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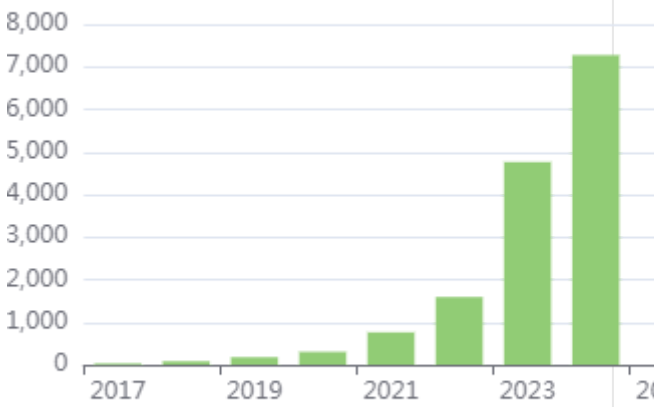

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Analysis of Changes in Students' Science Literacy Ability in Class V Elementary School Science Learning Using the RADEC Model

Postgraduate, University of Mataram Jurnal Penelitian Pendidikan IPA Vol. 10 No. 2 (2024): February 681-688

2024 DOI: 10.29303/jppipa.v10i2.3952 Accred : Sinta 2

The Effect of Taro Starch (Colocasia esculenta L Schoott) Edible Coating on the Quality of Red Chili (Capsicum annuum L)

Postgraduate, University of Mataram Jurnal Penelitian Pendidikan IPA Vol. 10 No. 2 (2024): February 441-448

2024 DOI: 10.29303/jppipa.v10i2.4078 Accred : Sinta 2

The Relationship Between Water Quality and Phytoplankton Abundance with Different Showing Density in Litopenaeus vannamei Ponds in Bayeman Village, Probolinggo District, East Java

Postgraduate, University of Mataram Jurnal Penelitian Pendidikan IPA Vol. 10 No. 2 (2024): February 749-756

2024 DOI: 10.29303/jppipa.v10i2.4364 Accred : Sinta 2

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2024 DOI: 10.29303/jppipa.v10i2.3346 Accred : Sinta 2

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Jurnal Penelitian Pendidikan IPA (JPPIPA), Online ISSN: **2407-795X**, Print ISSN: **2460-2582**

DOI: 10.29303/jppipa.v10i4

Research Articles | **Review** | **Published:** 2024-04-30

Cholesterol and Blood Profile of Bali Cattle Fed Chromolaena odorata Weed with Rice Straw as Basal Feed

Gustaf Oematan , Marthen Luther Mullik , Imanuel Benu , I Gusti Ngurah Jelantik , Twenfosel Dami Dato , Gusti Ayu Yudit Lestari , Gemini Ermiani Malelak , Erna Hartati , Edwin Lazarus , Marten Yunus

1458-1467

DOI: 10.29303/jppipa.v10i4.5263
Statistics: 296 | 294

Citations 0

FULL TEXT

Reducing Greenhouse Gas Emissions in Beef Cattle Farming through the Implementation of Animal Welfare Principles, as Part of Sustainable Rural Area Development

Encep Saefullah , Kenedi , Dedy Khaerudin

1468-1476

DOI: 10.29303/jppipa.v10i4.6824
Statistics: 431 | 335

Citations 0

FULL TEXT

The Influence of the Recitation-assisted Problem Based Learning Model on the Creative Thinking Abilities

Indah Pujiati TM , Mariani Natalina L , Riki Apriyandi Putra

1477-1485

DOI: 10.29303/jppipa.v10i4.6289
Statistics: 258 | 232

Citations 0

FULL TEXT

Digital Competence: A Study from the Prospective Biology Teachers in Papua

Nurbaya Nurbaya

1486-1494

DOI: 10.29303/jppipa.v10i4.5055
Statistics: 132 | 101

Citations 0

FULL TEXT

Development of PBL Based E-Student Worksheet Using an Ethnoscience Approach to Improve Students' Character Values and Conservation Attitudes on Redox Material

Artika , Jimmi Copriady , Rasmiwetti

1495-1505

DOI: 10.29303/jppipa.v10i4.6791

FULL TEXT

Isolation and Characterization of Pathogenic Mold Causing Potato Tuber Rot Disease

Rizal Koen Asharo , Reni Indrayanti , Azizatul Amala , Eldrian Daffa Raihan , Raymond Rayhand Tampanguma , Hilda Arsyah Eka Putri , Pinta Omas Pasaribu , Nurul Assyifa Wardana

1506-1512

DOI: 10.29303/jppipa.v10i4.6355

FULL TEXT

Analysis of Calcium Oxalate Content and Stomata Amaranth Leaves (Amaranthus tricolor var. Giti Red) as Response to Drought Stress

Imam Safir Alwan Nurza , Chika Shafa Maura

1513-1518

DOI: 10.29303/jppipa.v10i4.6354

FULL TEXT

Strategic Integration for Academic Excellence: Leveraging COBIT and PMBOK in Audit and Project Management Practices

Moch Yasin , Prasasti Karunia Farista Ananto , Bramasta Kurnia Aji , Ilham , Mohammad Khusnu Milad , Suryani DA

1519-1531

DOI: 10.29303/jppipa.v10i4.6887

FULL TEXT

Project-Based Module Development in the Electrical Circuit Course

Jean Dwi Ritia Sari , Ambiyar , Riki Mukhaiyar , Rizky Ema Wulansari

1532-1538

DOI: 10.29303/jppipa.v10i4.7385

FULL TEXT

Development Augmented Reality Based Flashcards on Molecular Geometry Material for Increasing Interest in Learning High School Student

Reny Alfina Rahmawati , Agus Kamaludin

1539-1550

DOI: 10.29303/jppipa.v10i4.7329

FULL TEXT

Development of an E-Module Based on a Guided Inquiry Learning Model in Natural Science Subjects in Elementary Schools

Elvia Maulia , Ramalis Hakim , Alwen Bentri , Darmansyah

1551-1555

DOI: 10.29303/jppipa.v10i4.6997

FULL TEXT

The Use of Insecticides Viewed from a Technical View of Applications in Corn Crops: Case Study of Corn Farmer Behavior

Arfan , Sri Sudewi , Mukhlis , Mismawarni Srima Ningsih

1556-1563

DOI: 10.29303/jppipa.v10i4.7158

FULL TEXT

Acemannan Hydrogel's Effects on Neutrophils at Concentrations of 25%, 50%, 75% Counts in Wistar Rats with Periodontitis Induced by Alloxan

Chandra Susanto , Cindy Denhara Wijaya , Gebriela Lam Ulina Putri Turnip

1564-1570

DOI: 10.29303/jppipa.v10i4.7054

FULL TEXT

Correlation Between Understanding Body Movement Systems and Habits of Maintaining Bone Health in Elementary School Students

Lili Kasmini

1571-1578

DOI: 10.29303/jppipa.v10i4.7103

FULL TEXT

Inbreeding Depression and Genetic Diversity of S1 Lines Corn Plants Under Drought Stress Conditionson Dry Land

I Wayan Sudika , I Wayan Sutresna , Dwi Ratna Anugrahwati , Ni Wayan Sri Suliartini , I Wayan Suana

1579-1585

DOI: 10.29303/jppipa.v10i4.6206

FULL TEXT

Understanding the Solution-Making Ability of Senior High School Students in Solving Photosynthesis Problems

Viki Afifah Almualimah , Wirawan Fadly , Munkhmaral Tumennasan

1586-1598

DOI: 10.29303/jppipa.v10i4.7340

FULL TEXT

Optimizing Teaching Empowerment: The Impact of Work Motivation, Professional Competence, and Organizational Culture on Teacher's Self-Efficacy

Paramudita Chintya Putri , Lia Yuliana

1599-1605

DOI: 10.29303/jppipa.v10i4.7078

FULL TEXT

Development of STEM-Based E-Modules on Freshwater Fisheries to Facilitate 21st Century Skills

Ina Setiawati , Rahma Widiantie , Anna Fitri Hindriana , Edi Junaedi

1606-1614

DOI: 10.29303/jppipa.v10i4.6650

FULL TEXT

Strategy for Implementing the Tiatiki Concept in Conservation Resource

Amida Laurita Snahan , Basa T. Rumahorbo , Yanviter Manalu , Maklon Warpur , Johnson Sialagan

1615-1623

DOI: 10.29303/jppipa.v10i4.7074

Rought Set: Effective Method for Determining Scholarship Recipients

Silfia Andin , Sarjon Defit

1624-1632

DOI: 10.29303/jppipa.v10i4.7088

Changes in Soil Chemical Properties and Growth of Palm Oil (Elaeis guineensis Jacq) with Comparative Composition of Plant Media

Murnita , Yulfi Desi , Meriati

1633-1639

DOI: 10.29303/jppipa.v10i4.7161

Measurement of Heavy Metal Mercury (Hg) Content in The Swamp Eel (Monopterusalbus) as a Bioindicator from Lake Rawa Taliwang

Dinda Noviantika , Khairuddin , M. Yamin

1640-1647

DOI: 10.29303/jppipa.v10i4.7324

Toxicity Test of Red-Shoot Leaves (Syzygium myrtifolium Walp.) Extract as Biolarvicide on Filariasis Vector Mortality

Supriatno , Riska , Hafnati Rahmatan , Yaumil Istiqlal M. Nur , Fitra Asma Ulhusna

1648-1654

DOI: 10.29303/jppipa.v10i4.5454

Diversity Biological Food in the Yards of the Skouw Village Community Muara Tami District

Judith Lainsamputty , Alfred A. Antoh , Basa T. Rumahorbo

1655-1667

DOI: 10.29303/jppipa.v10i4.7015

The Potential of Red Betel Leaf and Mangosteen Peel in Lowering Blood Sugar Levels in Patients with Diabetes Mellitus

Putri Dafriani , Weni Sartiwi , Gelsi Anggra Monita

1668-1673

DOI: 10.29303/jppipa.v10i4.5569

Development of Multiple Representation-based Electronic Teaching Materials Using Guided Inquiry on Acid-Base Topic

Isni Nurani , Suyanta

1674-1683

DOI: 10.29303/jppipa.v10i4.5118
Statistics: 220 | 162

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FULL TEXT

Improving Observation, Experiment Planning, and Communication Skills Based on the STEM Approach

Yuni Syahraini , Muhammad Syukri , Evendi , Elisa Kasli , Nurazidawati Mohamad Arsad , Elva Sesioria Putri

1684-1691

DOI: 10.29303/jppipa.v10i4.6806
Statistics: 138 | 106

Citations 0

FULL TEXT

Flip Science Module Using an Integrated PBL Model for Market Snacks to Improve Problem Solving Skills

Ragil Saputri , Insih Wilujeng , Suyanta , Raudhah Maharana Fahmi

1692-1697

DOI: 10.29303/jppipa.v10i4.6744
Statistics: 57 | 61

Citations 0

FULL TEXT

The Effect of Concentration Transition Metal Oxide CuO as Activated Carbon-Based Supercapacitor

Maryati Doloksaribu , Erniwati Halawa , Mukti Hamjah Harahap

1698-1706

DOI: 10.29303/jppipa.v10i4.5738
Statistics: 129 | 125

Citations 1

FULL TEXT

Guidance and Science Skills for Street Children

Eza Permata Sari , Fatmariza , Maria Montesossori , Delmira Syafrini

1707-1713

DOI: 10.29303/jppipa.v10i4.7091
Statistics: 124 | 81

Citations 0

FULL TEXT

Machine Learning Predicts the Level of Disease Spread

Dhio Saputra , Irzal Arief Wisky , Sarjon Defit

1714-1722

DOI: 10.29303/jppipa.v10i4.7070
Statistics: 71 | 65

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Accurately Determining Labor Test Results Using the Rough Set Method

Retno Devita , Sarjon Defit

1723-1730

DOI: 10.29303/jppipa.v10i4.7069
Statistics: 80 | 75

Citations 0

FULL TEXT

Development of Physics Interactive Learning Media based on Problem Based Learning assisted by SAC Application to Improve Student Problem Solving Ability

Anggriani Aristaria , Insih Wilujeng , Nadya Intan Herawati 1731-1738

DOI: 10.29303/jppipa.v10i4.6082
Statistics: 160 | 158

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Identifying Collaboration Skills Through Discovery Learning with A Contextual Approach

Elsima Nainggolan , Dyah Purwaningsih 1739-1746

DOI: 10.29303/jppipa.v10i4.6943
Statistics: 164 | 126

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Differentiated Learning: Analysis of Students' Chemical Literacy on Chemical Bonding Material through Culturally Responsive Teaching Approach Integrated with Ethnochemistry

Salma Fauzia Wardani , Sri Yamtinah , Bakti Mulyani , Endang Susilowati , Maria Ulfa , Mohammad Masykuri , Ari Syahidul Shidiq 1747-1759

DOI: 10.29303/jppipa.v10i4.6167
Statistics: 157 | 178

FULL TEXT

Synthesis, molecular docking, and in vitro tests of the Mannich base derivatives of Benzimidazolvanilin as an anti-inflammatory

Inas Priasti Siwi , Hayun , Arry Yanuar 1760-1769

DOI: 10.29303/jppipa.v10i4.6199
Statistics: 210 | 138

FULL TEXT

Optimizing of Physics Learning through PjBL-STEM Model to Improve Critical Thinking Skills and Students Responsibility Attitudes

Khairun Nisah , Saminan , Muhammad Syukri , Elisa , Markisni 1770-1778

DOI: 10.29303/jppipa.v10i4.6795
Statistics: 137 | 117

FULL TEXT

Enhancing 21st Century Skills for Prospective Physics Teachers through Arduino-Based Multiple Representations in Learning Heat and Temperature

Siska Desy Fatmaryanti , Eko Setyadi Kurniawan , Yusro Al Hakim , Sarwanto , Desy Luthfianti Ulfah 1779-1786

DOI: 10.29303/jppipa.v10i4.5315
Statistics: 116 | 97

FULL TEXT

Hematological and Histological Analysis of Tilapia (Oreochromis Niloticus) Cultured in Floating Net Cages After Disease Outbreak

Ririen Kartika Rini , Siti Aisiah , Olga , Lutfia Nafisah 1787-1793

DOI: 10.29303/jppipa.v10i4.5057
Statistics: 143 | 105

FULL TEXT

Inventory of Plant Types to Overcome Vertigo Through Betangas

Ruqiah Ganda Putri Panjaitan , Hayatul Fajri , Gisa Grasilla 1794-1800

DOI: 10.29303/jppipa.v10i4.4767
Statistics: 98 | 107

FULL TEXT

Determination of Sound Absorption and Water Absorption by Composite Boards Made from Egg Cardboard

Riska Aldania , Suparno 1801-1808

DOI: 10.29303/jppipa.v10i4.2830
Statistics: 166 | 104

FULL TEXT

Development of SETS-Based Independent Curriculum Learning Module Increases Understanding of Disaster Mitigation

Mahlianurrahman , Rapita Aprilia 1809-1815

DOI: 10.29303/jppipa.v10i4.5145
Statistics: 116 | 86

FULL TEXT

Development of Booklet Assisted by Video Animation by Utilizing QR Code on Constitutional Isomers Sub-Material

Nurzam Indah Utami , Rahmat Rasmawan , Ira Lestari , Rini Muharini , Maria Ulfah 1816-1826

DOI: 10.29303/jppipa.v10i4.5735
Statistics: 113 | 110

FULL TEXT

Strategy Analysis for Implementing Rice Transplanter Planting Machine Technology in Rice Farming Using the Interpretive Structural Modeling (ISM) Method in South Sulawesi

Irmayani , Meity Melani Mokoginta , Poornika Kumari Seelagama , Abdullah , Dina Aprianty Azis , Mukhlis , Masnur 1827-1836

DOI: 10.29303/jppipa.v10i4.7124
Statistics: 294 | 149

FULL TEXT

Implementation of Design Thinking on Match-up Interactive Media for Cell Learning

Zulkfiri S.Pou , Siti Rahmatia Badari , Martavina Yustita Pala , Dsiya Auralia Askanita , Moh. Dhuhri Surya Wirawan , Rita Lefrida 1837-1846

DOI: 10.29303/jppipa.v10i4.4999
Statistics: 136 | 80

FULL TEXT

The Influence of the Problem Based Learning (PBL) Learning Model Assisted by PhET Simulation Media to Increase HOTS of Class 6 Elementary School Students in Electrical Circuits

Hafiza Isbah , Banu Setyo Adi 1847-1854

DOI: 10.29303/jppipa.v10i4.6225
Statistics: 127 | 136

FULL TEXT

Content of Banten Leaf Extract (Lannea Coromandelica (Houtt.) Merr.) Traditional Medicine of Lombok as an Antipyretic in Mice (Mus Musculus)

Wanda Qoriasmadillah , Nirwana Haqiqi , Zuhratul Iman , Tri Wahyu Setyaningrum , Dining Aidil Candri , Andri Frediansyah , Eka Sunarwidhi Prasedya

1855-1862

DOI: 10.29303/jppipa.v10i4.6756

Homemade Soap with Vitis Vinifera Extract Using Framing Time

Roza Maiyarni , Hadi Purwanto , Annisa Miftahurrahmi , Suryanti

1863-1868

DOI: 10.29303/jppipa.v10i4.5540

Senior High School Students' Collaborative Skills through Acid-Base Chemistry Practicum Activities

Shofrina Surya Dewi , Nurfina Aznam , Nur Inayah Amaliyah

1869-1877

DOI: 10.29303/jppipa.v10i4.5081

The Impact of Educational Management Information Systems (EMIS) on Effective School Management in Tanzania

Julius Jonas Mbawala , Slamet Lestari , Ambakisye Mwakalindile

1878-1885

DOI: 10.29303/jppipa.v10i4.7033

Enhancing Science Learning Activities through the Implementation of Discovery Learning and Teaching at the Right Level Method

Irfan Ananda Ismail , Fadhila Ulfa Jhora , Qadriati , Munadia Insani

1886-1895

DOI: 10.29303/jppipa.v10i4.7359

Education Through Video Animation to Improve HIV/AIDS Knowledge Among Ship's Crew

Verra Karame , Wiwit Ciptaningsih Haryanto , Siska Olvie Manurip

1896-1900

DOI: 10.29303/jppipa.v10i4.7491

Effectiveness of Socio-Scientific Issue (SSI) Based Science E-Modules to Increase Students' Scientific Literacy

Muntari , Baiq Fitri Rahmayanti , Yayuk Andayani

1901-1906

DOI: 10.29303/jppipa.v10i4.5257

Physics Teaching Materials Based on The Creative Problem-Solving Model with Concept Maps: The Effect on Students' Learning Outcomes

Vinna Natasya Putri , Putri Dwi Sundari , Hufri Hufri , Silvi Yulia Sari 1907-1915

DOI: 10.29303/jppipa.v10i4.5805
Statistics: 106 | 94

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FULL TEXT

The Influence of Several Host Types on the Balance of Life Sitophilus Sp

Nikolas Nik , Aloysius Rusae 1916-1924

DOI: 10.29303/jppipa.v10i4.6925
Statistics: 160 | 184

Citations 0

FULL TEXT

Development of Student Worksheets Problem Solving Oriented to Train Students' Critical Thinking Skills on Acid-Base Material

Annisa Nabila , Utiya Azizah 1925-1933

DOI: 10.29303/jppipa.v10i4.6937
Statistics: 132 | 97

Citations 0

FULL TEXT

The Influence of The Problem Based Learning (PBL) Model and Learning Style on the Thinking Abilities

Ade Islamiati , Yanti Fitria , Elfia Sukma , Yaswinda , Elwil Fitria , Siska Tresia Oktari 1934-1940

DOI: 10.29303/jppipa.v10i4.6219
Statistics: 538 | 373

Citations 4

FULL TEXT

Project-Based Learning in Teaching Adsorption Isotherm: The Implementation and Students' Opinion

Fransisca Ditawati Nur Pamenang , Rikhardus Sani Wibowo , Felisitas Bety Marlinda 1941-1949

DOI: 10.29303/jppipa.v10i4.5543
Statistics: 82 | 58

Citations 0

FULL TEXT

The Effect of Flipped Classroom Learning Assisted by Computer Simulation on Students' Comprehension of Simple Harmonic Motion

Theo Jhoni Hartanto , Suhartono , Budi Santoso , Zen Frianto 1950-1960

DOI: 10.29303/jppipa.v10i4.4842
Statistics: 197 | 117

Citations 0

FULL TEXT

Analysis of The Heavy Metal Cd Content in Ricefield Eel from Rawa Taliwang Lake, West Sumbawa Regency

Khairuddin , M. Yamin , Kusmiyati 1961-1968

DOI: 10.29303/jppipa.v10i4.7516
Statistics: 52 | 57

Citations 0

FULL TEXT

Ethnoscientific Study of the Making of Traditional Uwi Kaju Ndota and Alu Ndene Food in Ende Regency

Veronika P. Sinta Mbia Wae , Melania Priska , Maimunah H. Daud

1969-1975

DOI: 10.29303/jppipa.v10i4.6293

Study of Urban Growth Center Development Factors and Simulation The Mamminasata Urban Area

Emil Salim Rasyidi , Jumadil , Syafri , Rahmawati Rahman , Rusneni , Hamsinah , Muh. Khalil Jibran

1976-1988

DOI: 10.29303/jppipa.v10i4.6380

Growth and Performance of Melon (Cucumis melo L) in Respect of Payments and Fruit Trimming

Narita Amni Rosadi , Rosalina Edy Swandayani , Baiq Inggar Linggarweni

1989-1993

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Project-Based Learning in Teaching Adsorption Isotherm: The Implementation and Students' Opinion

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Abstract: Project Based Learning is one of the learning models that can be chosen by lecturers in learning activities. This learning model is applied in surface chemistry learning, especially on the topic of the adsorption isotherm models. This research aims to find out more about implementation and students' opinions in project-based learning models. This study employs a mixed-method research approach, utilizing both questionnaires and documentation as data collection methods. The questionnaire instrument consisted of an open and closed questionnaire for the respondents. An open and closed questionnaire was used to collect respondents' descriptive data on the perception of the model. The project-based learning model received a positive response from students. This positive feedback encompasses interactions with the lecturer, motivation to learn, comprehension of the material, and the execution of project-based learning. This model recognized for its capacity to foster profound comprehension of subject matter, cultivate advanced cognitive skills, and stimulate learners' intrinsic motivation, serves as an effective approach to enhance student learning experiences.

Keywords: Adsorption isotherm; Learning experience; Project-Based Learning

Introduction

Surface chemistry is the study of phenomena that occur at the interface between two phases of a substance. Surface chemistry studies several concepts namely surface tension and adsorption. The phenomenon of surface tension arises because of an imbalance of forces experienced by the liquid molecules that are on the surface (Somorjai, 2010). Adsorption is a process that occurs on the surface. Adsorption is the event of settling several gases on the surface, for example, contact that occurs from a gas or solution on a metal. The interactions that occur will cause the properties of the metal to be modified or changed. The gas or solution that is attracted to the metal surface is called the adsorbate, while the metal surface is called the adsorbent. According to the strength of the interaction, there are 2 types of the adsorption, namely physical adsorption and chemical adsorption (Birdi, 2010). The adsorption process can be studied by knowing the surface composition of the adsorbent, for example by X-ray spectroscopy. The adsorption process can also be studied by measuring the adsorption intensity of an adsorbent. The adsorption intensity of an adsorbent can be measured by measuring the concentration of the adsorbate before and after treatment. By changing the factors that affect the adsorption ability, we can study the things that affect the adsorption process, which means it also affects the adsorption process. The adsorption process is expressed as an adsorption isotherm. There are several adsorption isotherm models, namely the Langmuir, BET, Freundlich, and Temkin isotherm models (Pashley & Karaman, 2004).

Surface chemistry course is one of the compulsory courses that must be taken by semester 5 undergraduate students of the Chemistry Education Department,

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Universitas Sanata Dharma. This course is a theoretical course that has not been integrated with practical work in the laboratory. Actually, practical activities are very important in science education. Practical work can help students understand concepts in depth because, through experiments, students get evidence based on the theories they have learned (Sotiriou et al., 2017). Practical work in the laboratory is important activity because it can support the creation of learning that can be actualized in real terms. According to Indriyani et al. (2022), laboratory experiments are part of teaching which aims to provide opportunities for students to test and implement in real situations what has been obtained theoretically.

Many studies have shown that practical work provides many benefits, including increased psychomotor abilities in the laboratory and scientific knowledge. Understanding of science concepts and theories also increases (Schwichow et al., 2016). Students who were taught using learning strategies in the laboratory showed better results than students who were taught using the lecture method. Learning methods in the laboratory are more effective. Students learned laboratory skill more effectively and improve their knowledge and confidence, so lecturers should equip students with problem-investigation skills in the laboratory rather than just telling facts about chemical concepts (Towns et al., 2015). Many concepts in chemistry need to be presented in the form of practical work because chemistry is an applied science. Some concepts are difficult to understand if not put into practice. With practical work in chemistry lessons, science becomes easier to understand and fun for them, so this can motivate students to understand chemistry better. Practical work helps students able to collaborate with friends, answer questions, and draw graphs (Shana & Abulibdeh, 2020).

In this research, practical work in the laboratory is integrated with project-based learning. Project-based learning relates to the research-based teaching method which guides students in building concept knowledge by working on important projects and developing actual outputs (Krajcik & Shin, 2014; Brundiers & Wiek, 2013; Torres et al., 2017). Project-based learning (PjBL) is an educational approach centered around the completion of a project as the primary objective. This shifts the dynamics of chemistry learning in the classroom away from a teacher-centered approach to one that emphasizes student engagement and activity. Utilizing project-based learning (PjBL) as an instructional model has the potential to enhance students' abilities in areas like planning, communication, problem-solving, and decision-making. The PjBL methodology proves especially effective when applied to subjects connected to real-life applications, such as science and technology (Subiki et al., 2023). PjBL is a problem-based and student-centered learning that focuses on developing projects (Thomas, 2020).

Krajcik & Shin (2014), identified six characteristics of PjBL, including provocative questioning, focus on learning objectives, role in educational activities, teamwork among students, use of frame techniques, and creation of concrete deliverables. A review by Chen & Yang (2019) analyzes the impact of PjBL and direct teacher instruction on student performance at the primary, secondary, and high school levels. PjBL refers to a learning process in which students engage in full-scale projects and product development. Results showed that PjBL had a better impact on student academic performance than direct instruction (Soffiany & Purbani, 2020). Practicum-based projects provide an increase in student learning outcomes (Khoiri et al., 2023). On the other hand, the use of a project-based practicum can increase creativity in preparing tools and materials, practicum stages, and the quality of practicum results (Ermayanti et al., 2020). Students' participation is improving because of information sharing and discussion.

Therefore, the PjBL method is highly suggested in learning by students and should be implemented in universities as well (Almulla, 2020). The focus of project-based learning is on the learning science of active construction. This process of generating new knowledge allows students to test and implement their ideas in any way they like, cultivating innovation skills. Therefore, there is a need to encourage higher education instructors to use project-based learning. PjBL can be described as a collaborative, inquiry-based teaching method in which students integrate, apply, and build their knowledge as they work together to create solutions to complex problems (Guo et al., 2020). Students must practice such work at school, because future generations will have to overcome global environmental problems. As such, science education must provide students with deeper learning rather than simple memorization of facts; students need the ability to apply their scientific knowledge in situations that require problem-solving and decision-making (Miller & Krajcik, 2019). According to research Lasauskiene & Rauduvaite (2015), lecturer also feels positive effects when applying project-based learning in the form of increasing student competence, good collaboration between lecturers and students, and development of lecturer professional competence.

Based on the findings of the problems above, this research was conducted to improve student academic achievement by applying the project-based learning model with practical work in the laboratory. The purpose of this study was to produce new learning that provides better learning outcomes and at the same time encourages students to get used to learning scientific

investigation and observation. The utilization of the PjBL model for learning is not arbitrary. It involves a structured sequence of steps outlined in the PjBL learning model, which are presented in Table 1 as follows.

This study aimed to enhance students' academic performance by implementing the PjBL model. Its primary objective was to assess how the PjBL model influences the learning outcomes of undergraduate students. The advantages of this research include acquiring cognitive knowledge in the field of science and offering alternative teaching methods within the classroom, while also serving as a reference for future research endeavors. Also, this study holds significance as it facilitates a comprehensive understanding of the application of the PjBL model in the realm of teaching adsorption isotherms. This research provides valuable insights into the integration of PjBL within surface chemistry education, specifically focusing on the topic of adsorption isotherms. Moreover, the inclusion of students' opinions and perspectives in this study offers valuable insights into the efficacy of this instructional approach. By comprehending the implementation of PBL and considering students' feedback, this research can serve as a guiding resource for educators aiming to improve the teaching of adsorption isotherms through a more interactive and project-oriented methodology.

Method

This study aims to investigate the implementation of PjBL in adsorption isotherm learning. The research method used in this study was a mixed-method (Creswell & Creswell, 2018). The strategy used in this study was a Sequential Explanatory Design with a scheme that can be seen in Figure 1. Based on the Sequential Explanatory Design scheme above, the explanatory sequential design is a way of collecting data that begins with collecting qualitative data and then proceeding with collecting quantitative data to help analyze the data obtained qualitatively, so that the results of research with this design are descriptive in general. The research starts with qualitative research and continues with quantitative research following an explanatory strategy. The research was conducted at the Chemistry Education Department, Universitas Sanata Dharma Yogyakarta with 12 respondents taking place on May 8, 2023.

The qualitative data for PjBL was collected through classroom observations. These observations captured complex situations that enhance our understanding of the practical aspects of implementing PjBL in real classroom settings. The observations focused on the implementation of PjBL stages within the classroom. These stages encompassed the determination of fundamental questions, development of a project plan, arrangement of a schedule, monitoring both students and project progress, conducting outcome assessments, and evaluating the overall learning experience.

The quantitative instrument used in this research is by using a questionnaire. The data collection technique was carried out by distributing open and closed questionnaires with Google Forms which were distributed online. The questionnaire aimed to find out student perceptions of isotherm adsorption learning with project-based learning. It consisted of four indicators, namely interaction between lecturer and students, learning motivation, material understanding, and implementation of project-based learning.

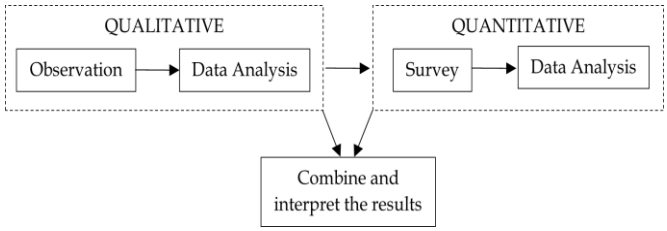

Figure 1. Schematic research design

The quantitative data obtained from the respondent's questionnaire were analyzed by grouping the answers from the respondents based on the questionnaire questions. Then give a score to each answer according to the scoring criteria. Then calculate the total score of the answers to each question. The questionnaire uses the Likert scale where the answer choices are by the contents of the question, namely strongly agree, agree, disagree, and strongly disagree with a score of 4, 3, 2, and 1. Then calculate the percentage score and interpret qualitatively. The formula used to calculate the percentage score for each item is as Question 1.

$$P = \frac{f}{N} \times 100\% \quad (1)$$

Description:
P = score percentage
f = the number of respondents who chose alternative answers
N = total number of respondents

Result and Discussion

This research aims to investigate the implementation of project-based learning in understanding adsorption isotherms and to gather students' opinions regarding the application of this

learning model. The findings in this research are based on quantitative data, which includes data collected from practical results and responses obtained from student questionnaires.

Implementation of PjBL and Students' Opinions

This research employs project-based learning, where students are tasked with determining adsorption isotherm models from various adsorption processes involving a specific adsorbent and adsorbate. In this project, students begin by collaboratively addressing essential questions relevant to everyday life in groups. The project-based learning model also received a positive response from students, as indicated by the results of the student response questionnaire.

At the outset of the learning activity, the students are presented with a question. This prompts them to explore different scenarios, formulate hypotheses, devise simple experiments based on each group's ideas, create schedules, design experimental tools and materials, conduct experiments, collect and process data, and present the results, engaging in discussions with their groups in class. The Project-Based Learning model employed in this research unfolds through a series of stages. Initially, participants engage in the process of determining fundamental questions. Subsequently, they progress to designing project plans, followed by the scheduling of tasks. The next stage involves the active supervision of project development. Finally, the participants engage in conducting assessments and evaluations to gauge the effectiveness and outcomes of the project-based learning experience (Almulla, 2020).

Determination of Fundamental Questions

During this stage, the lecturer poses essential questions designed as practical scenarios aligned with the content of the course material. These questions aim to inspire students to tackle problems creatively and innovatively (Zolfaghari et al., 2011). One such question is how to assess the adsorption capacity of an adsorbent. Project-based learning encourages students to be more active, fostering group activities where they can ask questions and share opinions or ideas. Figure 2 shows a significant 58.3% of respondents strongly agree that PjBL enhances students' creativity in project design, while 41.7% believed it fosters increased participation in discussion activities. The students respond to this challenge by identifying adsorbents and adsorbates for their research. Consequently, students are encouraged to formulate hypotheses, which they later validate through experiments or practical activities. Measuring the adsorbate's concentration before and after adsorption allows students to determine the adsorption capacity of the adsorbent used.

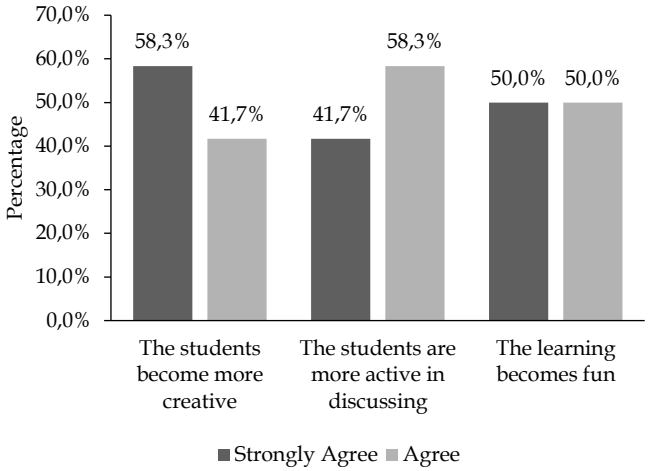

Figure 2. Students' perception on implementation of Project-Based Learning

Designing Project Plans

After students have formulated a hypothesis and devised one or more experiments, they proceed to plan their project by creating a project design. This project design includes the following elements: the project's type, estimated completion time, necessary tools, materials, and data sources. According to the questionnaire results, 58.3% of students planned their projects by gathering information from books, research journals, or the internet as sources for project design. The type of project students create involves practical work aimed at determining the adsorption capacity and adsorption isotherm models of an adsorbent they have identified. The proposed project design is initially reviewed by the lecturer. Table 1, phase 2 displays the project design proposed by the students.

The students presented very creative project designs. Each group initiates their project by selecting the adsorbent and adsorbate to be synthesized. The next step involves planning the project's stages, during which students design experimental procedures for adsorbent synthesis and test its adsorption capacity, including determining the adsorption isotherm model.

Table 1. PjBL Syntax and Aspect

PjBL syntax	PjBL aspect
Phase 1 Determination of fundamental questions (start with essential question)	In phase 1, students initiate their learning journey by exploring fundamental inquiries, which are questions designed to guide them in undertaking activities linked to the science content they will be studying.
Phase 2 Develop a project plan (design project)	In phase 2, students design a project that answers the problem of the adsorption isotherm model. Below are projects designed by students: Adsorption of $CuSO_4$ with eggshell adsorbent, Adsorption of methylene blue with coconut fiber adsorbent, Utilization of pineapple leaf fiber as an adsorbent for methylene blue dyes, Absorption of sengon wood ash biosorbent on Cu(II) ions, Adsorption of acetic acid using activated charcoal
Phase 3 Arrange a schedule (create a schedule)	In phase 3, both students and the teacher collaborate to establish a project timetable for project completion.
Phase 4 Monitoring students and project progress	In phase 4, the teacher monitors project-making activities by paying attention to adsorption experiments carried out by students.
Phase 5 Outcome assessment (assess the outcome)	In phase 5, the teacher evaluates the results of the project that the students have created by paying attention to the resulting adsorption isotherm model and other assessment criteria.
Phase 6 Evaluation of the experience	In phase 6, students and lecturer reflect (evaluate) the activities and results of projects that have been carried out

Arrange a Schedule

In this step, the students prepare a schedule for implementing the project. The lecturer explains the expected duration of the project. In this stage, students refine their critical and strategic thinking abilities by assessing the required tasks for project planning and implementation, ensuring that their projects are completed within the time frame set by the lecturer. Therefore, the implementation of the PjBL model has the most significant impact on students' critical thinking skills at university levels (Bilgin et al., 2015). In the subject category, applying the PjBL model exhibits a substantial effect on both critical thinking skills and creative thinking when employed in science and physics subjects (Hikmah et al., 2023).

Additionally, time allocation for working on the project is determined to enhance its effectiveness and efficiency. Nevertheless, certain students encountered challenges during the project implementation. One notable challenge they faced was the difficulty in locating appropriate research articles. Additionally, some students encountered obstacles in sourcing the right materials for use as adsorbents and adsorbate. These difficulties ultimately led to delays in the project's timeline, causing it to deviate from the originally scheduled timeframe.

Supervise Project Development

At this stage, the lecturer oversees the progress of students' projects conducted in the laboratory. This supervision aims to ensure that the project adheres to the previously prepared plans and to identify and address any obstacles students may encounter during project execution. Monitoring progress is crucial for lecturer to provide additional assistance if needed. Furthermore, students must learn to adhere to their schedules and ensure that everything proceeds smoothly. Lecturer conducts this project implementation monitoring as part of the project evaluation process. The interaction between lecturer and students also provides positive results, with lecturers providing valuable assistance when students encounter project-related difficulties. These positive outcomes are illustrated in Figure 3. The lecturer's role is crucial in this learning process, with 75% of students stating that lecturer provided assistance and guidance when they encountered project-related difficulties. According to the questionnaire results, 50% of students indicated that their lecturer encouraged active participation in group activities, promoting interaction through questions and idea sharing among students. Richardson & Mishra (2018), state that educators who employ creativity in their teaching methods can foster students' learning potential and enthusiasm. The research show that creative teaching as the capacity to actively involve students in the learning process, address challenges in teaching situations, and incorporate innovation or novelty into their instructional approaches (Ismayilova & Laksov, 2023).

Conduct Assessment

During this stage, students present the outcomes of their projects, and the lecturer assesses them. The lecturer evaluates both the process and the final results

of the project, offering feedback, and reinforcement to students.

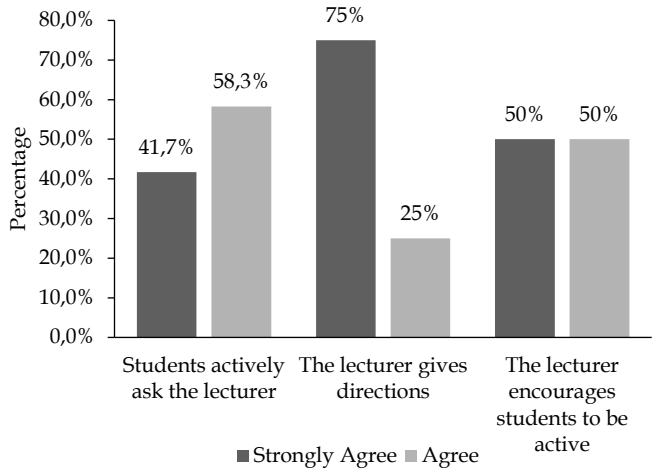

Figure 3. Students' perception on interaction between lecturer and students

Evaluate the Experience

Evaluation takes place after the completion of project-based learning. The experience gained from the projects undertaken by students deepens their understanding of adsorption learning.

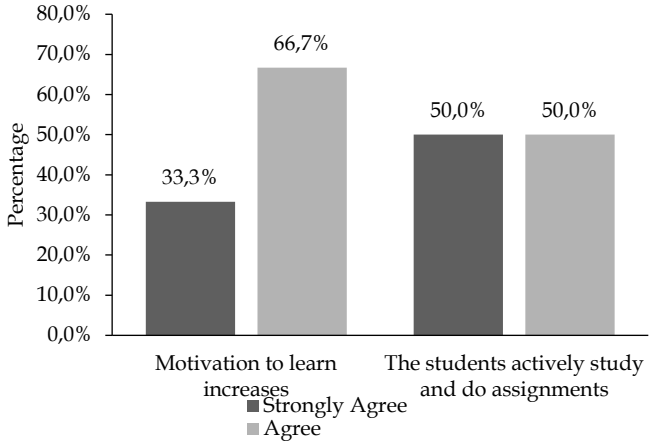

Figure 4. Students' perception on learning motivation

The students also noted that learning becomes engaging for students. Figure 2 demonstrates that learning through PjBL creates an enjoyable classroom atmosphere, with 50% of students strongly agreeing with this. Figure 4 reveals that 66.7% of students feel motivated to learn, resulting in increased activity and creativity in their assignments compared to before. Aligned with Chintya et al. (2023), the PJBL model is not solely about expressing opinions; it also involves problem-solving by assigning projects, aiming to enhance students' creativity and foster their creative thinking abilities (Zatya et al., 2022; Chintya et al., 2023). Lastly, Figure 5 shows that 66.7% of students believe the PjBL model helps them understand and comprehend the flow of adsorption experiments well, particularly in determining contact time, adsorbent mass, and adsorbate concentration for adsorption practicum.

Students express satisfaction and enthusiasm for learning about adsorption isotherms using the PjBL model, which has been implemented. They appreciate how the projects and discussions enhance their understanding of the material. According to Rijanto & Iqrammah (2020), their research found that classes utilizing the PjBL learning model tend to achieve superior average results compared to those not using this model. This finding is consistent with the outcomes of Subiki et al. (2023), which concluded that the adoption of PjBL can lead to enhanced student learning outcomes. The study outcomes revealed that project-based learning had a substantial positive impact on students' learning outcomes, academic achievement, affective attitudes, and thinking skills, particularly in comparison to the conventional teaching model (Zhang & Ma, 2023). Also, the research results indicate that these findings may lead to the conclusion that project-based learning (PjBL), supported by e-worksheets, has a positive impact on students' learning outcomes in science (Aprida & Mayarni, 2023).

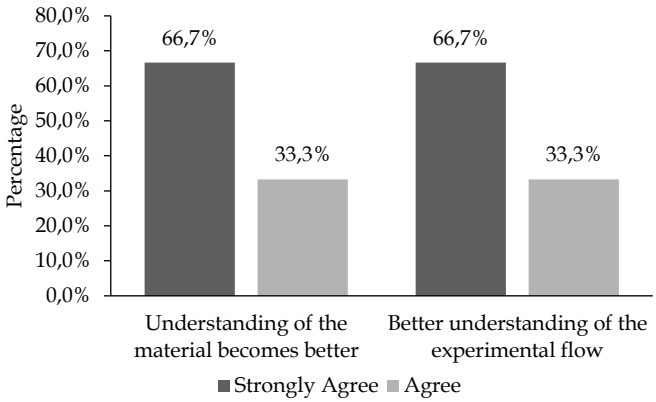

Figure 5. Students' perception on material understanding

Based on Yuli's research, this learning model also enhances students' cognitive learning outcomes across various aspects, including average scores, lowest scores, highest scores, the number of students who complete the learning objectives, and the percentage of overall learning completion. The average posttest score showed an increase of 29.38%. This demonstrates that the PjBL learning model, incorporating both process and product differentiation, effectively improves collaboration skills and cognitive learning outcomes among students (Efliana et al., 2022; Nestiyarum & Widjajanti, 2023).

Consequently, students express a desire for project-based learning to be integrated into other course materials. The PjBL model's curriculum comprises elements such as simplicity of execution, the capacity to

address everyday challenges, and student involvement. Students share a viewpoint that aligns with the characteristics of PjBL model students, encompassing the encouragement of active skills, critical thinking, effective communication, collaboration, ease, enjoyment, and the promotion of student learning accomplishments (Masbukhin et al., 2023; Monika et al., 2023). Two students also provided opinions regarding the implementation of PjBL.

S04: "In preparing and executing projects, I can actively engage in discussions with my group of friends to carry out our planned tasks. Additionally, seeking information from various sources has expanded my knowledge about adsorption. Through the project, I've gained a deeper understanding of the principles of adsorption because I was directly involved in the learning process."

S09: "The experience of conducting adsorption practicums has significantly improved my comprehension of the course material. Preparing the project was enjoyable as it allowed us to discuss and propose our ideas. During the practicum, we gained a more profound understanding of the steps involved in determining concentration, and adsorbent mass, and establishing the isotherm model."

Engaging in project-based learning exercises can cultivate students' creativity and self-awareness, thereby making their acquired knowledge more meaningful (Setiawan et al., 2023). Consequently, students tend to retain this knowledge for longer periods as they actively construct their own understanding. Additionally, the PjBL model fosters increased collaboration among peers and enhances scientific communication between students and lecturer, promoting scientific engagement and making students more active participants in the classroom.

Conclusion

The utilization of the project-based learning approach is a strategic method employed to enhance student performance within the adsorption isotherm model, with the goal of achieving improved learning outcomes. The results of data analysis allow to conclude that positive feelings of students while doing project-based learning, including interaction with the lecturer, learning motivation, understanding of the material, and the implementation of project-based learning, contribute to favorable conditions for adsorption isotherm learning. This learning process allows students to explore and accomplish their ideas in the way they want, which supports their ability to innovate. Therefore, we advocate for the promotion of project-based learning among higher education instructors.

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Conflicts of Interest

In this study, none of the authors have any conflicts of interest. The researchers' sole aim is to contribute to the advancement of education by sharing the findings, ultimately benefiting the readers.

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