

Developing the adaptive materials based on learning style to increase student's conceptual understanding

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Abstract: This study aimed to develop an adaptive electrical material based on Felder Silverman's learning style that can improve students' conceptual understanding. The method used in this research was the ADDIE research and development method which consists of the analysis, design, development, implementation, and evaluation stages. The data were gathered using learning style tests, concept understanding tests, and questionnaires. The data were then analyzed using descriptive analysis and N-gains. The analysis of the improvement of electrical learning outcomes used normalized gains. Based on the explanation, it can be concluded that the dominant student learning style characteristics are visual and sensing. The test results of the quality of electrical teaching materials with an average of 85.38 categories are very feasible. The results of the conceptual understanding test of students who received adaptive electricity material with an average N-gains of 0.7 categories were very high. The highest N-gains are students with visual and verbal learning styles, namely, 0.72. Based on the combination of the Felder Silverman learning style model, it is 0.73 for students with visual sensing learning style types.

Keywords: *electrical learning material, learning style, concept understanding*

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INTRODUCTION

The COVID-19 pandemic has had a significant impact on the world of education because the social restriction policy makes learning be carried out virtually without face-to-face interaction. Virtual learning is also known as web-based learning, e-learning, or online learning. The implementation of online learning requires knowledge and skills in using technology to avoid boredom in student learning. Therefore, during the covid-19 pandemic, professional teachers are trying to improve the quality of online learning by applying innovative teaching methods. The application of innovative methods in online learning aims to improve the quality of learning (Susilawati, Yasin, & Hambali, 2020; Widyaningsih & Yusuf, 2020).

In online learning, students and learning materials are connected virtually via desktop, laptop, or smartphone media using the internet. Interaction between students and teachers or with material occurs virtually on a desktop, laptop, or smartphone screen that has an internet network. Therefore, without an internet network, online learning cannot be carried out properly, or vice versa; without a desktop, laptop, or smartphone, the material presented

cannot be received properly. Thus, desktops, laptops, or smartphones, and internet networks are the leading media in online learning (Firdaus, Hunaepi, Muliadi, & Fitriani, 2020; Handayani & Jumadi, 2021).

Generally, learning consists of three stages: opening, core activities, and closing. In the opening activity, the teacher greets, prays, and provides motivation to stimulate students to learn. The stimulus provision aims to focus students in the learning process to create a sense of student curiosity about the given problem. Students' curiosity will naturally encourage students to seek knowledge from various sources, do practical work, or have discussions. Student involvement in learning activities directly influences student achievement (Mukaromah, Sugiyo, & Mulawarman, 2018; Sa'adah & Ariati, 2018). Therefore, preliminary activities in the learning process greatly influence the learning process that will take place.

In the core activity, the teacher guides students to learn using methods, approaches, or strategies to help students achieve learning objectives. The method, approach, or strategy used should be by the material discussed. In delivering learning materials, the teacher must try so that students can be maximally involved in the learning process. The involvement of students in the learning process can be in the form of seeking various information from various sources, discussing, experimenting, and doing the assigned tasks. The involvement of students in learning will impact the knowledge gained by students. In the closing activity, the teacher evaluates the learning activities carried out by carrying out various activities, including concluding,

Online learning activities include several activities, including opening greetings and reflecting on previous material through chat, or forums; delivery of materials by sending files in the form of text files, or videos or in the form of links that can be downloaded or read online; and closing by evaluating in the form of assignments sent via chat or included in the submitted material.

Online learning steps like this are still teacher-centered, so they do not provide sufficient opportunities for students to reflect on the material presented as new knowledge and do not provide students with the flexibility to apply the material (Kaymakamoğlu, 2017; Serin, 2018).

An effort to improve the learning process in the e-learning environment is to increase involvement in the learning process. The material in e-learning is packaged in the form of interactive multimedia, teaching materials, lecture assignments, online discussions, learning videos, and even video conferences (Shchedrina, Valiev, Sabirova, & Babaskin, 2021). E-learning enables interaction through the planning, implementation and evaluation stages (Nasser, Cherif, & Romanowski, 2011) connected to the internet (Lonn, Teasley, & Krumm, 2011) so the material can be used anytime and anywhere (Ain, Kaur, & Waheed, 2016).

PGRI University has built LMS-based e-learning to improve the quality of learning since 2018. All e-learning features work well and can be used for online learning. The e-learning system of the PGRI Palembang university provides the same material for each student. In this case, it cannot be denied that every student has different learning characteristics from one another (Hakim, Setiawan, & Sinaga, 2016; Setiawan, Sudomo, & Hasanah, 2019). Learning style is a student characteristic that is often used in developing adaptive e-learning and shows better results than without paying attention to student learning styles (Newton & Miah, 2017). Student learning styles relate to the way students receive, remember, and manage the information they receive. Therefore, the information

received by students will be appropriately processed if the information is in accordance with the student's learning style.

Efforts to improve student learning outcomes by applying learning styles to an adaptive e-learning system to accommodate differences in student characteristics such as learning styles (Ahmed & Hina, 2019; Christudas, Kirubakaran, & Thangaiah, 2018; Hakim, Setiawan *et al.*, 2016). Adaptive e-learning consists of three components: the student model, the pedagogical model, and the content model (Glushkova, 2015). Adaptive e-learning can present different materials according to student needs. Therefore, besides improving learning outcomes, adaptive e-learning can also increase satisfaction with the material presented (Denphaisarn, 2014).

The problem in the adaptive e-learning system is creating content that suits each student's learning style (El Guabassi, Bousalem, Al Achhab, Jellouli, & El Mohajir, 2018). Learning style is the right technique or method for students to learn, understand and get information (Sadhasivam & Babu, 2017). There are several models of learning styles (Hashim, Salam, Nurul, & Mohamad, 2017) with different classifications and descriptions. However, Felder Silverman's learning style describes student learning styles in more detail than other learning styles, and students with high preferences for specific behaviors can sometimes take different actions so that they are used in learning hypermedia and are very appropriate for open learning models (Fasihuddin, Skinner, & Athauda, 2017; Hashim *et al.*, 2017).

Felder Silverman's learning style consists of four dimensions that indicate the learning tendencies of each student, namely the processing dimension (active or reflective), the input dimension (visual or verbal), perception (sensitivity or intuition) and understanding (sequential or global) measured using the Index of Learning Style (ILS) Questionnaire.

The development of electronic learning materials based on the characteristics of the Felder Silverman learning style model affects student learning success in online learning (Chang, Hung, & Lin, 2015). Therefore, students are grouped based on Felder Silverman's learning style in order that each student gets electrical learning materials according to their respective learning styles.

The research aims to develop the electrical learning materials presented in e-learning based on Felder Silverman's learning style. The adaptive e-learning learning system presents material according to each student's learning style. Thus, in this study, the adaptive learning system presents different material for each student according to their respective learning styles. The difference in the material presented to students is in accordance with Felder Silverman's learning style characteristics. Dimensions of visual or verbal learning styles, which are part of the Felder Silverman learning style model, will train students to change the representation of the material given. Students with visual learning styles will get the dominant material presented in graphics or images and are trained to change representations in verbal form and vice versa. Therefore, developing adaptive electricity learning materials based on the Felder Silverman learning style can improve students' conceptual understanding.

The use of e-learning makes it easy to distribute the material to each student with various characteristics because e-learning has various materials stored in a database that can be called up when students need it. Even though students are in the same class, students can determine the material they will study for themselves. Therefore, students have the freedom to choose the material they prefer. Thus, the existence of adaptive material is an important part of the development of adaptive e-learning to help students learn material according to their learning style.

Concept understanding is the ability of students to understand every situation encountered in everyday life. Various research data are displayed in the form of tables or graphs that show trends in certain situations. With the ability to understand tables or graphs, students can conclude the actions taken in each situation. Thus the ability to understand students' concepts can help students optimally take advantage of every opportunity that exists. Therefore, using electric materials based on the Felder Silverman learning style can improve students' conceptual understanding.

METHOD

The method used in this research was the ADDIE research and development method which consists of the analysis, design, develop, implementation, and evaluation stages. In general, the research phase is divided into two phases, namely the development phase of the adaptive electrical material and the phase of testing the effectiveness of the adaptive material.

The adaptive material development phase aims to obtain adaptive electrical material based on the Felder Silverman learning style, consisting of several stages, namely, the analysis phase, the design phase, and the development phase. The product effectiveness testing phase aims to determine the effectiveness of the adaptive electrical material products developed in improving students' conceptual understanding.

The analysis stage was the needs analysis stage to build rationality for developing adaptive electrical materials based on the Felder Silverman learning style, which included an analysis of the feasibility and requirements for the development of adaptive electrical materials. The needs analysis consisted of several activities, including curriculum studies of electrical learning outcomes, analysis of electrical content from learning sources, including printed and electronic sources, and studies of student and lecturer perceptions of electrical materials in learning. Student perception included learning resources for electrical materials, presentation of electrical materials for electrical learning activities, interest in learning electrical concepts, and learning style tests based on the Felder Silverman learning style model.

The design stage aimed to design products at the concept level. At this stage, the design of adaptive material products based on Felder Silverman's learning style and evaluation instrument was carried out to determine the effectiveness of the products developed. The evaluation instrument was the basis for improving the developed product. Some of the activities carried out at the design stages are designing learning objectives, the flow of presentation of adaptive electricity material, and adaptive electricity content according to student characteristics, the lattice of concept mastery test instrument, and perception questionnaire on the product being developed.

The development stage was realizing the conceptual framework obtained at the product design stage. Activities in the development phase include the preparation of adaptive materials, material validation, and product and instrument testing.

The implementation of the product was carried out in an elementary teacher education study program at a university in the city of Palembang. The implementation stage was the stage of testing the product's effectiveness in improving students' conceptual understanding. The product effectiveness testing phase aimed to obtain a complete picture of the effectiveness of adaptive materials in improving students' conceptual understanding.

The evaluation stage aimed to review the impact of adaptive electrical materials in a critical way, analyze indicators of understanding the highest concepts that can be improved

during the application of adaptive materials, and seek information on the best way to present electrical materials to students. At the evaluation stage, an analysis of the data obtained be carried out. Quantitative data obtained during implementation is used to determine the effectiveness of adaptive e-learning in improving students' understanding of concepts.

The instrument used in this study consisted of a questionnaire and a test. Questionnaires are used to find out expert responses to the resulting electrical material products for e-learning. Felder Silverman learning style questionnaire to find out the learning styles of students who take electricity lessons. The results of the learning style test are used as the basis for grouping students in taking electricity lessons. Concept understanding test to determine the effectiveness of the electricity meter on improving students' electrical learning outcomes. The test questions, before being used were validated by experts and tested to determine the reliability of the instrument. The concept understanding test is in the form of multiple choice.

Analysis of the improvement of electrical learning outcomes used normalized gains. The normalized category of normalized gains effectiveness consists of high, medium, and low.

FINDING AND DISCUSSION

Analysis of the needs for the availability of facilities and infrastructure to support internet-based learning based on the results of interviews with students and lecturers who are experts in elementary school science concepts. Interviews with students covered the availability of the internet network and the frequency of accessing the internet. The results of interviews with students can be seen that each student has an internet network through a smartphone cellular network and a cable network, so that it can be concluded that electricity learning through adaptive e-learning based on student learning styles can be applied.

Analysis of the electrical content is conducted based on the search for learning resources for elementary science concept courses, curricula, and research articles, especially in science education. The results of the elementary science concept analysis of electrical material can be seen that the electrical concept is presented in the form of pictures or theoretical explanations. The material discussed is primary material about electrical concepts close to students' real lives. Therefore, a detailed explanation using pictures or verbal is very much needed in students' electricity learning.

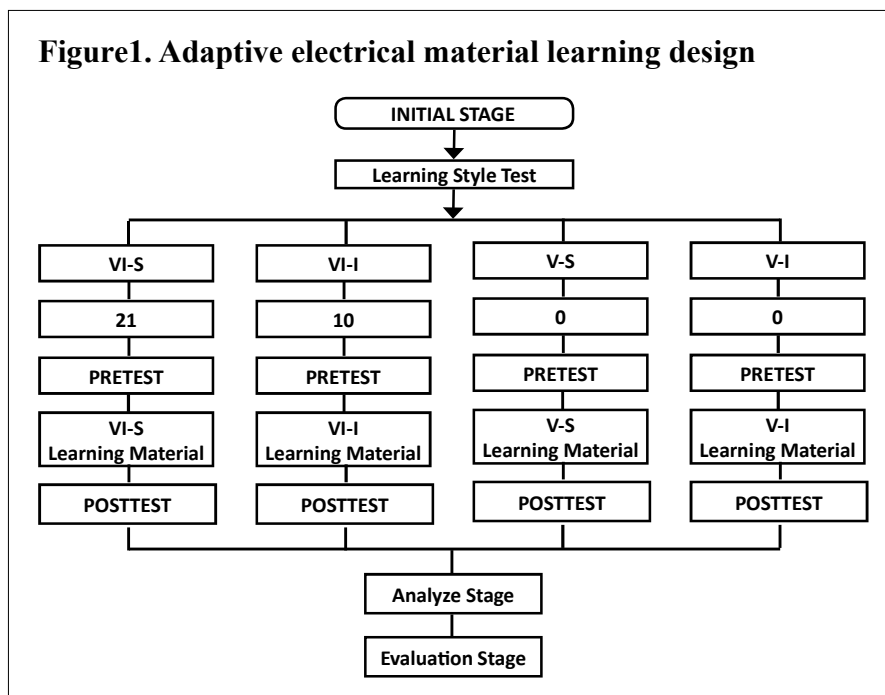
The development of electrical material begins with the Felder Silverman learning style test. The test results based on the Felder Silverman model are shown in Table 1. The results of the learning style test show that most students have visual learning references (Tatar & Şeker, 2019). Students with visual learning styles can understand the information they receive best and most efficiently if it is presented in the form of pictures, diagrams, or other visual forms. In addition, the dominant student learning style is sensing rather than intuitive. Sensing learning style tends to be with concrete materials and natural phenomena. Thus, the most prominent dimension of student learning style is Vi-S (Hashim *et al.*, 2017). Visual sensing students learn best when the material is presented visually with concrete phenomena.

Abstract concepts or phenomena are presented in visualizations so that they are easier for students to remember (Lindgren, Tscholl, Wang, & Johnson, 2016; Widiyatmoko, 2018). Thus, the electrical material presented in the form of mathematical equations equipped with a graph of the relationship between variables can help students understand abstract concepts.

Table1. Felder-Silverman student learning style characteristics

Learning Style	Frequency	Total
Visual	67%	20
Verbal	33%	10
Sensing	71%	21
Intuitive	9%	9

Based on the learning style test results, learning activities were designed using adaptive electricity material. Learning designs using adaptive materials are shown in Figure 1.



The design of presenting electrical material based on the Felder Silverman learning style is in accordance with the steps of complete learning (material learning). Complete learning states that each student can master the learning material in the different time needed. The complete learning model provides broad opportunities for students to learn according to their individual wishes. Complete learning is more effective in increasing the mastery of heterogeneous students' concepts (Pertwi, 2019). In the complete learning system, students themselves determine the material to be studied according to student needs. In addition, students themselves determine the exercises to be done and correct each exercise independently. Increased mastery of concepts is influenced by student learning independence (Sanita, Elisa, & Susanna, 2021). Therefore, using the complete learning style model, the electric material based on the Felder Silverman learning style can train students' independent learning.

The development stage is the stage of production and preparation of adaptive electrical materials. Experts validate the developed product to ensure that the adaptive electrical

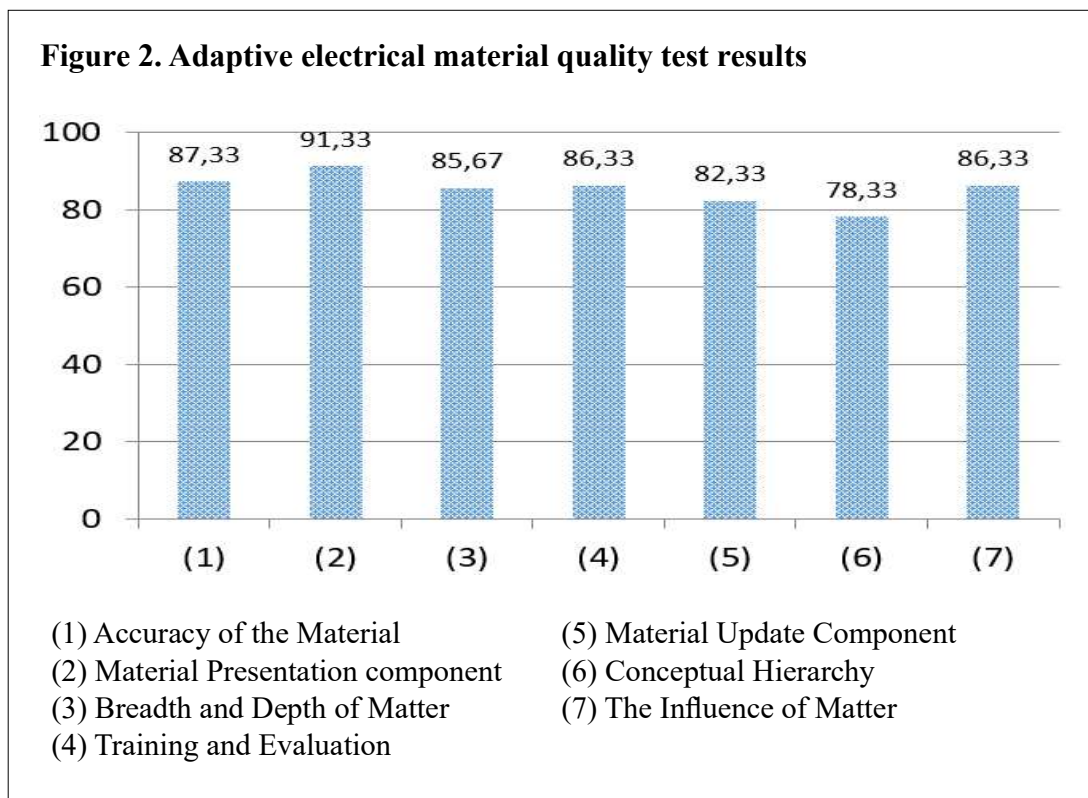
material complies with the content standards. Validation includes the suitability of indicators with Competency Standards (SK) and Basic Competencies (KD) and conformity between the concept of electricity and indicators, SK and KD. The validation results show that all validators state that the indicators are in accordance with KI and KD and the concept according to the learning indicators. Therefore, the electrical material product developed is valid according to the expert. Products in the form of valid teaching materials can improve student learning outcomes for the cognitive domain and increase student learning motivation (Wati, Hakim, & Lia, 2021).

Although all experts stated that the aspects assessed were appropriate and valid, there were some suggestions and recommendations to improve the material quality. Some examples of electrical problems and exercises use contextual values that were previously used in arbitrary examples of questions and exercises. The purpose of using values contextually is to help students understand the measurement results they encounter in everyday life. The use of operative words or measured verbs to express learning indicators such as understanding the electric field caused by two-point charges becomes able to calculate the electric field strength caused by point charges.

The electrical material that is declared valid is then tested to determine the quality. The initial trial consisted of testing the main idea and testing the quality of teaching materials. Suitable teaching materials if students easily understand them. Students' understanding shows students' understanding of adaptive electricity material in determining the main ideas of the paragraphs presented. The results of the main idea test show that 80% of students can determine the main idea well. Materials with a high level of understanding can be used as independent teaching materials because the reader's understanding of the main idea is an important element in adaptive electricity material in text form.

Testing the quality of teaching materials is carried out using textbook assessment instruments adapted from BNSP and textbook assessment instruments (Sinaga, Suhandi, & Liliyasi, 2014). The assessment instrument for teaching materials was distributed to lecturers who are competent teachers of elementary science concepts at one of the private universities in Palembang. The assessment carried out by the lecturer consists of several aspects, including the accuracy of the material, the presentation of the material, the breadth and depth of the material, practice and evaluation questions, the component of up-to-date, concept hierarchy, and influence. To improve the quality of the adaptive electrical material, validators can provide input or suggestions. The adaptive electrical material quality test results are shown in Figure 2.

Based on Figure 2, in general, the lecturer's response to the quality of the adaptive electrical material is, on average, 85.38 with a very decent quality category (Chania, Medriati, & Mayu, 2020). The material presentation component gets the highest score compared to other components. The presentation of adaptive electrical material is an important component because a good presentation of the material will increase students' interest in learning, foster curiosity, and help students understand the concept (Parong & Mayer, 2018). The presentation component includes the harmony of the letters with the content, concept illustration images, and concept descriptions. The description of the concept uses communicative and easy-to-digest language with the main idea of a paragraph that students easily understand. These results indicate that the paragraph's main idea on the presentation of adaptive electricity material has a big role in improving the quality of teaching materials (Hakim, Sinaga *et al.*, 2018).



However, the concept hierarchy indicator has the lowest average compared to other indicators. with an average of 78.33. Although the concept hierarchy indicator has the lowest average, the average concept hierarchy in the category is feasible. The concept hierarchy shows that the propositions used to relate a concept to other concepts are quite clear, and the writing organization moves from general to specific or vice versa from specific to general so that it can guide students to understand the concepts presented.

Implementation of adaptive electricity material aims to determine the effectiveness of adaptive electricity material in improving students' understanding of concepts. Effectiveness is seen from the normalized gain of students' conceptual understanding after participating in learning using adaptive electricity material. The pretest, posttest and n-gain results are shown in Figure 3.

Figure 3 shows the N-gains of students' understanding of electrical concepts in implementing adaptive electricity material is 0.7 in the high category. These results indicate that adaptive electricity material can greatly improve students' conceptual understanding. Increased understanding of concepts is caused by the material presented to students in accordance with student learning styles (Bire, Geradus, & Bire, 2014). In addition, providing materials according to students' learning styles can improve students' mathematical reflective thinking skills (Nindiasari, Novaliyosi, & Subhan, 2016). These results indicate that providing material according to students' learning tendencies can effectively improve students' understanding of concepts (Khuluq, Abidin, & Ulfa, 2021; Widiawati, Widiawati, Hikmawati, & Wahyudi, 2018).

Students' conceptual understanding is based on Felder Silverman's learning style index for the perceptual and input dimensions, as shown in Table 2. The N-gain for the visual and sensitive dimensions has the same average and is higher than the verbal and intuitive

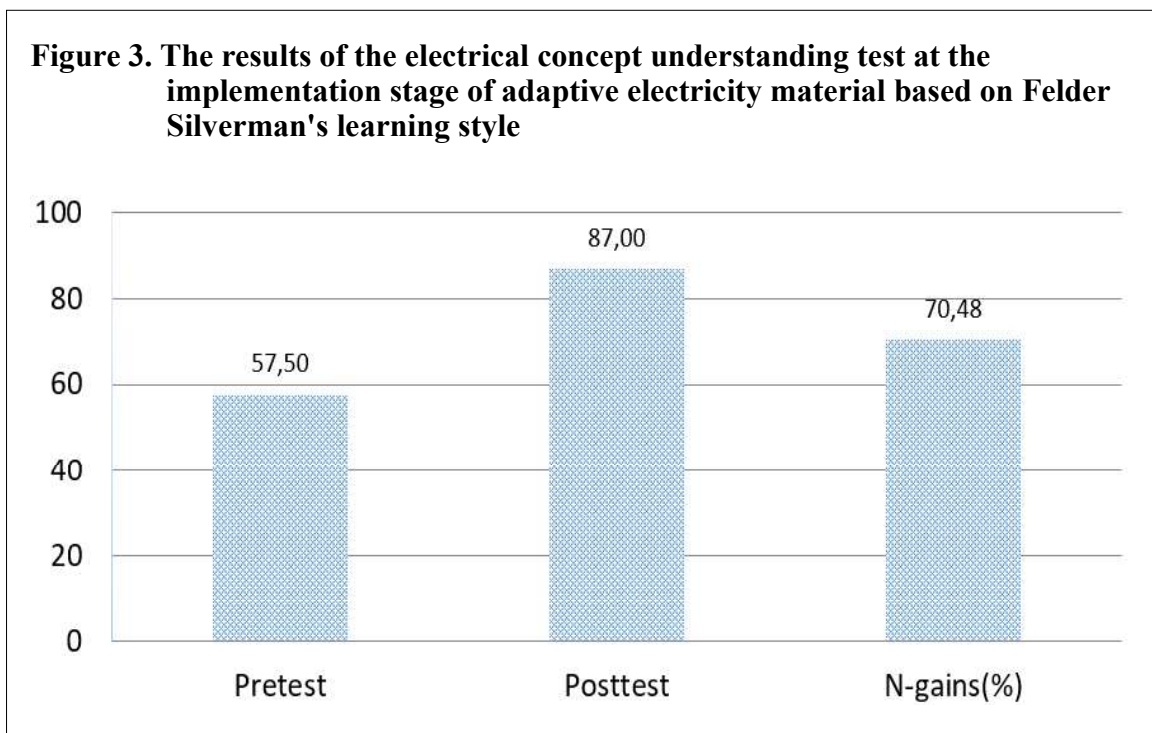


Table 2. Concept understanding test results based on Felder Silverman's learning style index

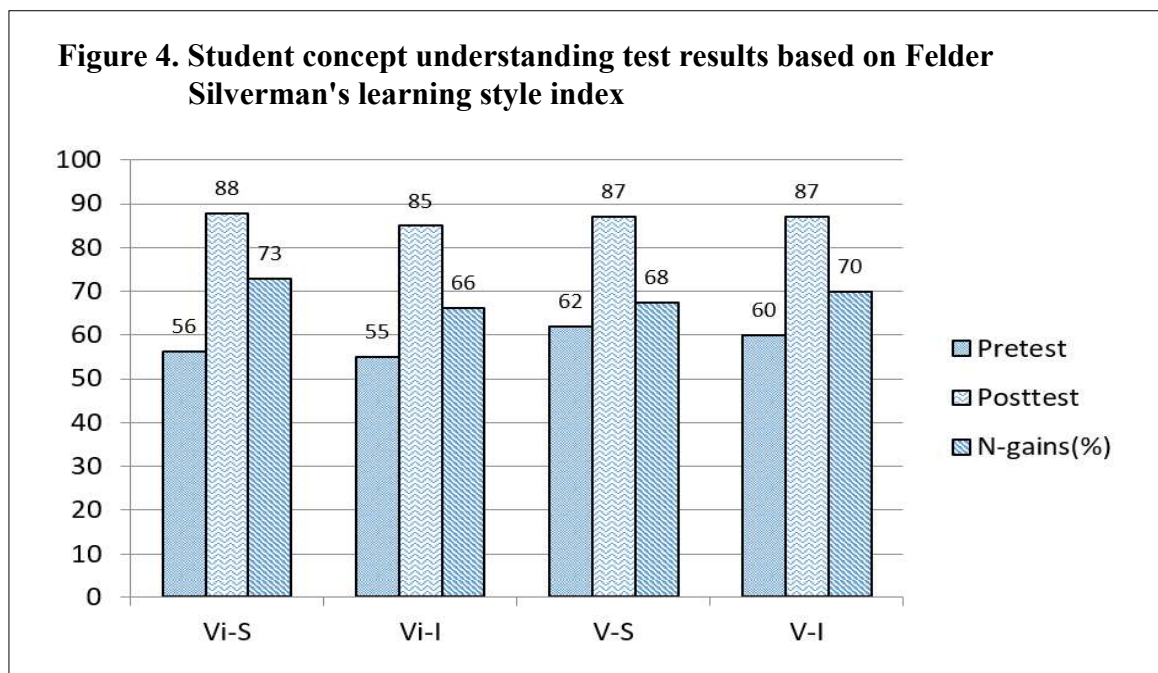
Test Results	Dimensions of Learning style			
	Input		Perception	
	Visual	Verbal	Sensitive	Intuitive
Pretest	56.00	61.00	57.62	57.78
Posttest	87.25	87.00	87.62	86.11
N-gains	0.72	0.69	0.72	0.68

dimensions. The visual dimension shows that the tendency of students to learn is better if it is presented in visual form than in the form of lectures or explanations in text form. In addition, the post-test results of the visual group were also higher than students with verbal learning styles. These results show that material visualization can help students understand concepts better than delivering material in a text (Milana & Jannati, 2018; Pratama & Saregar, 2019). However, if you look at the results of the pretest group of students with verbal learning styles, they are higher than visual styles. These results support the opinion that students with verbal groups have a better understanding of concepts than students with visual styles (Tristanti & Sudarti, 2021). Students with visual learning styles are more likely to use materials presented in the form of more detailed illustrations that can help students understand abstract concepts. The results of this study indicate that students who take electricity lessons are not familiar with abstract concepts so the presentation of abstract concepts needs to be displayed in detail so that they become more concrete (Pangestu, Mayub, & Rohadi, 2019).

This result is also supported by the dimensions of the perception of students' learning styles. The N-gains of conceptual understanding of students with sensitive learning styles

are higher than those with intuitive learning styles. Students with sensitive learning styles can easily understand the material presented in a concrete and contextual form. Contextual examples are more attractive to sensitive students than physics formulas. In learning activities, students are presented with materials related to actual and current problems to be more interesting for students. Learning activities with contextual topics can make learning more interesting to improve students' understanding of concepts.

Based on Figure 4, the general posttest results for the combination of learning styles based on the model dimensions of Felder Silverman's learning style index have no significant differences or similarities. However, the highest post-test results were found in students with the Vi-S learning style, which showed that the best student learning tendencies used concrete material presented in visualization. These results support the results of developing adaptive electrical materials based on Felder Silverman's learning style by providing contextual concrete material. Adaptive electrical material based on Felder Silverman's learning style which is presented in visual sensing, is most effective in improving students' conceptual understanding compared to the material presented in intuitive visual form.



Improving understanding of concepts occurs in students with intuitive visual learning styles. Intuitive visual material is presented in the form of abstract visual material. Developing intuitive visual material is the most difficult stage of development in this research. This is because the definition of intuitive visual material is still not very strong. This study material needs to be considered in further research studies. In addition, these results contradict the statement that students with intuitive learning styles have higher abilities in mathematics and theory than students with sensing learning styles. Based on these findings raises suspicion about the problem of understanding the electrical concepts used in the study.

Students with better mathematical abilities will tend to ask questions in the form of mathematical equations. Problems presented in pictures are less attractive to students than

problems presented in the form of mathematical equations. This is because students are usually trained with routine questions without being actively involved in the learning process. Therefore, it is necessary to learn electricity by involving contextual problems in training students to solve the problems they face in everyday life.

Based on the study results, in general, the increase in students' concept understanding of test results in the high category. Although the results of improving students' understanding of concepts are good, some of the obstacles in the development of adaptive electrical material based on the dimensions of the perceptual learning style and information input of Felder Silverman, among others, are whether Felder Silverman's learning style is hierarchical or has the same level. This is based on the fact that the visualization of concepts or materials is an aid to students to achieve higher material. If a student has not achieved the learning objectives of material, then he is given verbal assistance.

In learning the first aid given to students in the form of verbal, students achieve the desired goal, then given assistance in visual form so that students more readily accept it, likewise, with the sensing and intuitive dimensions. If students have problems understanding concepts in abstract form, they are assisted by providing concrete examples. Therefore, students in the early stages are best-given material in the form of visual sensing. This is strong because the material developed is electrical material for elementary school teacher education students prepared to become elementary school teachers. The concepts given to elementary school teacher students are initial concepts that require natural visualization in the form of concrete examples.

CONCLUSION

Based on the explanation, it can be concluded that the dominant student learning style characteristics are visual and sensing. The test results of the quality of electrical teaching materials with an average of 85.38 categories are very feasible. The results of the conceptual understanding test of students who received adaptive electricity material with an average N-gains of 0.7 categories were very high. The highest N-gains are students with visual and verbal learning styles, namely, 0.72. Based on the combination of the Felder Silverman learning style model, it is 0.73 for students with visual sensing learning style types.

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