Prof. Dr. Izaak H. Wenno, M.Pd**	
		Welcome Remarks followed by the Official Opening of the Conference by the Rector of Pattimura University: **Prof. Dr. Fredy Leiwakabessy, M.Pd**	

Eastern IndonesiaTime (GMT+09.00)	Local Times	Event	Information
		Pray	Committee
10.00 am – 01.00 pm		**Plenary Session:**	
(10.00 am - 11.00 am)	09.00 pm-09.45 pm Central Standard Time (CST) (November 24th, 2025)	Keynote Speaker 1: **Latrenda Knighten, BA, M.Ed** **(President of NCTM)**	Moderator : Darma A. Ngilawajan, M.Pd
	09.45 pm-10.00 pm Central Standard Time (CST) (November 24th, 2025)	Question and Answer	
(11.00 am - 12.00 pm)	12.00 pm – 12.45 pm AEST	Keynote Speaker 2: **Assoc. Prof. Kin Eng Chin, Ph.D** **(School of Education, Murdoch University, Perth, Western Australia, Australia)**	
	12.45 pm – 01.00 pm AEST	Question and Answer	
12.00 pm - 01.00 pm		**Lunch Break**	Committee
(01.00 pm - 02.00 pm)	11.00 am – 11.45 am West Indonesia Time	Keynote Speaker 3: **Assoc. Prof. Dr.rer.nat. Adi Nur Cahyono** **(Universitas Negeri Semarang, Jawa Tengah, Indonesia)**	Moderator : Darma A. Ngilawajan, M.Pd
	11.45 am – 12.00 pm West Indonesia Time	Question and Answer	
(02.00 pm – 03.00 pm)	01.00 pm-01.45 pm Singapore Time (06.00 am – 06.45 am	Keynote Speaker 4: **Assoc. Prof. Choy Ban Heng, Ph.D** **(Nanyang Technological University, Singapore)**	

Eastern IndonesiaTime (GMT+09.00)	Local Times	Event	Information
	Central European Time)		
	01.45 pm – 02.00 pm Singapore Time (06.45 am – 07.00 am Central European Time)	Question and Answer	
03.00 pm – 03.15 pm		**Coffee Break**	Committee
03.15 pm - 06.00 pm		**Parallel Session**	Committee
06.00 pm – 06.30 pm		**Closing:**	
		Closing Remarks by Head of Department of Mathematics and Natural Sciences : Dr. Christina M. Laamena, M.Sc	

PARALLEL SESSION OF THE 3RD ICMMED 2025

Zoom Link:
Time: November 25th, 2025, 03.15 pm Eastern Indonesia Time

Join Zoom Meeting:
https://us06web.zoom.us/j/88550853640?pwd=i3QDuRRAjJio1lOZViaobgML8YKTht.1
Meeting ID : 885 5085 3640
Passcode : ICMMED25

Class : Ethnomathematics
Room : 01
Moderator : Eunike Mataheru, M.Pd.

Time	Number	Name	Title of Manuscripts
03.15 pm - 03.25 pm	1	Ahmad Rifai Siregar	Integrating Traditional Music and Technology in Circle Geometry Learning: A Learning Trajectory to Enhance Geometrical Reasoning
03.25 pm – 03.35 pm	2	Theresia Laurens	Transformation of Students' Cognitive Representations through Culture-Based Augmented Reality Learning Reviewed from Cognitive Load Theory
03.35 pm – 03.50 pm	**Discussion**		
03.50 pm – 04.00 pm	3	Wa Ode Dahiana	From Culture to Technology: A Qualitative Exploration of 3D Geometric Representation in Moluccas Buildings Through Augmented Reality
04.00 pm – 04.10 pm	4	Yohanis Ndapa Deda	Ethnomathematics in Traditional Houses of the Indonesian Archipelago: A Systematic Review
04.10 pm – 04.25 pm	**Discussion**		
04.25 pm – 04.35 pm	5	Christi Matitaputty	Error and Misconception Analysis of First-Semester Mathematics Education Students in Determining Cone Surface Area and Volume Using a Fishing Net Context
04.35 pm – 04.45 pm	6	Susana Labuem	Comparison of Traditional Number Systems of the Aru, Malind, Amanuban, and Golo Tolang Tribes: A Study of Ethnomathematics Literature in the Archipelago
04.45 pm – 05.00 pm	**Discussion**		

Class : Assessment in Mathematics Education
Room : 02
Moderator : Neneng Anastasyia, M.Pd.

Time	Number	Name	Title of Manuscripts
03.15 pm - 03.25 pm	1	Vicardy Kempa	Problems in Developing Numeracy Skills at Elementary Schools in Ambon City
03.25 pm – 03.35 pm	2	Gunawan	Student Computational Thinking Skills Profile Reviewed from Self-Efficacy: A Case Study of Contextual Problems
03.35 pm – 03.50 pm	**Discussion**		
03.50 pm – 04.00 pm	3	Ria Noviana Agus	Integrating EEG and Visualization Strategies to Enhance Mathematical Modelling
04.00 pm – 04.10 pm	4	Magy Gaspersz	Measuring High School Students' Mathematical Power: Partial Credit Model (PCM)
04.10 pm – 04.25 pm	**Discussion**		
04.25 pm – 04.35 pm	5	Saddam Al Aziz	Assessment of Students' Mathematical Critical Thinking Through Deductive Indicators: A Study on Circle Problems
04.35 pm – 04.45 pm	6	Pietter Tulaseket	Analysis of Eighth-Grade Students' Mathematical Creative Thinking Ability at SMP Negeri 15 Ambon on Three-Dimensional Geometry Viewed from Self Regulated Learning (SRL)
04.45 pm – 05.00 pm	**Discussion**		
05.00 pm – 05.10 pm	7	Rifaldo R. Sigmarlatu	Students' Numeracy Literacy Ability in Solving Higher Order Thinking Skills (HOTS) Problems on Integer Material in Class VII of SMP Negeri 6 Ambon
05.10 pm – 05.20 pm	8	Shinta Sari	Self-Efficacy and Mathematical Literacy Skills of Pre-Service Mathematics Teachers in Solving Mathematical Literacy Problems
05.20 pm – 05.35 pm	**Discussion**		

Class : **Mathematics Learning Models, STEM in Mathematics Education**
Room : **03**
Moderator : **Pieter Z. Tupamahu, M.Pd.**

Time	Number	Name	Title of Manuscripts
03.15 pm - 03.25 pm	1	Ika Muji Wahyuni	The Development And Validation Of A Digital Teaching Module Based On Learning Trajectory To Enhance Students' Critical And Creative Thinking In Geometry
03.25 pm – 03.35 pm	2	Muhammad Akfal T.	Students' Mathematical Problem Solving and Connection Abilities: The Role of Self-efficacy.
03.35 pm – 03.50 pm	**Discussion**		
03.50 pm – 04.00 pm	3	Dr. Susanah, M.Pd	Mathematics Education Students' Readiness in Developing Problem-Based Lesson Plan with Deep Learning Approach
04.00 pm – 04.10 pm	4	Vicardy Kempa	Integrating Deep Learning Models to Improve Students' Understanding Of Circles At SMA Negeri 1 Ambon
04.10 pm – 04.25 pm	**Discussion**		
04.25 pm – 04.35 pm	5	Maulani Meutia Rani	STEAM-PjBL: A Solution to Improve 4C Skills
04.35 pm – 04.45 pm	6	Gregoria Ariyanti	Development of GeoGebra Interactive Media for Volume of Rotating Objects
04.45 pm – 05.00 pm	**Discussion**		
05.00 pm – 05.10 pm	7	Rita Desfitri	Development of Learning Media: Challenges Encountered by Mathematics Education Students – A Case Study
05.10 pm – 05.20 pm	8	Anderson Leonardo Palinussa	Effectiveness of Project-Based Learning Based on Realistic Mathematics Education in Teaching Systems of Linear Equations in Two Variables to Eighth-Grade Students
05.20 pm – 05.30 pm	9	Francis Yunito Rumlawang	Exploration of External Didactic Transposition on The Concept of Continuity of Function
05.30 pm – 05.45 pm	**Discussion**		

Class : Mathematical Physics, Dynamical Systems and Differential Equations, Mathematical Statistics, Calculus and Analysis
Room : 04
Moderator : Eka Triatna, S.Pd., M.Mat.

Time	Number	Name	Title of Manuscripts
03.15 pm - 03.25 pm	1	Vina Lusiana	A Deterministic SVEIQHR–SEI Mathematical Model for Monkeypox Transmission: Integrating Vaccination Strategy and Human–Rodent Interaction
03.25 pm – 03.35 pm	2	Meri Kase	Determination of Eigenvalues and Eigenvectors in Solving Linear Differential Equation Systems
03.35 pm – 03.50 pm	**Discussion**		
03.50 pm – 04.00 pm	3	Andrea Tri Rian Dani	Modeling Earth Skin Temperature and Cloud Amount: A Hybrid Fourier Series-Neural Network Approach for Kalimantan Environmental Patterns
04.00 pm – 04.10 pm	4	Nurhayati	Hybrid GSTAR–GJR-GARCH Modeling with Skew-t Innovations for Asymmetric Spatio-Temporal Volatility in Rainfall
04.10 pm – 04.25 pm	**Discussion**		
04.25 pm – 04.35 pm	5	Nur Khasanah	On the Generating Functions and Polynomial Relations of Chebyshev Polynomials of The First Kind
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Reimagining and Revitalizing the Mathematics Experience for ALL

Latrenda Knighten[1, a)]

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Abstract. Reimagined, Revitalized, and Relevant are the new three "Rs" of mathematics. To foster student engagement and promote positive mathematical identities, we must reimagine what the student experience in mathematics classrooms looks like. This involves moving away from the traditional "I do, we do, you do" teaching and towards more student-centered approaches that encourage exploration, application, discussion, problem-solving and sense making. In the reimagined mathematics classroom, students are actively engaged in the learning process, collaborate with peers, and engage in meaningful discussions as they make sense of mathematics concepts. Educators in the revitalized mathematics classroom organize content in meaningful ways to make it relevant, connected, and coherent to make learning applicable to students' lived experiences and the real-world.

Teaching Through Problem Solving for Low-Progress Learners: Lessons from Mr. Faizad

Ban Heng Choy[1, a)]

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Abstract. Teaching through problem solving (TTPS) is an instructional approach that introduces new concepts to students by giving them opportunities to solve carefully crafted mathematics problems. Although this approach places problem solving at the centre of mathematics instruction, many teachers struggle to design and implement TTPS lessons, especially when working with low-progress students, who struggle with mathematics in schools. In this keynote, I will share insights into how a primary school mathematics teacher, Mr Faizad, learned to teach mathematics through problem solving. These insights provide implications for both teachers and teacher educators as they strive towards deep learning for ALL students.

Rethinking the Roles of Mathematics Educators in the Age of AI

Kin Eng Chin[1, a)]

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Abstract. A rapid rise in AI tools has directly influenced mathematics education. Mathematics educators now employ a variety of AI technologies to support teaching and learning, leading to a significant shift in the way we teach and learn. Tasks that were once central to a teacher's work, such as explaining concepts, providing feedback, designing tasks, and assessing students, can now be partially or fully supported by AI systems. As AI capabilities continue to grow, they challenge the traditional roles and responsibilities of mathematics educators. This raises an important question about how we should respond to these changes while preserving the essence of mathematics education. The purpose of this paper is to exemplify and analyse how the conventional roles of mathematics educators are evolving in an AI-mediated educational environment. The intention is not to debate whether AI should or should not be used, but to encourage critical, reflective, and constructive consideration of how the field can move forward. By examining emerging practices and tensions, the paper seeks to contribute to ongoing discussions about how mathematics educators can adapt, innovate, and maintain pedagogical purpose in an era increasingly shaped by AI technologies.

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Mathematical Modelling within STEM Trails in the Digital Era for a Sustainable Future through Interdisciplinary Partnerships

Adi Nur Cahyono[1, a)]

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Abstract. This presentation elaborates the mathtrailslab.id roadmap (2013–2035), a sustained research and innovation agenda that advances mathematical modelling within STEM Trails—learning environments that invite students to learn mathematics in the digital age through journeys "from real-world trails to immersive adventures," explicitly aligned with the UN Sustainable Development Goals (SDGs). Over more than two decades, STEM Trails have evolved from mobile and outdoor math trails toward augmented reality modelling, virtual/extended reality trails, 3D-printing supported tasks, Robo–Drone trails, and AI-enhanced modelling and creative STEAM experiences, culminating in the vision of a Maths Adventure Park that blends real, virtual, and extended realities to foster 21st-century competencies for sustainability. At the core of this ecosystem, mathematical modelling functions as a bridge connecting mathematics with science/engineering, digital technology, health, environmental studies, and creative domains. Through data collection, mathematization, simulation, and validation in authentic settings, learners and teachers investigate socio-scientific challenges while strengthening mathematical literacy, critical thinking, and collaborative problem solving. A defining feature of the framework is its interdisciplinary partnership model, strengthened through cross-institutional and cross-country collaboration that operationalizes SDG 17 (Partnerships for the Goals). International and landmark-based cross-country STEM Trails co-design learning tasks, tools, and contexts that connect local issues in the archipelago with global SDG priorities. Interdisciplinary task design targets urgent sustainability issues, with a strong emphasis on wellbeing and public health (SDG 3). For example, modelling activities are linked to Indonesia's Free Nutritious Meals Programme (MBG), where students engage with real nutritional data and community health contexts to build meaningful models for decision-making. Environmental sustainability is also foregrounded through trails addressing themes such as green transportation and CO_2 reduction, greywater reuse and water conservation, and local marine–coastal ecology that support SDG 14 (Life Below Water) demonstrating how modelling can anchor environmental stewardship in learners lived environments. Partnerships with the world of work further enrich the trails by embedding financial literacy, robotics, coding, and AI-supported modelling experiences. These components prepare future-ready graduates and directly contribute to SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure) through classroom-based innovation. Overall, mathtrailslab.id offers a scalable blueprint for digitally empowered, partnership-driven mathematics education that equips learners to co-create sustainable and resilient futures.

THE ABSTRACT OF PRESENTERS

The Use of Rebana Traditional Music as a Geometry Reasoning-Based Learning Media in Circle Geometry Instruction

Nur 'Afifah[1, 6, a)] Ahmad Rifai Siregar[1, b)] Hizmi Wardani[2, c)]
Hamzah Sa'ban Saragih[1, 3, d)] Rina Ardillah Lubis[1, 4, e)]
Regina Sabariah Sinaga[1, 5, f)] Indra Maryanti[1, 6, g)] and
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Abstract. This study aims to analyze the effectiveness of the traditional musical instrument rebana as an ethnomathematics-based learning medium for enhancing students' geometric reasoning in the circle topic, as well as to assess students' learning interest and reasoning performance during the instructional activities. Using a descriptive qualitative design supported by quantitative data, the study involved 32 eighth-grade students through classroom observations, a learning interest questionnaire, and a geometric reasoning questionnaire. The results showed that the reasoning questionnaire obtained a percentage of 76,41% in the good category, while the learning interest questionnaire reached 66,88%, indicating increased motivation and engagement during measurement and exploration activities with the rebana. Classroom observations further revealed that 62.50% of students demonstrated high reasoning performance. Overall, the findings confirm that the rebana functions as an effective, contextual, and culturally meaningful learning medium that strengthens geometric reasoning, fosters learning interest, and enhances students' understanding of circle concepts through direct experiential learning.

Transformation of Students' Cognitive Representations through Culture-Based Augmented Reality Learning Reviewed from Cognitive Load Theory

Theresia Laurens[1, a)] Andarias Siahay[1, b)] Marlin Blandy Mananggel[1, c)] and Widya Putri Ramadhani[1, d)]

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Abstract. This study aims to analyze the transformation of students' cognitive representations through the application of Augmented Reality (AR) learning based on the local culture of Maluku using the "Tifa" medium as a representative object in spatial geometry learning, specifically on the material of volume and surface area of the Tifa. The development of AR media was carried out by integrating cultural elements through the physical form and ornaments of the Tifa, which resemble a tube, and visualizing them in a virtual digital environment. This study used a mixed methods approach with a pretest-posttest design to measure changes in students' cognitive representations before and after using AR media. The instruments used included cognitive representation tests (visual, symbolic, and verbal), cognitive load observation sheets, and reflective interviews. Data analysis was conducted quantitatively through representation score improvement tests and qualitatively through descriptive analysis of cognitive load based on Cognitive Load Theory. The results showed that the use of Tifa culture-based AR was able to facilitate the transformation of students' cognitive representations from concrete to abstract, increase their understanding of spatial geometry concepts, and reduce extraneous cognitive load during the learning process. These findings indicate that the integration of local wisdom into learning technology can be an effective strategy in building meaningful and contextual learning experiences in mathematics learning.

From Culture to Technology: A Qualitative Exploration of 3D Geometric Representation in Moluccas Buildings Through Augmented Reality

Wa Ode Dahiana[1, a)] La Moma[1, b)] Hanisa Tamalene[1, c)]
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Abstract. This study explores the transformation of ethnomathematics concepts into Augmented Reality (AR) visualization through three-dimensional geometric analysis of four historical buildings in Moluccas: Imanuel Church, Wapauwe Mosque, Amsterdam Fort, and Lating Nustapy Old House. Using a descriptive qualitative approach, this study aims to identify geometric elements contained in traditional Maluku architecture and investigate the process of transforming them into interactive AR visualizations. Data collection was conducted through field observations, photographic and videographic documentation using drones, interviews with community leaders and local architecture experts, and analysis of historical documents. Data analysis using the Miles and Huberman technique included data reduction, data presentation, and conclusion drawing. The results showed that the four buildings had unique geometric characteristics that reflected Molucca's local wisdom, including basic shapes such as cubes, blocks, prisms, and pyramids with modifications specific to the local culture. The transformation process to AR was carried out in stages: (1) identification and decomposition of the geometric structure of the building; (2) 3D modeling using Blender software; (3) integration into the Assembler Edu platform with a barcode scanning system; and (4) validation of the visualization by experts and the local community. The main findings reveal that AR visualization can preserve the essence of ethnomathematics while improving the accessibility of geometric concept understanding through dynamic interaction and multi-perspective representation. This research contributes to the development of culture- and technology-based mathematics learning media and offers a model for cultural heritage preservation through innovative digitization.

Ethnomathematics in Traditional Houses of the Indonesian Archipelago: A Systematic Review

Yohanis Ndapa Deda[1, a)] Yosepha Patricia Wua Laja[1, b)] Stanislaus Amsikan[1, c)] and Selestina Nahak[1, d)]

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Abstract. Indonesia's traditional houses encode rules of form, space, and construction that are rich in mathematical ideas, yet the evidence is scattered across many small case studies. This review consolidates those findings through a PRISMA 2020–guided systematic literature review. A primary search in Scopus (2017–2025) identified 166 documents; after screening by one reviewer, 20 studies were analyzed and synthesized narratively. The results converge on four domains. First, ornament functions as a "calculus of transformations," embedding symmetry, tessellation, translation, rotation, and reflection. Second, spatial layouts mirror social-ritual norms-sacral hierarchies and gender segregation-measurable via space-syntax metrics (depth, integration, intelligibility). Third, proportion–module–measure operate as explicit/implicit design rules, tending toward simple integer ratios. Fourth, vernacular structural rationality-lightweight mass, raised floors, and friction joints-helps explain resilience to hazards, including earthquakes. Cross-ethnic and regional variation is primarily driven by the interplay of cosmology, climate/topography, and local technologies and materials. Methodologically, the field is shifting toward integrating ethnography with computational analytics, environmental measurements, and open data. In education, recent evidence shows that integrating ethnomathematics enhances students' sense of connection and mathematics learning outcomes. Key limitations include heterogeneous study designs and a focus on indexed publications. This review contributes a holistic map of "architecture-as-ethnomathematics" in Indonesia, a clear bridge to classroom practice, and a call to strengthen ethics of community engagement and heritage preservation.

Error and Misconception Analysis of First-Semester Mathematics Education Students in Determining Cone Surface Area and Volume Using a Fishing Net Context

Christi Matitaputty[1, a)] Wilmintjie Mataheru[1, b)] Novalin Calasin Huwaa[1, c)] and Vicardy Kempa[1, d)]

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Abstract. Context-based geometry tasks that link mathematical concepts with real-life objects play an important role in strengthening conceptual understanding, particularly for pre-service mathematics teachers. This study aims to analyse the types of errors and misconceptions made by first-semester undergraduate Mathematics Education students in solving surface area and volume of cone problems using a fishing net (jala ikan) context. A descriptive qualitative design was employed involving 27 first-semester Mathematics Education students who were provided with image-based contextual geometry tasks related to the shape of a traditional fishing net, which resembles a cone. Students' written responses were examined to identify misconceptions and categorized into three types of errors: conceptual, procedural, and calculation errors. The findings reveal that conceptual errors were predominant, particularly in interpreting the components of the fishing net image and mapping them accurately to cone properties such as height and slant height. Procedural errors occurred as students applied incorrect or incomplete steps in determining the surface area and volume of the cone, while calculation errors were found in arithmetic processes despite correctly chosen methods. These results indicate that first-semester pre-service mathematics teachers still face difficulties when transitioning from real-life representations to abstract mathematical models. The study highlights the need for structured scaffolding and context-based teaching strategies to develop stronger conceptual foundations in 3D geometry learning. Recommendations for teaching practice and future research are provided.

Comparison of Traditional Number Systems of the Aru, Malind, Amanuban, and Golo Tolang Tribes: A Study of Ethnomathematics Literature in the Archipelago

Susana Labuem[1, a)] Sitti Hajar Kaliky[1, b)] and Saharuddin[1, c)]

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Abstract. This research is a literature study that aims to describe and compare the traditional number systems of the Aru tribe (Maluku), Malind tribe (Papua), Amanuban tribe, and Golo Tolang tribe (East Nusa Tenggara) from an ethnomathematics perspective. The main focus of this study is on number structures, base units, number formation patterns, and the mathematical cultural values contained in these number systems. This research is motivated by the importance of preserving local wisdom in mathematics, as well as an effort to bridge traditional knowledge with formal education through a contextual approach. The method used was library research, which involved collecting and analyzing various written sources such as journal articles, books, research reports, and relevant cultural documents. The data were analyzed descriptively and comparatively by theme to identify similarities, differences, and mathematical meanings in the fourth number system. The results of the study show that the traditional number systems of the Aru, Malind, Amanuban, and Golo Tolang tribes are unique in terms of number terminology, number system base, and the way communities construct large numbers. All four tribes use an approach based on local culture and language that reflects the numerical thinking of their communities. In addition, these number systems are not only used for counting, but are also closely related to social systems, beliefs, and daily practices. This study is expected to contribute to the development of numeracy literacy based on local culture and encourage the integration of ethnomathematics into mathematics learning in schools, especially in 3T (underdeveloped, frontier, and outermost) areas.

Problems in Developing Numeracy Skills at Elementary Schools in Ambon City

Tanwey Gerson Ratumanan[1, a)] Novalin Calasin Huwaa[1, b)]
R. H. Yanti Silitonga[1, c)] and Vicardy Kempa[1, d)]

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Abstract. This study aims to identify problems in developing numeracy skills in elementary schools in Ambon City. A qualitative approach was used. Six elementary schools representing the subdistricts of Sirimau, Nusaniwe, and Teluk Ambon were selected as subjects. Data were collected through questionnaires for mathematics and non-mathematics teachers, observations, and interviews. The data were then analyzed through data reduction, data presentation, and conclusion drawing stages. The results indicate various obstacles in numeracy development. Of the 19 statements in the questionnaire for mathematics teachers, nine were most often answered "never" and two were answered "sometimes" at one of the elementary schools. This indicates significant obstacles in the planning and implementation of numeracy learning. In the questionnaire for non-mathematics teachers, nine of the sixteen statements showed that teacher involvement was still limited. Interview results also revealed a lack of numeracy training. They showed the non-implementation of real-life context-based numeracy programs and traditional games, as well as a lack of facilities, infrastructure, and displays of numeracy information in the school environment. This shows that numeracy development in Ambon City still faces obstacles. The findings indicate a need for teacher training, the provision of learning facilities, and implementation of contextual numeracy programs.

Student Computational Thinking Skills Profile Reviewed from Self-Efficacy: A Case Study of Contextual Problems

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Abstract. Computational thinking (CT) and self-efficacy are two important competencies that play a role in supporting the success of mathematics learning in the 21st century. This study aims to describe the profile of CT ability from self-efficacy in solving contextual problems. The research subject involved junior high school students in grade VIII. The research method used is qualitative. Data collection was carried out by CT tests, questionnaires, interviews, and documentation. The results of the student selective-efficacy questionnaire were grouped into high, medium, and low categories. Each category was taken by one student as a respondent with a purposive sampling technique. Data analysis includes data reduction, presentation, and drawing conclusions. The results showed that students in the high and medium self-efficacy categories met the CT indicators clearly and precisely which consisted of abstraction, decomposition, algorithms, and evaluation. Students with low self-efficacy categories have difficulty in finding solutions, especially in the section presenting problems in the form of simple mathematics. Research findings can be used as a reference to develop meaningful and fun learning strategies for students.

Integrating EEG and Visualization Strategies to Enhance Mathematical Modelling

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Abstract. This study examined the effectiveness of integrating electroencephalogram (EEG) monitoring with visualization strategies to enhance students' mathematical modelling competence on quadratic functions. Using a quasi-experimental one-group pretest–posttest design, 100 undergraduate mathematics education students participated in a three-phase intervention combining digital graphing worksheets, EEG-based feedback, and reflective tasks. The mathematical modelling test assessed five dimensions: identification, model formulation, solution, interpretation, and evaluation/reflection. Results revealed a significant improvement across all dimensions, with total modelling scores increasing from M = 9.8 (SD = 2.1) in the pretest to M = 15.4 (SD = 2.6) in the posttest, $t(99) = 12.05$, $p < .001$, $d = 0.95$. The most substantial gains were observed in interpretation ($d = 0.96$) and evaluation/reflection ($d = 1.02$), indicating strengthened conceptual understanding and metacognitive awareness. Analysis of digital activity logs showed that higher graph interaction frequency was positively correlated with modelling gains, underscoring the central role of visual exploration. Self-efficacy scores also improved significantly across all four dimensions ($p < .001$), with the largest increases in model formulation and interpretation. EEG data revealed a steady decline in the Theta/Beta ratio from pre (M = 0.51, SD = 0.12) to post (M = 0.39, SD = 0.09), suggesting a reduction in cognitive load and improved attentional regulation. Although the correlation between EEG changes and self-efficacy gains was weakly negative ($r = –0.11$), qualitative reflections provided converging evidence: students reported that visual cues from EEG feedback helped them focus, regulate effort, and build confidence. Thematic analysis identified three dominant themes, visualization for interpretation, EEG as focus regulation, and difficulty in model formulation, highlighting both the cognitive and affective dimensions of the learning experience. These findings demonstrate that integrating EEG-based feedback with visualization strategies can promote not only cognitive efficiency but also reflective engagement in mathematical modelling. The study contributes to extending Cognitive Load Theory into neuroeducational contexts and provides practical implications for designing adaptive, visualization-rich learning environments in mathematics education.

Measuring High School Students' Mathematical Power: Partial Credit Model (PCM)

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Abstract. Mathematical ability is crucial for students' success in learning mathematics. However, some students still face difficulties in understanding mathematics and solving mathematical problems. This quantitative study aimed to measure the mathematical ability, including problem-solving skills and mathematical connections, of 152 high school students focusing on trigonometry. The instrument used was an essay-type test that was validated for validity and reliability. The analysis was conducted by testing the construct of the instrument using Confirmatory Factor Analysis (CFA), followed by measurement analysis using unidimensional Item Response Theory (IRT) with the Partial Credit Model (PCM) to assess student ability. The CFA results showed that the model was a good fit, with a Comparative Fit Index (CFI) of 0.982, Tucker-Lewis Index (TLI) of 0.969, RMSEA of 0.041, and SRMR of 0.038. Cronbach's alpha reliability analysis yielded a good criterion of 0.707. The PCM analysis showed that the RMSEA and chi-square values were met, and the percentage of Item Fit Index (TIF) was high, resulting in a minimal error in measuring the mathematical power of high school students in Maluku. Students' mathematical power in trigonometry remains in the moderate to low range, with problem-solving skills in the low category and mathematical connection skills in the mild and low categories. Furthermore, the developed instrument can be used to measure the mathematical power of high school students in trigonometry.

Assessment of Students' Mathematical Critical Thinking Through Deductive Indicators: A Study on Circle Problems

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Abstract. Critical thinking skills are one of the 4Cs of the 21st century. In mathematics, mathematical critical thinking skills are understood as the process of making reasonable decisions about what to believe and do, especially when solving mathematical problems. One important indicator, which has rarely been examined in previous studies, is the deductive indicator, namely, the ability to draw logical conclusions from general principles to specific cases. This study aims to assess students' mathematical critical thinking skills through deductive indicators in circle material. The research subjects were 30 eighth-grade students at a public junior high school in Padang, West Sumatra, who were selected purposively according to the scope of the learning material. The research instrument was a proof question designed to elicit deductive thinking, proving the formula for the area of a circle based on the diameter, using the formula based on the radius. The results showed that only one student successfully fulfilled the deductive indicator completely. The rest answered incorrectly or were unable to construct a correct proof, and many errors in algebraic operations and symbolic manipulation were found. This low level of proof ability indicates that students are not yet trained in the process of proving or constructing formulas. Theoretically, this study confirms the importance of assessing mathematical critical thinking through deductive indicators, which are rarely studied. Practically, these results suggest the application of constructivist-based learning, enabling students to become accustomed to discovering their own knowledge and thereby developing skills in proving, constructing formulas, and cultivating deductive critical thinking.

Analysis of Eighth-Grade Students' Mathematical Creative Thinking Ability at SMP Negeri 15 Ambon on Three-Dimensional Geometry Viewed from Self Regulated Learning (SRL)

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Abstract. This study aims to describe the mathematical creative thinking abilities of eighth-grade students at SMP Negeri 15 Ambon on the topic of three-dimensional shapes, viewed from the perspective of self-regulated learning (SRL). A mixed-method approach was employed, using quantitative analysis to determine students' SRL categories and qualitative analysis to describe their creative thinking abilities based on the indicators of fluency, flexibility, originality, and elaboration. The results show that among 30 students, 10% demonstrated high SRL, 60% moderate SRL, and 30% low SRL. Students' mathematical creative thinking abilities were categorized as high (10%), moderate (56.67%), and low (33.33%). In-depth interviews revealed that students with high SRL fulfilled all creative thinking indicators, those with moderate SRL met them only partially, while students with low SRL experienced difficulties in almost all indicators. It is concluded that the higher the students' SRL, the better their mathematical creative thinking abilities, particularly in solving problems related to three-dimensional shapes. The findings highlight the importance of strengthening SRL in mathematics instruction, as increased learning autonomy can foster students' creative ideas. This study may serve as a reference for developing instructional models that integrate SRL with mathematical creative thinking skills.

Students' Numeracy Literacy Ability in Solving Higher Order Thinking Skills (HOTS) Problems on Integer Material in Class VII of SMP Negeri 6 Ambon

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Abstract. This study aims to describe the numeracy literacy skills of seventh-grade students at SMP Negeri 6 Ambon in solving Higher Order Thinking Skills (HOTS) questions on integer material. The research employed both quantitative and qualitative approaches. The research subjects consisted of 3 students representing high (KF), medium (AJ), and low (AP) ability categories. The results showed that students' overall numeracy literacy skills were still low, with 93.75% of students (30 students) falling into the low category, 3.12% (1 student) into the medium category, and 3.12% (1 student) into the high category. In-depth analysis of the three subjects revealed that the high-ability subject (KF) met all numeracy literacy indicators (communication, mathematization, representation, reasoning and argumentation, problem-solving strategies, and the use of mathematical language and symbols). The medium-ability subject (AJ) met most indicators but made errors on question number 1, while the low-ability subject (AP) met only a few indicators (communication, mathematization, and representation) and still struggled to convert problems into mathematical form and draw accurate conclusions. These findings indicate the need for greater teacher attention in habituating students to solving HOTS questions in order to improve numeracy literacy and higher-order thinking skills.

Self-Efficacy and Mathematical Literacy Skills of Pre-Service Mathematics Teachers in Solving Mathematical Literacy Problems

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Abstract. Mathematical literacy is one of the six fundamental literacy skills that must be mastered in the 21st century. Pre-service mathematics teachers are expected to possess strong self-efficacy and mathematical literacy skills before they design learning activities to strengthen students' mathematical literacy. This study aims to analyze the levels of self-efficacy and mathematical literacy skills of pre-service mathematics teachers in solving mathematical literacy problems. A mixed-method design was employed, using quantitative descriptive statistics and qualitative thematic analysis. The participants consisted of 31 seventh-semester students enrolled in a Mathematical Literacy course at the Department of Mathematics, Universitas Negeri Padang. Data were collected using three instruments: a mathematical literacy test, a self-efficacy questionnaire, and semi-structured interviews. The findings provide an overview of students' literacy levels, ranging from high to low literacy. The results highlight the need for interventions to improve students' mathematical literacy and self-efficacy to support future teaching practices.

The Development and Validation of a Digital Teaching Module Based on Learning Trajectory to Enhance Students' Critical and Creative Thinking in Geometry

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Abstract. This Research and Development (R&D) study aims to design and validate a digital teaching module based on a learning trajectory approach to enhance the critical and creative thinking skills of 11th-grade vocational high school students (SMK) in the topic of circle geometry. The development model employed is the Dick and Carey framework (front-end analysis phase), encompassing needs analysis, instructional analysis, learner and context analysis, formulation of performance objectives, and development of evaluation instruments. Expert validation, readability testing, classroom observation, teacher interviews, and post-learning assessments were conducted to evaluate product feasibility. The research subjects comprised 36 students from the Film Production concentration at SMKN 2 Kediri during the first semester of the 2024/2025 academic year. Validation results indicated that the digital teaching module achieved an average score of 3.48 (high validity), while the critical–creative thinking test instrument obtained a score of 3.46 (high validity). The Content Validity Index (CVI) ranged from 0.84 to 0.92, and the Flesch Reading Ease index in Indonesian reached 71.2 ("easy to understand" category). Effectiveness testing showed an average critical thinking score of 74.8, with 80% of students meeting the mastery criterion (28 out of 36), while the average creative thinking score was 79.34, with 71.43% of students achieving mastery (25 out of 36), slightly below the 75% benchmark. Qualitative data confirmed the strengths of the module in contextualizing geometry, structuring progressive learning activities, and providing reflective scaffolding; however, further enrichment with project-based and simulation activities is recommended to better foster creativity.

Students' Mathematical Problem Solving and Connection Abilities: The Role of Self-Efficacy

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Abstract. This study aims to analyze the influence of self-efficacy on students' mathematical problem-solving ability and mathematical connection ability in the topic of Linear Equations in One Variable (LEOV) among eighth-grade students at SMP Negeri 14 Ambon. The contribution of this research lies in providing empirical evidence on the relationship between students' self-belief and two essential mathematical competencies emphasized in the Merdeka Curriculum. Theoretically, the study is grounded in Bandura's concept of self-efficacy as well as established indicators of mathematical problem-solving and mathematical connection abilities. The research involved 31 students from class VIII-1 selected through purposive sampling. A quantitative descriptive approach with a causal design was employed, using a self-efficacy questionnaire along with tests measuring problem-solving and mathematical connection skills. The findings indicate that higher levels of self-efficacy tend to align with improved mathematical problem-solving and connection abilities. Overall, this study concludes that self-efficacy plays a crucial role in students' mathematics learning processes, suggesting the need for instructional strategies that strengthen students' confidence and independence.

Readiness of Mathematics Education Students in Developing Problem-Based Instructional Tools with a Deep Learning Approach

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Abstract. A teacher must understand the characteristics of students and the material being taught before starting to create instructional tools. This is necessary so that teachers can formulate meaningful and student-centered lesson plans. Mathematics education students are prospective mathematics teachers who will teach in secondary schools. Therefore, their readiness to develop instructional tools is key to ensuring the success of the learning process in their future classrooms. In implementing the Independent Curriculum (Kurikulum Merdeka), problem-based learning with a deep learning approach is one strategy to facilitate higher-order thinking skills (HOT), including critical, reflective, and creative thinking. Therefore, mathematics education students, who will become future teachers, must be prepared and able to design problem-based learning with a deep learning approach. This study aims to measure the readiness of mathematics education students in developing problem-based instructional tools with a deep learning approach. A descriptive qualitative approach was used in this study, involving 36 mathematics education students taking the Lesson Planning course. The data collected were problem-based lesson plan documents with a deep learning approach developed by the students. The results showed that, in general, the students demonstrated good readiness. However, several obstacles remain, such as the problem content presented in student worksheets tending to be limited to story problems that do not facilitate higher-order thinking skills, and the lack of technology involvement in the developed teaching modules. These findings have implications for the need to strengthen the pedagogical competence of prospective teachers through intensive guidance focused on the application of problem-based learning with deep learning approaches.

Integrating Deep Learning Models to Improve Students' Understanding of Circles at SMA Negeri 1 Ambon

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Abstract. Deep learning represents an instructional innovation designed to foster students' conceptual understanding and problem-solving abilities through attentive, meaningful, and engaging learning experiences. The present study aims to examine the conceptual understanding of Grade X students at SMA Negeri 1 Ambon concerning the circle concept through the implementation of a Deep Learning based instructional approach. This approach was operationalized through a sequence of learning activities intended to analyze interconceptual relationships, construct alternative representations, and generalize fundamental principles of circles within authentic contexts. A descriptive qualitative research design was employed, involving Grade X students of SMA Negeri 1 Ambon. Data were collected through classroom observations, analysis of student assignments, and reflective interviews. The findings reveal that the integration of the Deep Learning model effectively enhances conceptual connectedness, cognitive flexibility, and students' ability to articulate and apply circle-related concepts comprehensively. The implications of this study underscore the significance of deep learning oriented instructional design as a pedagogically robust strategy for strengthening mathematical conceptual understanding at the secondary education level.

STEAM-PjBL: A Solution to Improve 4C Skills

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Abstract. The 21st century demands students to master the 4Cs: Critical Thinking, Creativity, Collaboration, and Communication. Yet, these skills remain relatively low among mathematics education students. This study investigates the effectiveness of integrating the Science, Technology, Engineering, Art dan Mathematics (STEAM) approach with Project- Based Learning (PjBL) to enhance students' 4C competencies. A quasi-experimental design with a pretest-posttest control group was applied, involving two classes: the experimental group, taught with STEAM-PjBL, and the control group, taught conventionally. Research instruments included a critical thinking test, a mathematical creativity test, collaboration observation, and a communication questionnaire. Data were analyzed using the Mann-Whitney test and N-gain scores to compare differences and improvements. Findings indicate that the experimental group showed significantly greater improvement in 4C skills, categorized as moderate to high. These results suggest that STEAM-PjBL is an effective approach to strengthening 4C skills in mathematics education students.

Development of GeoGebra Interactive Media for Volume of Rotating Objects

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Abstract. This research aims to develop interactive GeoGebra-based learning media for the volume of rotating objects. This media can help students understand the concept of integrals in determining the volume of rotating objects. The research method used is Research and Development (R&D) with the ADDIE development model, which includes the stages of analysis, design, development, implementation, and evaluation. The resulting product is an interactive GeoGebra media that displays a visualization of the process of forming rotating objects through the rotation of a function about a specific axis. A trial was conducted with high school students to determine the feasibility and effectiveness of the media. Validation results by material and media experts indicated that the product was in the feasible category. In contrast, student responses indicated that the media was engaging, easy to use, and helpful in understanding the concept of volume of rotating objects. Therefore, this interactive GeoGebra media is suitable for use as an alternative technology-based mathematics learning media that supports visual and interactive learning.

Development of Learning Media: Challenges Encountered by Mathematics Education Students – A Case Study

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Abstract. In todays' technological era, it is imperative that learning media adapt to the needs of generation Z, who are increasingly tech-savvy. The use of static image or text-heavy material alone no longer sufficient to capture their interest. The same principle applies to mathematics lessons. Instructional materials are required to be engaging, easy to understand, and enjoyable for the students, while also providing sufficient challenge to motivate them actively engaged with the content being taught. This study explores the predominant challenges encountered by mathematics education students in the development of learning media. The participant of this research were two pre-service teachers working on the final projects who chose to concentrated on the development of learning media. The data indicates that the primary challenges associated with the development of learning media encompass not only constraint in infrastructure (accessibility, internet and devices), but also a dearth of competence and creativity among teachers in managing technology and media design, along with digital and mathematical literacy skills.

Effectiveness of Project-Based Learning Based on Realistic Mathematics Education in Teaching Systems of Linear Equations in Two Variables to Eighth-Grade Students

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Abstract. This study aims to determine the effectiveness of Project-Based Learning (PjBL) integrated with the Realistic Mathematics Education (RME) approach on students' mathematics learning outcomes in the topic of Systems of Linear Equations in Two Variables (SPLDV) for eighth-grade junior high school students. A quasi-experimental method with a Nonequivalent Control Group Design was employed, involving two classes: an experimental class that received PjBL with an RME approach and a control class that received conventional instruction. Learning outcomes were measured using pretest and posttest instruments administered to both classes. Data analysis using SPSS version 26 showed that both samples were normally distributed and homogeneous based on prerequisite tests. The results revealed that the mean posttest score in the experimental class was 53.5, higher than the control class mean of 42.47. The average N-Gain score of the experimental class was 42.55%, categorized as moderately effective, while the control class achieved 28.19%, categorized as ineffective. Furthermore, the independent t-test indicated a significant difference between the two classes, with a Sig. (2-tailed) value of $0.005 < 0.05$. These findings conclude that PjBL integrated with the RME approach is more effective in improving students' mathematics learning outcomes on SPLDV compared to conventional learning.

Exploration of External Didactic Transposition on The Concept of Continuity of Function

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Abstract. This study aims to describe the external didactic transposition process, namely scholarly knowledge and knowledge-to-be-taught, on the topic of function continuity in basic mathematics courses at higher education. The analysis focuses on how the concept of function continuity, which involves an abstract formal definition of limit, is adapted into a simpler and more pedagogically relevant form for first-year students at a university in Ambon. Through curriculum review, textbook analysis, and comparison between formal mathematical references and teaching materials, this study found that external didactic transposition on function continuity is primarily achieved through: (1) selecting a more intuitive definition before introducing the formal approach, (2) simplifying the scope of the material by limiting the discussion to real functions of one variable, and (3) emphasizing concrete examples and graphical representations to build students' initial understanding. The results show that the quality of the transformation from scholarly knowledge to knowledge-to-be-taught significantly determines students' success in constructing the meaning of function continuity and connecting it to the concept of limit.

A Deterministic SVEIQHR–SEI Mathematical Model for Monkeypox Transmission: Integrating Vaccination Strategy and Human–Rodent Interaction

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Abstract. Monkeypox is a zoonotic viral disease capable of causing outbreaks in humans, particularly in regions where close interactions occur between humans and rodent reservoirs. The increasing frequency of zoonotic transmission highlights the need for comprehensive modeling approaches to understand and control disease dynamics. This study aims to develop and analyze a deterministic two-population mathematical model of monkeypox transmission by incorporating a vaccination compartment in the human population. The model is designed to evaluate the impact of vaccination and other interventions on reducing disease spread. The model divides the human population into seven compartments susceptible, vaccinated, exposed, infectious, isolated, hospitalized, and recovered while the rodent population consists of four compartments: susceptible, exposed, infectious, and recovered. A system of ordinary differential equations (ODEs) is formulated to describe the time-dependent behavior of both populations. Stability analyses of the disease-free and endemic equilibria are conducted, the basic reproduction number (R_0) is derived, sensitivity analysis is performed using elasticity indices, and numerical simulations are used to assess the effectiveness of control strategies. The analysis shows that parameters such as contact rate, isolation, hospitalization, and early diagnosis strongly influence the value of R_0. Although vaccination parameters do not explicitly appear in the expression of R_0, vaccination significantly reduces the number of susceptible individuals through partial protection that depends on vaccine efficacy. Simulation results demonstrate that the inclusion of a vaccination compartment markedly decreases the number of infectious cases and slows the overall transmission rate. The findings suggest that vaccination, when combined with other interventions such as isolation of infectious cases and reduction of contact rates, represents an effective and sustainable strategy for controlling the spread of monkeypox in human populations.

Determination of Eigenvalues and Eigenvectors in Solving Linear Differential Equation Systems

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Abstract. This article formulates the role of eigenvalues and eigenvectors in determining the solutions of linear differential equation systems with constant coefficients. The foundation is established using a first-order (state-space) model, whose solution is expressed through the matrix exponential e^{At}. For second-order systems, we demonstrate the connection with the Quadratic Eigenvalue Problem (QEP) in the mechanical model $M\ddot{x} + C\dot{x} + Kx = 0$. For third-order systems, the article highlights two mixed configurations: (i) one real root and one pair of complex-conjugate roots (with real coefficients), and (ii) two real roots and one complex root (possible only for complex coefficients). The generalization to the $\boldsymbol{n}$-th order (scalar/vector) case is formalized through block-companion forms and matrix polynomials. Stability criteria, modern numerical guidelines, and appendices containing detailed proofs and numerical studies are also provided.

Modeling Earth Skin Temperature and Cloud Amount: A Hybrid Fourier Series-Neural Network Approach for Kalimantan Environmental Patterns

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Abstract. This study modeled Earth Skin Temperature and Cloud Amount for Balikpapan and Samarinda using the Fourier Series (Fs), Double Layer Feed Forward Neural Network (DLFFNN), and Hybrid Fs-DLFFNN models. To assess model performance, we evaluated mean squared error (MSE), root mean squared error (RMSE) and mean absolute percentage error (MAPE) for both training and test datasets. Notably, the Hybrid Fs-DLFFNN model achieved the lowest error metrics for both variables and cities. Building on this, forecasts for the subsequent 12 periods showed distinct trends: Balikpapan is projected to reach a peak in Earth Skin Temperature in March 2026, whereas Samarinda is predicted to experience a consistent decline. In addition, Cloud Amount forecasts indicate an increased drought risk in Balikpapan and heightened flooding risk in Samarinda. These forecasting results support the conclusion that the Hybrid Fs-DLFFNN model provides accurate and reliable climate predictions. Informed by these insights, the study contributes to Sustainable Development Goal 13 (Climate Action) by highlighting the importance of disaster risk mitigation and the necessity for climate-responsive policies and effective management to address hazards such as droughts and floods. Overall, this study advances climate prediction models to support local adaptation strategies in urban environments.

Hybrid GSTAR–GJR-GARCH Modeling with Skew-t Innovations for Asymmetric Spatio-Temporal Volatility in Rainfall

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Abstract. Conventional spatio-temporal models are generally built on the assumption of constant and symmetric residual variance. However, real-world environmental phenomena often exhibit time-varying volatility and asymmetric responses to positive and negative shocks. To address these limitations, this study develops a hybrid GSTAR–GJR-GARCH model with a Skew-t distribution, integrating spatio-temporal dependence with heteroskedastic and asymmetric volatility mechanisms within a unified framework. The proposed model extends the capabilities of the Generalized Space-Time Autoregressive (GSTAR) structure by allowing location-specific volatility and asymmetric reactions to shocks. The application is conducted using rainfall data from two regions with contrasting topographical characteristics, namely Gunung Satria and Cacaban Salopa. The analysis results indicate that the heteroskedastic asymmetric model provides a significant improvement in model fit and predictive accuracy compared to the conventional GSTAR. The skew-t distribution is also shown to work well for heavy-tailed and skewed patterns, especially in areas with a lot of spatial heterogeneity. These findings enrich the literature on spatio-temporal modeling and open new opportunities for developing more realistic and adaptive environmental models that account for asymmetry and volatility instability.

On the Generating Functions and Polynomial Relations of Chebyshev Polynomials of The First Kind

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Abstract. The Chebyshev polynomials are a class of orthogonal polynomials characterized by their recursive definition. Among them, the first kind, denoted ($Tn(x)$), represents the most fundamental form. These polynomials possess significant potential in the context of generating functions and have been widely utilized in various mathematical and applied fields. This motivates further investigation into the generating functions of the first-kind Chebyshev polynomials. The aim of this study is to determine the generating functions corresponding to the first-kind Chebyshev polynomials ($Tn(x)$) and to analyze the relationship between ordinary polynomials and Chebyshev polynomials of the first kind. The generating functions considered in this work include both the ordinary generating function and the exponential generating function. Based on a literature-based analysis, the study derives the explicit forms of the generating functions for the first-kind Chebyshev polynomials and establishes the relationship between ordinary polynomials and first-kind Chebyshev polynomials. Specifically, it is shown that any ordinary polynomial can be expressed as a linear combination of first-kind Chebyshev polynomials. This result is verified using the principle of mathematical induction.

From Limits to Physical Reality: The Paradox of Instantaneous Velocity and Extreme Acceleration in Free Fall

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Abstract. This study examines the epistemological paradox of instantaneous velocity, particularly in the context of free-fall motion and extreme conditions involving infinite acceleration. Although differential calculus defines instantaneous velocity through the limit $\lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$, classical mechanics assumes a continuous, smoothly differentiable, or non-discrete structure of time—an idealization that often does not fully align with physical reality. Through historical, philosophical, and comparative analysis based on reputable international literature (Russell, Tooley, Lange, Arntzenius), this research evaluates the coherence of applying differential limits to gravitational systems. The findings reveal three major epistemic problems. First, the Weierstrassian formalization of limits presupposes a process of letting $\Delta t \to 0$ that is ontologically problematic: eliminating temporal duration removes the very conditions required for motion, whereas retaining an infinitesimal remainder violates the definition of the limit itself. Second, free-fall situations that exhibit discontinuous changes in velocity—such as ideal impacts, sudden releases, or scenarios involving singular forces—produce mathematically divergent accelerations, indicating that the assumption of C^2 differentiability in calculus is not representative of the structure of physical reality. Third, Lange's non-locality argument shows that velocity at time t_0 essentially depends on the trajectory configuration over the interval $[t_0-\varepsilon, t_0+\varepsilon]$, thereby challenging the notion that instantaneous velocity is an intrinsic property of an atomic temporal moment. This research proposes an authentic structural instrumentalist framework, which regards differential limits as representational structures rather than ontological reflections—structures that model the invariance of kinetic phenomena without asserting metaphysical equivalence. Within this framework, instantaneous velocity is positioned as a theoretical construct that bridges the mathematical continuum idealization with empirical measurements that are discrete and finite. The epistemological implications include (1) a shift in the relation between mathematics and physics from realist correspondence to pragmatic stability, (2) an affirmation of the limits of applicability of differential concepts in domains involving singularities, discontinuities, or non-analyticity, and (3) the opening of conceptual space for alternative paradigms such as discrete spacetime models, stochastic mechanics, or non-commutative frameworks. These findings enrich contemporary philosophy-of-physics discourse by clarifying the status of mathematical entities in modeling gravitational motion, particularly under extreme conditions involving infinite acceleration.