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STUDENTS' MISCONCEPTIONS IN ELECTRICITY AND LEARNING STRATEGIES TO REDUCE THEM: A LITERATURE ANALYSIS

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ABSTRACT

Misconception is a conceptual misunderstanding experienced by students where the concept owned by students does not correspond to the scientific concept. Misconceptions are often found in science, especially in the topic of electricity. Electricity is one of the important topics in science that has many phenomena and connections with everyday life. In addition, electricity is assumed as an abstract concept that is difficult to understand by students. This study aims to analyse literatures that discussed about the detection of students' misconceptions in electricity concepts and the learning strategies to reduce those misconceptions. The method used in this study is a literature review with four stages: designing the review, conducting the review, analysing the literatures, structuring and writing the review findings. The research findings indicate that the most widely discussed misconception is that the lamp closest to the positive pole of the voltage source receives the largest current. In contrast, the next component receives the remaining current from the previous component. These misconceptions are still being attempted to be reduced or even eliminated. Efforts that have been applied to reduce misconceptions include implementing certain learning strategies that can build students' complete understanding of electrical concepts and combining them with simulations or virtual laboratories that can present concepts visually so that the concepts presented are no longer abstract for students. To conclude, the concept of electricity is abstract and likely to cause misconceptions in students. Therefore, the effective learning strategies have to be implemented to reduce students' misconceptions in electricity. The list of misconceptions and learning strategies that have been analysed can be used as a reference for teachers to plan appropriate learning strategies in the future to minimize misconceptions.

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Introduction

Electricity is something abstract and difficult to observe in real life. Electricity is one of the important topics in science that has many phenomena and connections with everyday life. However, there are still many misconceptions on this topic (Assem et al., 2024), and 159 misconceptions related to electricity still frequently occur (Suparno, 2013). Many of these misconceptions occur because electricity is an abstract concept that is difficult to understand (Hernandez et al., 2022). The learning that is usually done only asks students to imagine the physical phenomena of electricity. Students are not yet able to think related to abstract concepts and imagine the physical phenomena that occur in the concept of electricity (Upayogi & Juliawan, 2019).

Misconception is a conceptual misunderstanding experienced by students where the concept owned by students does not correspond to the scientific concept. Misconceptions are often found in science (Suprapto, 2020). Misconceptions can arise from various things, such as incorrect analogy, the use of everyday words that have similar meanings, or incorrect reasoning constructions (López & Marco, 2022). In addition, misconceptions can also be caused by interactions between students and their environment before they enter formal classes. Through everyday life phenomena, students build their concepts before they acquire new knowledge or concepts in the classroom (Mufit et al., 2023). When students try to build their concepts, errors may occur in constructing the correct concept and give rise to misconceptions (Mulyastuti et al., 2016).

Misconceptions held by students should not be left for too long. Teachers must immediately try to reduce misconceptions when they find out their students are experiencing misconceptions. Students who experience misconceptions must immediately receive appropriate treatment so that they realize that they are experiencing misconceptions (Mufit et al., 2023). Misconceptions can prevent students from accepting new concepts by scientific concepts. Research conducted by Ramnarain & Moosa (2017) on electrical material found that some misconceptions became resistant and difficult to eliminate even though special interventions had been given to reduce students' misconceptions. It can happen because the misconceptions held by students have been held for too long, so students will find it difficult to accept new concepts (concepts that are scientific concepts) and cause their misconceptions to persist.

There have been many studies that have revealed misconceptions about electrical materials (Aligo et al., 2021; Andriani et al., 2015; Assem et al., 2024; Hidayatulloh et al., 2019; Ismail et al., 2015; Ivanjek et al., 2021; Pratama et al., 2023; Rohmah et al., 2017; Sarni et al., 2023; Trisnawati & Eso, 2020) and efforts to reduce misconceptions experienced by students (Assem et al., 2024; Frans & Wasis, 2022; Pratama et al., 2023; Ramnarain & Moosa, 2017; Ratnaningdyah & Sugiarti, 2024; Upayogi & Juliawan, 2019). The results of this literature study present a list of misconceptions about electrical materials that have been found, the discovery of the consistency of old misconceptions from year to year, and the discovery of new misconceptions that have not been widely studied before. The list of misconceptions and learning strategies that have been identified can be used as a reference for teachers to plan appropriate learning strategies in the future to minimize misconceptions. In addition, a review of misconceptions is carried out so that readers and subsequent researchers can easily identify students' misconceptions, especially for other researchers who will conduct further research on misconceptions, learning strategies to overcome misconceptions, and the creation of misconception analysis instruments on electrical materials.

Research Methods

Library research or literature study is the method used in this research. Four phases are carried out in this research literature study: designing the review, conducting the review, analyzing, structuring and writing the review (Snyder, 2019). The first stage is designing the review. The design is carried out by considering the scheme in the form of research contributions, objectives, methods, and literature search strategies. This stage is carried out by searching and selecting several literatures appropriate and relevant to the research and topics to be studied. The literature taken is from national and international journals related to the topic of electricity, and the search is carried out online and offline. The second stage is conducting the review by reading the literature to obtain and filter research data. At this stage, data on student misconceptions and their learning strategies in electricity material are obtained. The third stage is

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analysis. The analysis produced is descriptive information such as author, year, topic, type of research, and impact. Then, the last stage is structuring and writing the review related to the research topic that has been written.

Results and Discussion

The discussion is conducted by describing the misconceptions found. In addition, it is also discussed regarding learning strategies and their implications for reducing misconceptions in these sub-topics.

Misconception Review

Table 1 presents an analysis of literature studies based on a combination of several scientific articles related to student misconceptions about electricity material. The topics are divided into five subtopics: electric current, electric circuits, Kirchoff's law, electrical resistance, and Ohm's law.

Table 1. Misconceptions in electricity material

Concept	Research Sources
ELECTRIC CURRENT	
The current has the same value at every point	(Turgut et al., 2011)
In a series circuit, the lamp closest to the positive pole of the voltage source receives the largest current. In contrast, the next component receives the remaining current from the previous component.	(Andriani et al., 2015; Fajar & Supardi, 2013; Hidayatulloh et al., 2019; Sarni et al., 2023; Turgut et al., 2011)
The lights in the circuit can absorb current, so every time it passes the light, the current decreases.	(Ivanjek et al., 2021; Sarni et al., 2023; Siong et al., 2023; Suparno, 2013; Turgut et al., 2011)
A lamp close to the battery will shine brighter than a lamp far from the battery.	(Aligo et al., 2021; Suparno, 2013; Turgut et al., 2011)
The current will flow from the negative pole to the positive pole, so the current closer to the negative pole has a greater value than the current closer to the positive pole.	(Ismail et al., 2015; Rohmah et al., 2017; Trisnawati & Eso, 2020; Turgut et al., 2011)
Current causes a potential difference to occur.	(Fajar & Supardi, 2013; Hidayatulloh et al., 2019)
Electric current strength is the amount of electric current that flows.	(Andriani et al., 2015)
The voltage or potential difference at the battery poles causes electric current (positive charge) to flow from the positive pole to the negative pole of the battery.	(Andriani et al., 2015)
The current in a circuit is always constant.	(Siong et al., 2023)
ELECTRICAL CIRCUITS	
In a parallel circuit, removing one bulb will make the other bulbs shine brighter and increase their potential difference	(Hidayatulloh et al., 2019; Trisnawati & Eso, 2020)
A circuit with a battery powering one light bulb will produce a greater current than a circuit using a battery to power two light bulbs.	(Peşman & Eryılmaz, 2010; Sarni et al., 2023)
In a series circuit, the lights must be placed next to each other along the wire, whereas in a parallel circuit, the lights must be placed right next to each other.	(Ivanjek et al., 2021)
Increasing the number of lights in a circuit will cause the total resistance to become greater.	(Aligo et al., 2021; Peşman & Eryılmaz, 2010; Sarni et al., 2023)
Electric current will flow through the branch with more lights and the branch closest to the voltage source.	(Andriani et al., 2015)
If the switch is connected to two batteries connected in parallel, the brightness of the lamp and the electric current will increase.	(Hamdani, 2014; Sarni et al., 2023)
Lights connected in parallel will always be brighter than lights connected in series.	(Mbonyiryivuze et al., 2019; Turgut et al., 2011)
KIRCHOFF'S LAW	
In a parallel circuit, the electric current entering the branched circuit has the same magnitude in each branch and does not depend on the value of the resistor used.	(Andriani et al., 2015)
The amount of energy used to move the battery's charge and the charge in the circuit components is the same because the battery's resistance is smaller than the resistance of the circuit components.	(Andriani et al., 2015)
ELECTRICAL RESISTANCE	
Lamps are not included in electrical resistance because lamps only change electric current into light.	(Andriani et al., 2015)
The magnitude of electrical resistance is not influenced by the type of resistance, cross-sectional area, and length of the conducting wire.	(Andriani et al., 2015)
OHM'S LAW	
In a series circuit, if one of the resistors is increased, it will affect the current flowing in the next resistor but will not affect the current flowing in the previous resistor.	(Ismail et al., 2015; Sarni et al., 2023)
If the resistance value in the circuit is changed, then only the lamp on the (-) pole of the voltage source will change, while the lamp on the (+) pole will remain the same. This means that the	(Ismail et al., 2015; Sarni et al., 2023)

Concept	Research Sources
electric current at a point in a series circuit depends on its distance from the battery poles.	

The misconceptions identified above can be used as a reference for teachers to plan future learning strategies to minimize conceptual misunderstandings so as not to hinder students from receiving new knowledge in the learning process that students will receive. Teachers can also create question instruments concerning the table above to conduct misconception analysis on their students.

Learning Strategies and Their Implications for Reducing Misconceptions of Electrical Material

Research related to reduction of misconceptions is still being intensively carried out to overcome learning difficulties and misconceptions experienced by students. In order to reduce misconceptions through learning, teachers must have information related to students' initial knowledge and in which parts students experience misconceptions so that teachers can direct appropriate learning to build correct concepts (Turgut et al., 2011). Teachers must identify students' prior knowledge before introducing concepts to learning (Mbonyiryivuze et al., 2019). Based on this, it is important to conduct a pretest before learning to determine students' initial knowledge and identify misconceptions they experience.

Handling misconceptions is ideally done by providing scientific facts and confronting wrong concepts with correct concepts based on direct experience (Mufit et al., 2023). Here are some learning strategies that have been carried out and the results of their reduction in electrical material.

Table 2. Summary of research on learning strategies to reduce misconceptions about electricity material

Article Information	Research Summary
(Assem et al., 2024) **Title:** Identifying and Dispelling Students' Misconceptions about Electricity and Magnetism Using Inquiry-Based Learning in Selected Junior High Schools **Journal:** ASEAN Journal for Science Education	**Research Purpose:** To identify misconceptions and eliminate student misconceptions by using inquiry-based learning. **References/Supporting Statements:** Determining appropriate and effective learning strategies in dealing with misconceptions can be done if teachers understand the potential for misconceptions and students' prior knowledge (Turgut et al., 2011). Identification of prior knowledge can be used to guide students' conceptual development and change. Students must be aware of the presence of misconceptions and make decisions about whether or not to reconstruct the concept (Cakir, 2008). To improve conceptual understanding of electricity and magnetism material, constructive methods such as Inquiry-Based Learning (IBL) are suggested (Afra et al., 2009). Inquiry-based learning is designed using five teaching stages: exploring, explaining, exploring, elaborating, and evaluating (Assem et al., 2024). This activity will help students to reconstruct concepts and handle their misconceptions. **Research Results:** The use of inquiry learning models is effective in eliminating student misconceptions. Inquiry makes students learn through conceptual investigation so that students can clarify the concepts they have and realize the existence of misconceptions. This awareness can make students willing to replace their misconceptions with scientific concepts.
(Ratnaningdyah & Sugiarti, 2024) **Title:** Mereduksi Jumlah Mahasiswa yang Mengalami Miskonsepsi Fisika pada Materi Listrik Dengan Model Pembelajaran Inkuiri **Journal:** Jurnal Inovasi dan Pembelajaran Fisika (JIPF)	**Research Purpose:** This study aims to determine the effect of the inquiry learning model on reducing student misconceptions. **References/Supporting Statements:** Inquiry learning will prepare students for independent experimental situations and connect one discovery with another so that later, students can build their understanding of concepts to form scientific conceptions and reduce the level of misconceptions (Ratnaningdyah & Sugiarti, 2024) ***Research Results:*** The inquiry learning model based on the stages of investigation can facilitate students' management of cognitive conflicts and building correct scientific conceptions. It can reduce student misconceptions and improve them into appropriate scientific conceptions. The use of the inquiry learning model resulted in a 20% reduction in misconceptions.
(Pratama et al., 2023) **Title:** Reduksi Miskonsepsi Mahasiswa pada Prinsip Kerja Kapasitor melalui Penerapan Simulasi PhET **Journal:** Inovasi Pendidikan Fisika	**Research Purpose:** This study aims to reduce students' misconceptions about the concept of capacitors. **References/Supporting Statements:** Students involved in visual experiments can gain a correct scientific conceptual understanding related to capacitors' working principles, observe voltage and current changes, and manipulate possible variables (El-Tawargy & Elshabaan, 2023). This visual experiment was used with the help of PhET. PhET simulations can be used to explore information related to student misconceptions about electricity (Eveline & Permatasari, 2022) and are effective in reducing student

10.21107/jps.v12i1.29495 Mulyastuti et al. E-ISSN: 2527-7634

Article Information	Research Summary
	misconceptions (Hikmawati et al., 2023). **Research Results:** The percentage of misconception reduction obtained was 34.3%. This presentation was obtained by reducing misconceptions during the pretest by 41.3% and the posttest by 6.9%. The results of this study can be used as a reference that virtual simulations can be used in learning complex physics materials.
(Frans & Wasis, 2022) **Title:** Penerapan LKS Berbasis PhET untuk Mereduksi Miskonsepsi Siswa pada Materi Arus Listrik Bolak Balik **Journal:** Jurnal Penelitian Pembelajaran Fisika	**Research Purpose:** Reduce students' misconceptions about alternating current electricity material by implementing LKS assisted by PhET virtual laboratory simulations. **References/Supporting Statements:** Students need scientific investigations through experiments and remember every step of the activities carried out by students so that students can continue to develop their scientific investigation and concept discovery skills independently by using virtual laboratories such as PhET. This PhET simulation media can help teachers understand concepts to students and effectively improve conceptual (Masita et al., 2020). **Research Results:** This study obtained the results of an increase in conceptual understanding in 3 classes of respondents as indicated by an increase in the average score (N-gain) of 0.7944, 0.6819, and 0.8421, with a category that tends to be high. This increase in conceptual understanding is in line with a decrease in misconceptions.
(Upayogi & Juliawan, 2019) **Title:** Reduksi Miskonsepsi Melalui Pembelajaran Berbasis Virtual Lab **Journal:** Journal of Teaching and Learning Physics	**Research Purpose:** Reduce misconceptions by building conceptual knowledge and building students' procedural knowledge through virtual laboratory-based learning, namely using PhET. **References/Supporting Statements:** The learning process by instilling procedural knowledge is very important to develop in physics learning. This procedural knowledge is mostly developed through laboratory practicums, causing conceptual knowledge to develop in every learning process (Yusrizal et al., 2017). However, the limited equipment in the laboratory means that students cannot visualize the electrical concepts they have obtained. (Upayogi & Juliawan, 2019). Virtual laboratories are one solution to the limited equipment in the learning environment. Learning is carried out using the help of virtual laboratories such as PhET and Student Worksheets which contain detailed and clear steps and

Article Information	Research Summary
	stages of PhET operational simulation. The advantage of PhET, which can present a visualization of electrical phenomena, allows students to see in detail abstract events that are not visible so that they can build concepts correctly and have an impact on reducing student misconceptions (Upayogi & Juliawan, 2019). **Research Results:** There was a 50% decrease in misconceptions about static electricity phenomena, a 41% decrease in misconceptions about physical quantities in electrical circuits, and a 41% decrease in misconceptions about energy and electrical power.
(Hidayatulloh et al., 2019) **Title:** Reduksi Miskonsepsi Siswa Pada Materi Listrik Dinamis Menggunakan Ebook Interaktif **Journal:** Jurnal Pendidikan Fisika dan Teknologi	**Research Purpose:** Develop an interactive ebook to reduce misconceptions about dynamic electricity material. This study describes the validity of the ebook, the effectiveness of the ebook to reduce misconceptions, and the practicality of the ebook. **References/Supporting Statements:** Using simulation software is important to foster interest in learning, visualize knowledge, and minimize learning difficulties (Fiscarelli et al., 2013). The minimal learning difficulties are expected to improve students' conceptual understanding and reduce their misconception levels. **Research Results:** The results showed that interactive ebooks were very effective in reducing students' misconceptions about dynamic electricity material to the point that misconceptions could decrease by 52%, and it can be concluded that the ebook is suitable for use in physics learning in dynamic electricity material.
(Ramnarain & Moosa, 2017) **Title:** The Use of Simulation in Correcting Electricity Misconceptions of Grade 10 South African Physical Science Learners **Journal:** International Journal of Innovation in Science and Mathematics Education	**Research Purpose:** The use of interactive computer simulation to overcome misconceptions about the concept of electrical circuits. Misconceptions were detected using a three-tier diagnostic test on 130 student samples. **References/Supporting Statements:** Computer simulations offer an ideal and dynamic representation of concepts compared to direct experiments conducted in laboratories, which tend to be expensive and dangerous in electrical concepts (Obsborne & Hennessy, 2003). The simulation was conducted using Physics Education Technology (PhET) developed by the University of Colorado. Some of the advantages offered by PhET on electrical materials are: (1) teachers do not need to spend many teaching costs to buy circuit

10.21107/jps.v12i1.29495 Mulyastuti et al. E-ISSN: 2527-7634

Article Information	Research Summary
	boards, and students can get fast and quality conceptual feedback through PhET (Finkelstein et al., 2005) and avoid the possibility of failed experiments due to equipment damage, (2) PhET simulations enable students to be more active in learning, and students can construct their knowledge independently to produce conceptual changes and eliminate misconceptions (Jaakkola et al., 2011), (3) can create more visualizations of the circuits at one time which allows students to compare the circuits to build a concept, (4) allows students to reflect on the concept, modify the concept with direct feedback (Zacharia & Olympiou, 2011), (5) encourage students to interact with their peers to share experiences and discuss problems they encounter (Upayogi & Juliawan, 2019). **Research Results:** The use of simulation can be used as a learning medium to develop cognitive understanding and can facilitate students' investigations into their preconceptions. The decrease in misconceptions occurred in 6 discussions of concepts out of 11 concepts given. Some misconceptions still exist and are difficult to eliminate because some misconceptions are resistant, even though there are interventions that have been specifically designed to eliminate these misconceptions.
(Fajar & Supardi, 2013) **Title:** Pengaruh Penggunaan Model Pembelajaran Inkuiri (Inquiry Learning) Terhadap Penurunan Miskonsepsi Pada Materi Listrik Dinamis Kelas X SMA 2 Jombang **Journal:** Jurnal Inovasi Pendidikan Fisika	**Research Purpose:** Find out the profile of misconceptions in dynamic electricity material and to test the effect of using the inquiry learning model to reduce students' misconceptions in Dynamic Electricity material **References/Supporting Statements:** This inquiry learning through personal discovery is inseparable from cognitive conflict-based learning. Cognitive conflict arises due to conflict in the minds of students because of observing a phenomenon that is "anomalous". In order to reduce misconceptions and change preconceptions held by students, students must be actively involved in managing cognitive conflicts to find solutions (Suparno, 2013). **Research Results:** This study obtained the results of reducing misconceptions on questions about current consumption models, namely 37.5% and 43.8%. Electrical circuits decreased by 28.1% and 37.5%. Questions about current sources decreased by 28.1% and 3.1%.

The majority of studies in Table 2 use inquiry learning models and scientific approaches. They are combined with multimedia assistance to teach electrical concepts. In physics learning, the use of inquiry learning models, problem-based learning and scaffolding learning becomes more effective when combined with virtual laboratory media such as PhET (Banda & Nzabahimana, 2021). Learning involving media or multi-learning models can help students understand concepts as a whole so that it can improve conceptual understanding and reduce misconceptions (Ulfah et al., 2021). Learning using inquiry learning can also be very effective if proper learning guidance is carried out (Siantuba et al., 2023). Building conceptual understanding is a very important element in reducing the level of misconceptions. Reducing misconceptions in students can be done by strengthening their conceptual and procedural knowledge. The use of additional media, such as virtual laboratories, can present visualizations of abstract concepts in electrical concepts so that students understand more about the concepts they are studying. It makes simulations and virtual laboratories widely used in learning to reduce misconceptions about electrical material.

Conclusion

The concept of electricity is abstract and likely to cause misconceptions in students. Some sub-concepts often detected as misconceptions are in the sub-concept of electric currrent. Many studies that use multimedia assistance in learning are solutions to build conceptual understanding and reduce student misconceptions. The multimedia that is widely used is a virtual laboratory in the form of PhET, which is considered to be able to visualize abstract electrical concepts so that students can construct knowledge correctly. Choosing the right simulation and learning strategy is crucial to reduce student misconceptions, especially in abstract concepts such as electricity.

References

Afra, N. C., Osta, I., & Zoubeir, W. (2009). Students' Alternative Conceptions about Electricity and Effect of Inquiry-Based Teaching Strategies. *International Journal of Science and Mathematics Education*, *7*(1), 103–132. https://doi.org/10.1007/s10763-007-9106-7

Aligo, B. L., Branzuela, R. L., Faraon, C. A. G., Gardon, J. D., & Orleans, A. V. (2021). Teaching and Learning Electricity-A Study on Students' and Science Teachers' Common Misconceptions. *Manila Journal*

10.21107/jps.v12i1.29495 Mulyastuti et al. E-ISSN: 2527-7634

of Science, *14*(October), 22–34.

Andriani, E., Indrawati, & Harijanto, A. (2015). Remedi Miskonsepsi Beberapa Konsep Listrik Dinamis Pada Siswa SMA Melalui Simulai PhET Disertai Lks. *Jurnal Pendidikan Fisika*, *3*(4), 362–369.

Assem, H. D., Owusu, M., Issah, S., & Issah, B. (2024). *Identifying and Dispelling Students' Misconceptions about Electricity and Magnetism Using Inquiry-Based Learning in Selected Junior High Schools*. https://ejournal.bumipublikasinusantara.id/index.php/ajsed

Banda, H. J., & Nzabahimana, J. (2021). Effect of integrating physics education technology simulations on students' conceptual understanding in physics: A review of literature. *Physical Review Physics Education Research*, *17*(2), 023108. https://doi.org/10.1103/PhysRevPhysEducRes.17.023108

Cakir, M. (2008). Constructivist approaches to learning in science and their implications for science pedagogy: A literature review. *International Journal of Environmental and Science Education*, *3*(4), 193–206.

El-Tawargy, A. S., & Elshabaan, M. M. (2023). Charging and Discharging a Capacitor through a DC Circuit: "PHET" Demonstration and Data Analysis. *Scientific Journal for Damietta Faculty of Science*, *13*(1), 135–144.

Eveline, E., & Permatasari, E. (2022). Miskonsepsi pada konsep rangkaian listrik sederhana: digali menggunakan individual demonstration interview berbantuan phet simulation. *Jurnal Pendidikan Dasar*, *10*(1), 114–123.

Fajar, D. M., & Supardi, Z. A. I. (2013). Pengaruh Penggunaan Model Pembelajaran Inkuiri (Inquiry Learning) Terhadap Penurunan Miskonsepsi Pada Materi LIstrik Dinamis Kelas X SMAN 2 Jombang. *Jurnal Inovasi Pendidikan Fisika (JIPF)*, *02*(02), 24–29.

Finkelstein, N. D., Adams, W. K., Keller, C. J., Kohl, P. B., Perkins, K. K., Podolefsky, N. S., Reid, S., & LeMaster, R. (2005). When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment. *Physical Review Special Topics - Physics Education Research*, *1*(1), 010103. https://doi.org/10.1103/PhysRevSTPER.1.010103

Fiscarelli, S. H., Bizelli, M. H. S. S., & Fiscarelli, P. E. (2013). International Journal of Learning Interactive Simulations to Physics Teaching : A Case Study in Brazilian. *International Journal of Learning and Teaching*, *5*(1), 18–23.

Frans, B. U., & Wasis, W. (2022). Penerapan LKS Berbasis PhET untuk Mereduksi Miskonsepsi Siswa pada Materi Arus Listrik Bolak Balik. *Jurnal Penelitian Pembelajaran Fisika*, *13*(1), 31–40. https://doi.org/10.26877/jp2f.v13i1.11529

Hamdani. (2014). DESKRIPSI MISKONSEPSI SISWA TENTANG KONSEP-KONSEP DALAM RANGKAIAN LISTRIK. *Jurnal Pendidikan Matematika Dan IPA*, *4*(1). https://doi.org/10.26418/jpmipa.v4i1.6194

Hernandez, E., Campos, E., Barniol, P., & Zavala, G. (2022). Phenomenographic analysis of students' conceptual understanding of electric and magnetic interactions. *Physical Review Physics Education Research*, *18*(2), 020101. https://doi.org/10.1103/PhysRevPhysEducRes.18.020101

Hidayatulloh, M., Wiryokusumo, I., & Walujo, D. A. (2019). Remidiasi Miskonsepsi Siswa Pada Materi Listrik Dinamis Menggunakan Ebook Interaktif. *Jurnal Pendidikan Fisika Dan Teknologi*, *5*(1), 30–39. https://doi.org/10.29303/jpft.v5i1.986

Hikmawati, H., Kosim, K., & Ayub, S. (2023). Analisis Ketuntasan Hasil Belajar Ranah Kognitif Mahasiswa Pada Perkuliahan Gelombang dan Optik Dengan Menggunakan Media Simulasi PhET. *Journal of Clasroom Action Research*, *5*(2), 360–365.

Ismail, I. I., Samsudin, A., Suhendi, E., & Abstrak, I. K. (2015). *Diagnostik Miskonsepsi Melalui Listrik Dinamis Four Tier Test*.

Ivanjek, L., Morris, L., Schubatzky, T., Hopf, M., Burde, J.-P., Haagen-Schützenhöfer, C., Dopatka, L., Spatz, V., & Wilhelm, T. (2021). Development of a two-tier instrument on simple electric circuits. *Physical Review Physics Education Research*, *17*(2), 020123. https://doi.org/10.1103/PhysRevPhysEducRes.17.020123

Jaakkola, T., Nurmi, S., & Veermans, K. (2011). A comparison of students' conceptual understanding of electric circuits in simulation only and simulation-laboratory

10.21107/jps.v12i1.29495 Mulyastuti et al. E-ISSN: 2527-7634

contexts. *Journal of Research in Science Teaching*, *48*(1), 71–93. https://doi.org/10.1002/tea.20386

López, A. I. M., & Marco, P. T. (2022). Misconceptions, Knowledge, and Attitudes Towards the Phenomenon of Radioactivity. *Science & Education*, *31*(2), 405–426. https://doi.org/10.1007/s11191-021-00251-w

Masita, S. I., Donuata, P. B., Ete, A. A., & Rusdin, M. E. (2020). Penggunaan Phet Simulation Dalam Meningkatan Pemahaman Konsep Fisika Peserta Didik. *Jurnal Penelitian Pendidikan Fisika*, *5*(2), 136–141.

Mbonyiryivuze, A., Yadav, L. L., & Amadalo, M. M. (2019). Students' conceptual understanding of electricity and magnetism and its implications: A review. *African Journal of Educational Studies in Mathematics and Sciences*, *15*(2), 55–67. https://doi.org/10.4314/ajesms.v15i2.5

Mufit, F., Festiyed, Fauzan, A., & Lufri. (2023). The Effect of Cognitive Conflict-Based Learning (CCBL) Model on Remediation of Misconceptions. *Journal of Turkish Science Education*, *20*(1), 26–49. https://doi.org/10.36681/tused.2023.003

Mulyastuti, H., Setyarsih, W., & Jauhariyah, M. N. R. (2016). 2016 Identifikasi Peningkatan Pemahaman Konsep Siswa Materi Dinamika Rotasi Sebagai Pengaruh Penerapan Model Pembelajaran ECIRR. *Pros. Semnas Pend. IPA Pascasarjana UM*, *1*, 255–261.

Obsborne, J., & Hennessy, S. (2003). *Literature Review in Science Education and The Role of ICT: Promise, Problems and Future Directions*. Futurelab.

Peşman, H., & Eryılmaz, A. (2010). Development of a Three-Tier Test to Assess Misconceptions About Simple Electric Circuits. *The Journal of Educational Research*, *103*(3), 208–222. https://doi.org/10.1080/00220670903383002

Pratama, D., Jurusan, #, Elektro, T., & Bandung, N. (2023). *Reduksi Miskonsepsi Mahasiswa pada Prinsip Kerja Kapasitor melalui Penerapan Simulasi PhET*. *12*(2), 91–96.

Ramnarain, U., & Moosa, S. (2017). The Use of Simulations in Correcting Electricity Misconceptions of Grade 10 South African Physical Sciences Learners. In *International Journal of Innovation in Science and Mathematics Education* (Vol. 25, Issue 5).

Ratnaningdyah, D., & Sugiarti. (2024). MEREDUKSI JUMLAH MAHASISWA YANG MENGALAMI MISKONSEPSI FISIKA PADA MATERI LISTRIK DENGAN MODEL PEMBELAJARAN INKUIRI. *Jurnal Inovasi Dan Pembelajaran Fisika (JIPF)*, 175–180.

Rizaldi, D. R., Jufri, A. W., & Jamaluddin, J. (2020). PhET: SIMULASI INTERAKTIF DALAM PROSES PEMBELAJARAN FISIKA. *Jurnal Ilmiah Profesi Pendidikan*, *5*(1), 10–14. https://doi.org/10.29303/jipp.v5i1.103

Rohmah, R. N., Lesmono, A. D., & Harijanto, A. (2017). Identifikasi Miskonsepsi Siswa Pada Pokok Bahasan Rangkaian Arus Searah di Kelas XII MAN 1 Jember. *Prosiding Seminar Nasional Pendidikan Fisika FKIP Universitas Jember*, *2*, 4–7.

Sarni, N., Sukariasih, L., & Anas, M. (2023). Identifiskasi Miskonsepsi Peserta didik Kelas X Pada Konsep Listrik Dinamis dengan Menggunakan Four-Tier Diagnostic Test di SMK Negeri 1 Muna Barat. *Jurnal Penelitian Pendidikan Fisika*, *8*(3). https://doi.org/10.36709/jipfi.v8i3.60

Siantuba, J., Nkhata, L., & de Jong, T. (2023). The impact of an online inquiry-based learning environment addressing misconceptions on students' performance. *Smart Learning Environments*, *10*(1), 22. https://doi.org/10.1186/s40561-023-00236-y

Siong, L. C., Tyug, O. Y., Phang, F. A., & Pusppanathan, J. (2023). The Use of Concept Cartoons in Overcoming The Misconception in Electricity Concepts. *Participatory Educational Research*, *10*(1), 310–329. https://doi.org/10.17275/per.23.17.10.1

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Suparno, P. (2013). *Miskonsepsi dan Perubahan Konsep dalam Pendidikan Fisika*. PT Gramedia Widiasarana Indonesia.

Suprapto, N. (2020). Do We Experience Misconceptions?: An Ontological Review of Misconceptions in Science. *Studies in Philosophy of Science and Education*, *1*(2), 50–55. https://doi.org/10.46627/sipose.v1i2.24

Trisnawati, A., & Eso, R. (2020). Analisis Miskonsepsi Terhadap Materi Rangkaian Listrik Searah (DC) pada Siswa SMK Negeri Kota Kendari Menggunakan Four-Tier Diagnostic Test. *JIPFi Jurnal Penelitian Pendidikan Fisika*, *5*(4), 287–294. http://ojs.uho.ac.id/index.php/JIPFI

Turgut, Ü., Gürbüz, F., & Turgut, G. (2011). An investigation 10 th grade students' misconceptions about electric current. *Procedia - Social and Behavioral Sciences*, *15*, 1965–1971. https://doi.org/10.1016/j.sbspro.2011.04.036

Ulfah, L., Kusasi, M., & Almubarak, A. (2021). REDUCTION OF STUDENT MISCONCEPTIONS: APPLICATION OF TTW-PBL LEARNING WITH CHEMICAL REPRESENTATION ON BUFFER SOLUTION MATERIALS. *Jurnal Pena Sains*, *8*(2), 48–57. https://doi.org/10.21107/jps.v8i2.8610

Upayogi, I. N. T., & Juliawan, D. I. W. (2019). Reduksi Miskonsepsi Melalui Pembelajaran Berbasis Virtual Lab. *Journal of Teaching and Learning Physics*, *4*(2), 45–53. https://doi.org/10.15575/jtlp.v4i2.5611

Yusrizal, Halim, A., & Junike. (2017). THE EFFECT OF INQURY BASED LEARNING ON THE PROCEDURAL KNOWLEDGE DIMENSION ABOUT ELECTRIC AND MAGNET CONCEPT. *Jurnal Pendidikan Fisika Indonesia*, *13*(2), 88–93.

Zacharia, Z. C., & Olympiou, G. (2011). Physical versus virtual manipulative experimentation in physics learning. *Learning and Instruction*, *21*(3), 317–331. https://doi.org/10.1016/j.learninstruc.2010.03001.

10.21107/jps.v12i1.29495 Mulyastuti et al. E-ISSN: 2527-7634