

# Integrating Contextual Chemistry Content on Redox Reactions in Chassis Maintenance for Light Vehicle Engineering Vocational Program

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Received: May 08, 2025

Revised: June 13, 2025

Accepted: July 25, 2025

Published: July 31, 2025

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DOI: [10.29303/jppipa.v11i7.11296](https://doi.org/10.29303/jppipa.v11i7.11296)

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**Abstract:** This study aims to analyze the relevance and integration of contextual chemistry content, particularly focusing on redox reactions in the context of corrosion in automotive chassis maintenance, into the vocational education curriculum of Light Vehicle Engineering (Teknik Kendaraan Ringan Otomotif/TKRO) programs. Utilizing the Qualitative Content Analysis (QCA) method, this research examines curriculum documents, IPAS (Ilmu Pengetahuan Alam dan Sosial) modules, and interviews with both science and vocational teachers to identify gaps between chemistry teaching and vocational practices. The results reveal that essential chemical concepts such as oxidation-reduction reactions, electrochemistry, and corrosion science are currently absent or underrepresented in the general science curriculum. These omissions hinder students' understanding of crucial maintenance procedures related to metal degradation, material selection, and protective treatments. The study proposes a contextualized chemistry material outline to bridge this gap, enabling vocational students to apply scientific principles effectively in real-world automotive settings. Findings from this study advocate for the incorporation of redox and electrochemical content in vocational science education to enhance both conceptual understanding and technical competency.

**Keywords:** Chassis Maintenance; Contextual Chemistry; Corrosion; Redox Reaction

## Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results. State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Vocational High Schools (SMK) are formal educational institutions designed to equip students with specific skill competencies tailored to meet the needs of the workforce (Suherman et al., 2024). According to the National Education System Law (2003), SMK holds a strategic position in producing graduates who not only

master theoretical knowledge but are also capable of directly applying practical skills in industrial and service sectors (Hidayati et al., 2021). Vocational education emphasizes practical training based on technology and engineering, ensuring SMK graduates are ready to compete in the workforce or pursue higher education (Prihanto et al., 2024). In this context, learning in SMK must align with curriculum demands that adapt to the development of science and technology, especially in the rapidly evolving field of automotive engineering (Jumadin, 2023).

One of the flagship programs within the Technology and Engineering cluster is Automotive Light Vehicle Engineering (TKRO). In this program,

### How to Cite:

Deva, S., Anwar, S., & Rohman, I. Integrating Contextual Chemistry Content on Redox Reactions in Chassis Maintenance for Light Vehicle Engineering Vocational Program. *Jurnal Penelitian Pendidikan IPA*, 11(7), 273-279. <https://doi.org/10.29303/jppipa.v11i7.11296>

students are provided with various productive subjects such as *Light Vehicle Engine Maintenance (PMKR)*, *Chassis and Power Transmission Maintenance (PSPTKR)*, and *Light Vehicle Electrical Maintenance (PKKR)*. Specifically, in the PSPTKR subject, students are prepared to understand the structure and function of the chassis and power transmission systems, which include the transmission, differential, clutch, drive shaft, and other components. All these components operate in complex environments and are prone to physical and chemical changes, such as mechanical stress, high temperatures, friction, and exposure to corrosive substances. Therefore, the success of chassis and power transmission maintenance highly depends on the understanding of the characteristics of materials and chemicals used in vehicles (Aritonang & Murniati, 2024).

Unfortunately, although automotive SMK students deal directly with metal components, lubricants, coolants, and other chemicals, the chemistry material they receive in class is very limited and often not directly connected to vocational contexts. In the *Merdeka Curriculum*, chemistry is only included in general science (IPA/IPAS) subjects and is not specifically designed to support the technical competencies of SMK students. The chemistry content taught mostly covers basic theories without an applied approach that aligns with the automotive work environment. In fact, understanding chemical concepts such as the structure and properties of metals, redox reactions, corrosion mechanisms, metal plating, lubricant viscosity, and material degradation due to temperature and pressure is crucial in maintaining the chassis and power transmission systems (Ariani, 2022).

In practice, many technical problems in vehicles stem from chemical reactions—both desired and undesired (Saptaji et al., 2023). For instance, corrosion or rust on the chassis is caused by oxidation reactions between metal, water, and oxygen in the air. Without understanding the chemical mechanisms, students may only address the surface effects without analyzing the root causes and long-term solutions, such as choosing anti-rust coatings or adjusting the pH of the working environment. Similarly, in transmission systems, lubricants or transmission oils have specific viscosity and chemical stability that must be maintained. Overheating or mixing with water and other substances can alter the chemical properties of the oil, ultimately damaging the transmission system. These examples illustrate that effective vehicle maintenance requires a solid understanding of applied chemistry (Kurniawati & Wati, 2024).

The importance of contextual chemistry learning is also emphasized in various vocational education literature. Crossley et al. (1969) state that learning linked

directly to work contexts helps students understand the connection between theory and practice (Nuai & Nurkamiden, 2022). With contextual learning, students not only know *what* to do but also understand *why* a technical action is taken based on scientific principles. In the context of PSPTKR, this means students should know the scientific reasons behind using certain types of lubricants, using ethylene glycol-based coolants, or the need to maintain components made from lightweight metal alloys to prevent deformation or corrosion (Azhari et al., 2025).

However, several previous studies indicate that chemistry learning in SMK, particularly in automotive programs, remains general and has not directly addressed the needs of the labor market. Fahmi et al. (2019); Herlina (2020); Misnah et al. (2020); Silfianah (2020), note that limited teaching materials and a lack of contextual approaches make it difficult for students to see the relevance of chemistry to the competencies they are learning. Studies by Anggraeni (2017) also show that automotive engineering students often struggle to relate chemical concepts such as redox reactions and material properties to the practice of vehicle component maintenance, including chassis and transmission maintenance. This indicates a gap between chemistry subject matter and the real needs of the job market.

Therefore, it is crucial to conduct a needs analysis on the content and context of chemistry learning that can support skill mastery in the subject of *Chassis and Power Transmission Maintenance for Light Vehicles*. The development of chemistry learning based on actual needs will make the learning process more relevant, applicable, and meaningful for students. With strengthened chemistry understanding integrated into productive subjects, SMK students will be more prepared to address technical problems scientifically, critically, and professionally. They will also be better equipped to adapt to the demands of the modern automotive industry, which increasingly emphasizes the importance of interdisciplinary knowledge between fundamental science and technical skills (Latifah et al., 2024).

Based on this background, the researcher sees the need to conduct a study focused on analyzing the content and contextual needs of chemistry in vocational learning, particularly in the PSPTKR subject in SMK with a competency in *Automotive Light Vehicle Engineering*. This research is expected to serve as a foundation for developing more relevant and contextual teaching materials, thereby improving the quality of vocational education and the readiness of graduates for the real world of work.

## Method

This study employed a Qualitative Content Analysis method adapted from Mayring (2000), which is widely used for systematically analyzing textual and documentary data. The QCA method allows the researcher to interpret and evaluate content in a detailed and structured way, particularly suitable for identifying the relevance and alignment of chemistry content with vocational education contexts. The purpose of this study was to analyze the content and contextual needs of chemistry materials in the IPAS project that support the vocational learning process in the Light Vehicle Engineering Expertise Program (TKRO) at SMK.

The research was conducted at SMKN 8 Bandung, with participants consisting of one IPAS chemistry teacher and three vocational subject teachers from the TKRO program. The selected participants were considered relevant to the research objectives because they have direct experience in implementing the IPAS project and vocational learning, especially in subjects such as engine maintenance, chassis and power transmission maintenance, and vehicle electrical systems. These informants contributed data regarding the suitability, relevance, and needs of chemistry content to support TKRO-specific competencies.

The research process was divided into four stages in accordance with the QCA model: (1) materials collection, (2) descriptive analysis, (3) category selection, and (4) material evaluation. In the first stage, materials collection was carried out through several techniques, including documentation study, interviews, and expert reviews. The documentation study included an in-depth examination of the Merdeka Curriculum documents, chemistry textbooks used in the IPAS project, TKRO subject syllabi, and teaching modules used in the vocational field. Interviews were conducted with teachers using semi-structured interview sheets, aiming to collect information on the current chemistry content in the IPAS project and its alignment with vocational needs. Additionally, the study involved collecting teacher opinions on what chemistry concepts were still lacking and what should be integrated into TKRO learning.

In the second stage, a descriptive analysis was conducted on the collected documents and interview transcripts. This process aimed to identify themes and categories of vocational content that had potential chemical relevance. For example, concepts such as corrosion, oxidation-reduction, lubricant viscosity, and metal properties emerged from vocational subjects and were compared to the chemistry content currently available in IPAS modules. The analysis was guided by the *Capaian Pembelajaran (CP)* outlined in the Merdeka

Curriculum for both general science and TKRO vocational subjects.

The third stage was category selection. At this point, the researcher mapped the vocational subject content from TKRO to relevant chemistry themes, forming specific categories of required chemical knowledge. These included, but were not limited to: the nature and behavior of metals, types of chemical reactions (especially oxidation-reduction), corrosion mechanisms, chemical stability of lubricants and coolants, and the role of acids, bases, and pH in vehicle maintenance. Each category was reviewed and confirmed by vocational teachers to ensure its relevance to the technical problems encountered in TKRO learning.

In the final stage, the material evaluation was conducted to ensure that the selected chemistry categories were feasible and appropriate for integration into vocational subjects. This process involved review sessions using validation and review instruments, where teachers provided assessments on whether the identified chemistry materials aligned with the needs of vocational competencies. The evaluation criteria were based on the conformity with CP standards from BSKAP (2022) and the practical applicability of the content in real-world vocational settings.

The instruments used in this study consisted of interview guidelines, review sheets, mapping formats, and content alignment checklists. These instruments helped systematically collect and analyze data, allowing the researcher to design a chemistry content outline tailored to TKRO needs. For example, the researcher used a review checklist to evaluate the correspondence between chemistry content in the IPAS curriculum and the actual needs in the chassis and power transmission maintenance subject. In addition, mapping instruments were used to analyze prerequisite chemistry knowledge and its relevance to vocational material sequences, resulting in an outline that shows the chemistry content, material breakdown, and contextual application in TKRO.

Overall, this QCA-based research method provided a comprehensive and structured approach to analyzing the chemistry content needs in vocational education. It allowed the researcher to identify existing gaps, understand the expectations of vocational educators, and propose a contextually rich and practically oriented chemistry teaching material outline that could support student learning in the TKRO expertise program.

## Result and Discussion

Results should be clear and concise. The discussion should explore the significance of the results of the work,

not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

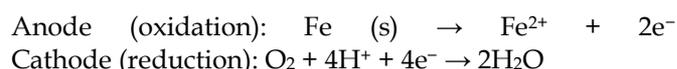
This study was conducted in response to the limited contextual relevance of chemistry content in the Merdeka Curriculum, particularly concerning the needs of vocational high school students majoring in Teknik Kendaraan Ringan Otomotif (TKRO), or Light Vehicle Engineering. The main objective of this research was to examine the alignment between the general chemistry material provided in the IPAS (Ilmu Pengetahuan Alam dan Sosial) subject and the specific chemical knowledge needed to understand and perform maintenance on vehicle chassis systems. The study employed a qualitative descriptive approach using Qualitative Content Analysis (QCA) as elaborated by Mayring (2000), which involves several stages: materials collection, descriptive analysis, category selection, and material evaluation. Primary data sources consisted of curriculum documents (BSKAP No. 032/H/KR/2024), IPAS teaching modules, and direct interviews with one IPAS teacher and three productive TKRO teachers from a vocational high school in Bandung. The findings from this stage of data collection highlighted a significant discrepancy between the theoretical chemistry content offered and the actual demands of the automotive industry, especially in understanding complex phenomena such as corrosion, which involves electrochemical and redox processes.

The chemistry content in the IPAS subject, though foundational, primarily covers general topics such as classification of matter, physical and chemical properties, phase changes, and identification of hazardous and toxic substances. However, these topics are presented in a context more appropriate for general science education, without a strong link to real-world applications within the automotive field. Interviews with vocational teachers indicated that students often struggle to relate the abstract chemical concepts taught in IPAS with the tangible problems they encounter in automotive maintenance workshops. For instance, while students are taught about chemical reactions in theory, they are not introduced to how oxidation and reduction govern the degradation of metal components, such as the corrosion of steel chassis due to exposure to moisture, oxygen, and environmental pollutants. As a result, students lack the scientific literacy needed to make informed decisions about material preservation, corrosion prevention, or the application of chemical treatments like anti-rust coatings. This aligns with previous research by Ernawati et al. (2024); Naimah et al. (2025), which similarly concluded that chemistry content in the Merdeka Curriculum has not been sufficiently

adapted to serve the vocational competencies expected of SMK (*Sekolah Menengah Kejuruan*) graduates.

#### *Descriptive Analysis*

One of the most pressing chemical phenomena encountered in the field of light vehicle maintenance is corrosion—specifically, the oxidation of iron and its alloys used in chassis construction. This process is a classic example of a redox reaction, where iron (Fe) loses electrons (oxidation) and reacts with oxygen and water to form iron oxide, commonly known as rust ( $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ ). The simplified redox equations are as follows:



The combination of these half-reactions explains the electrochemical mechanism that deteriorates the metal's structure over time. In an automotive context, such degradation can lead to severe consequences, including loss of structural integrity, safety risks, and increased maintenance costs. Despite the real-world significance of corrosion, the IPAS curriculum does not explicitly address redox reactions, nor does it contextualize corrosion in a way that aligns with automotive maintenance. This educational gap results in students perceiving chemistry as disconnected from their vocational interests, which diminishes both engagement and retention.

Vocational teachers emphasized the necessity for students to understand not only the symptoms but also the causes and prevention of corrosion. Concepts such as electrode potential, galvanic series, and sacrificial anodes should be introduced in a simplified yet contextualized manner to illustrate how redox principles are employed to protect chassis structures. For example, galvanizing a chassis with a layer of zinc works by allowing the more reactive zinc to oxidize in place of the underlying steel, effectively sacrificing itself and thereby delaying rust formation on the structural component. Electrochemical techniques such as cathodic protection are standard practices in the automotive industry, yet their underlying chemical principles are absent from the current high school curriculum. As Wahyuni et al. (2020) asserted, students show significant improvement in comprehension and critical thinking when scientific content is taught through real-life vocational scenarios.

#### *Category Selection*

In order to propose chemistry content that is relevant and necessary for TKRO students, this study classified themes based on their direct applicability to

chassis maintenance and their alignment with fundamental chemical concepts. The categories that emerged as essential include: redox reactions, electrochemistry, chemical bonding, stoichiometry, acid-base chemistry, hazardous substances, and thermochemistry. Among these, redox reactions stand out as the most critical due to their central role in corrosion. Electrochemistry complements redox by explaining the electrical aspects of corrosion and protection methods such as electroplating. Chemical bonding is essential for understanding the structural properties of metals and polymers used in protective coatings. Stoichiometry enables accurate formulation of rust removers or anti-corrosive treatments. Acid-base chemistry provides the basis for understanding how cleaning agents work and how acidic environments accelerate corrosion. Knowledge of hazardous materials is important for safety in handling industrial chemicals. Lastly, thermochemistry explains heat-induced oxidation during welding or heat treatment.

The importance of these themes is not merely theoretical but based on daily practices in the automotive workshop. For example, applying a rust converter involves a redox reaction where iron oxide is reduced to a more stable compound, often accompanied by the formation of a protective polymer layer. Electroplating processes used to coat bolts, screws, and other chassis parts require knowledge of electrode polarity, electrolyte composition, and redox potential. Even basic maintenance tasks, such as inspecting for rust or applying underbody coatings, require an understanding of the chemical conditions that lead to corrosion. Hence, integrating these themes into the curriculum ensures that students are not only memorizing formulas but also gaining practical knowledge applicable to their future careers.

The following table outlines the core chemistry content areas that are relevant for automotive chassis maintenance, demonstrating the direct vocational application of each topic.

**Table 1.** Outline of Chemistry Teaching Material

Theme	Chemistry Content Description	Application in Chassis Maintenance
Redox Reactions	Definition of oxidation & reduction, electron transfer, oxidation numbers, galvanic series	Explaining iron oxidation into rust, sacrificial anode protection, redox potential comparison
Electrochemistry	Galvanic cells, electrolysis, electrode potential	Understanding galvanic corrosion, electroplating chassis components
Chemical Bonding	Metallic bonds, covalent & ionic bonds, bond strength	Understanding strength and flexibility of chassis materials and coatings
Acid-Base Chemistry	pH concept, neutralization, acid/base strength	Using alkaline cleaners to neutralize road acid or battery leaks on chassis surfaces
Stoichiometry	Mole concept, molarity, ppm, solution preparation	Preparing anti-corrosion or rust-removal solutions accurately
Toxic and Hazardous Chemicals (B3)	MSDS, hazard symbols (GHS), waste management	Safe use of thinners, degreasers, and anti-rust agents in the workshop

### Material Evaluation

Evaluating the relevance and impact of chemistry content on vocational competence reveals a stark contrast between current educational offerings and the skills required in the automotive industry. Redox reactions, the focal point of this analysis, are entirely omitted from the IPAS module, despite being the fundamental explanation for one of the most prevalent maintenance issues—corrosion. This omission leaves students ill-equipped to analyze, predict, or prevent rust formation, which is a daily concern in the maintenance of vehicle chassis. The redox process is not limited to rusting; it also explains the functionality of anti-corrosive agents, inhibitors, and galvanic protection systems. Without a solid understanding of redox, students lack the conceptual foundation necessary to appreciate the science behind these protective strategies.

Contextualizing chemistry through vocationally relevant examples, such as rust formation on wheel arches or the use of zinc spray coatings, significantly

enhances student motivation and comprehension. This approach is supported by Context-Based Learning (CBL) theories, which suggest that connecting scientific concepts to real-life contexts enhances meaningful learning and student engagement (Gungor et al., 2023; Kan & Kumaş, 2023; Yılmaz et al., 2022). Moreover, Broman et al. (2022) emphasize that affective factors such as perceived relevance and interest significantly influence students' willingness to engage with science content. By redesigning chemistry modules to include examples from chassis maintenance—such as electroplating, pH adjustment of cleaning solutions, or calculating concentrations for rust removers—teachers can foster deeper understanding and increase vocational preparedness.

Ultimately, incorporating contextualized redox content into the chemistry curriculum is not merely a pedagogical enhancement but a necessity for producing graduates who are scientifically literate and vocationally

competent. Students trained under such an integrative model will be better prepared to diagnose material degradation, apply corrosion prevention techniques, and contribute meaningfully to the automotive sector.

## Conclusion

Based on the results of this study, it is concluded that the integration of contextualized chemistry material, especially focusing on redox reactions and corrosion processes, is essential to bridge the gap between theoretical science education and the technical needs of Light Vehicle Engineering (TKRO) students. The current IPAS curriculum lacks alignment with the vocational competencies needed to understand and address issues such as rust formation, material degradation, and chemical treatment of automotive components. Redox reactions, as a fundamental concept in corrosion, should be presented in a vocational context to enhance relevance, understanding, and application. Additionally, complementary topics such as electrochemistry, bonding, and acid-base reactions are necessary to fully support the chassis maintenance curriculum. The implementation of contextual science content not only improves students' conceptual grasp but also prepares them to be more competent and confident in applying chemistry in the field of vehicle maintenance. Therefore, curriculum developers and educators are encouraged to revise existing teaching materials and approaches to ensure better alignment with industrial practices and student needs in vocational education.

## Acknowledgments

The author extends gratitude to the IPAS project teacher (Yuyun S.Pd), chemistry teacher (Abdul S.Pd.), and vocational teachers at SMKN 8 Bandung who have been willing to be resource persons and reviewers in this study.

## Author Contributions

The author extends gratitude to academic supervisors and validator as well, Dr. paed. Sjaeful Anwar and Dr. Ijang Rohman, M.Si

## Funding

This research received no external funding

## Conflicts of Interest

The authors declare no conflict of interest.

## References

Anggraeni, E. (2017). Contextual-based knowledge creation for agroindustrial innovation. *Gadjah Mada International Journal of Business*, 19(2), 97–122. <https://doi.org/10.3316/informit.05795993161972>

- 3
- Ariani, B. (2022). *Pengantar Korosi Perkapalan*. Aceh: Syiah Kuala University Press.
- Aritonang, S., & Murniati, R. (2024). *Material Pertahanan*. CV. Aksara Global Akademia.
- Azhari, P., Azhari, M., & Munte, H. (2025). Penerapan Pendekatan Kontekstual Metode Tanya Jawab Untuk Meningkatkan Prestasi Belajar IPA Siswa Kelas IV. *Indonesian Journal of Multidisciplinary Scientific Studies*, 3(2), 95–114. <https://doi.org/10.33151/ijomss.v3i2.443>
- Broman, K., Bernholt, S., & Christensson, C. (2022). Relevant or interesting according to upper secondary students? Affective aspects of context-based chemistry problems. *Research in Science & Technological Education*, 40(4), 478–498. <https://doi.org/10.1080/02635143.2020.1824177>
- Crossley, W. A., Cooper, R. W., Page, J. L., & Van Stapele, R. P. (1969). Faraday rotation in rare-earth iron garnets. *Physical Review*, 181(2), 896. <https://doi.org/10.1103/PhysRev.181.896>
- Ernawati, E., Marsithah, I., & Jannah, M. (2024). Pengembangan Modul Project IPAS berbasis Lingkungan dalam Kurikulum Merdeka pada Fase E. *Jurnal Penelitian, Pendidikan Dan Pengajaran: JPPP*, 5(1), 50–63. <https://doi.org/10.30596/jppp.v5i1.16968>
- Fahmi, F., Setiadi, I., Elmawati, D., & Sunardi, S. (2019). Discovery learning method for training critical thinking skills of students. *European Journal of Education Studies*. <https://doi.org/10.46827/ejes.v0i0.2540>
- Gungor, B. A., Saracoglu, S., & Metin, M. (2023). Perspective of teachers to context-based learning and its use in science education. *Canadian Journal of Science, Mathematics and Technology Education*, 23(1), 27–47. <https://doi.org/10.1007/s42330-023-00266-1>
- Herlina, H. (2020). Upaya Meningkatkan Aktivitas dan Hasil Belajar Kimia dengan Pendekatan Contextual Teaching Learning di Kelas X SMAN 7 Rejang Lebong. *PENDIPA Journal of Science Education*, 4(1), 24–30. Retrieved from <https://shorturl.asia/YjZB4>
- Hidayati, A., Barr, F. D., & Sigit, K. N. (2021). Kesesuaian kompetensi lulusan SMK dengan kebutuhan dunia usaha dan industri. *Ekuitas: Jurnal Pendidikan Ekonomi*, 9(2), 284–292. <https://doi.org/10.23887/ekuitas.v9i2.39508>
- Jumadin, S. P. (2023). *Kualitas Pembelajaran Dan Kesiapan Kerja Lulusan Pendidikan Vokasi*. Makassar: Rizmedia Pustaka Indonesia.
- Kan, S., & Kumaş, A. (2023). Bibliometric Analysis of Studies Based on Context-Based Learning Method

- in Science Teaching. *Erzincan University Journal of Education Faculty*, 25(4), 683–695. <https://doi.org/10.17556/erziefd.1335286>
- Kurniawati, I. L., & Wati, D. A. R. (2024). *Korosi: Teori dan Pencegahannya*. Yogyakarta: UGM Press.
- Latifah, U., Yulastri, A., Yuliana, Y., & Fiandra, Y. A. (2024). Pengembangan Kurikulum Pendidikan Teknologi Vokasi Berbasis Kewirausahaan untuk Menghadapi Revolusi Industri 4.0 di Bidang Teknologi Manufaktur. *Al Qalam: Jurnal Ilmiah Keagamaan Dan Kemasyarakatan*, 18(6), 4202–4218. <https://doi.org/10.35931/aq.v18i6.4159>
- Mayring, P. (2000). Pensionierung als Krise oder Glücksgewinn? Ergebnisse aus einer quantitativ-qualitativen Längsschnittuntersuchung. *Zeitschrift Für Gerontologie Und Geriatrie*. Retrieved from <https://psycnet.apa.org/record/2000-15686-002>
- Misnah, M., Gamar, M. M., Mutawakkil, M., Malla, H. A. B., & Herlina, H. (2020). Training on Contextual Based Thematic Learning Media Development for Elementary School Teachers in Sigi Regency, Central Sulawesi. *Journal of Physics: Conference Series*, 1477(4), 42007. Retrieved from <https://repository.uindatokarama.ac.id/id/eprint/1666/>
- Naimah, A., Situmorang, R., & Kusumawardani, D. (2025). Analysis and Exploration of Hypermedia-Based Learning Materials Proyek IPAS in Grade 10 Vocational High School. *Journal of Science and Education (JSE)*, 6(1), 682–694. Retrieved from <https://jse.rezkimedia.org/index.php/jse/article/view/543>
- Nuai, A., & Nurkamiden, S. (2022). Urgensi kegiatan praktikum dalam pembelajaran ilmu pengetahuan alam di sekolah dasar dan menengah. *SEARCH: Science Education Research Journal*, 1(1), 48–63. Retrieved from <https://ejurnal.iainsorong.ac.id/index.php/jaser/article/view/1240>
- Prihanto, A., Subaidah, S., Aripin, M., & Warman, W. (2024). Strategi pengelolaan sekolah berbasis industri dalam meningkatkan daya saing dan kualitas pendidikan. *Pendas Mahakam: Jurnal Pendidikan Dan Pembelajaran Sekolah Dasar*, 9(2), 136–142. Retrieved from <https://jurnal.fkip-uwgm.ac.id/index.php/pendasmahakam/article/view/1836>
- Saptaji, K., Sari, A. M., Ramadhan, A. I., Rahardja, I. B., Saputra, M. D., Firmansyah, F., & Umar, E. (2023). Studi Pengembangan Nanofluida Hijau Berasal Dari Bahan Lokal Alam Untuk Aplikasi Di Bidang Teknik. *Jurnal Teknologi*, 15(2), 345–358. <https://doi.org/10.24853/jurtek.15.2.345-358>
- Silfianah, I. (2020). Development of Multiple Representation-Based General Chemistry Textbook Using Guided Inquiry. *EduChemia (Jurnal Kimia Dan Pendidikan)*, 5(2), 180–196. <https://doi.org/10.30870/educhemia.v5i2.7508>
- Suherman, M., Soro, S. H., Ahmad, I., Ningsih, R. F., & Pawaka, W. (2024). Peran Pendidikan Vokasi dalam Melahirkan Wirausahawan (Studi Kasus Peserta Didik SMK Negeri 1 Cicalongkulon Kabupaten Cianjur). *EDUKASIA Jurnal Pendidikan Dan Pembelajaran*, 5(1), 2401–2410. <https://doi.org/10.62775/edukasia.v5i1.1307>
- Wahyuni, P., Haryani, S., & Jumaeri, J. (2020). Design of Integrated Corrosion E-module Vocational Context to Improve Critical Thinking Skills of Class X Students in Vocational High School. *International Journal of Active Learning*, 5(2), 86–93. Retrieved from <https://www.learntechlib.org/d/218511/>
- Yılmaz, S., Yıldırım, A., & İlhan, N. (2022). Effects of the context-based learning approach on the teaching of chemical changes unit. *Journal of Turkish Science Education*, 19(1). <https://doi.org/10.36681/tused.2022.119>