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Development of SKORLP Four Tier Test Form Diagnostic Test Instruments to Identify Conception Profiles of Parallel Electrical Circuits

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Abstract

Researchers developed the Parallel Electrical Circuit Online Conceptual Survey (SKORLP) instrument into a four-tier diagnostic test. The purpose of the study was as a first step in the development of the SKORLP four-level test format into a diagnostic test instrument on Parallel Electrical Circuit materials. The research method used is a 4D model (Defining, Designing, Developing, and Disseminating). The instrument developed has been tested on 23 students in one of the MTs of South Jakarta. From the results of the study, it was found that the development of SKORLP in the form of a four-tier test allows it to be presented online and has great potential in producing student conception profiles in the parallel electrical circuit material, that is, students who understand the concept of Sound Understanding (SU), understand but partially or Partial Understanding (PU), misconceptions or Misconceptions (MC), do not understand the concept of Parallel Electrical Circuits at all or No Understanding (NU).

INTRODUCTION

Ideas or knowledge abstracted from a real event are interpreted by concepts, so it can be concluded that concepts represent things that are abstract from facts or realities that occur in everyday life. Concepts help in simplifying, summarizing and organizing information. Imagine if in the world there is no concept, then we will not be able to formulate a problem and cannot solve the problem.

With concepts, we can understand the world and help us in remembering so that everything becomes more efficient. Students form a concept because they experience firsthand the objects and events that occur around them, as well as through the experiences involved with symbols such as words. Some concepts become relatively simple, clear, and real, but in contrast, some concepts are complex, vague, and abstract. People will easily agree on the meaning of babies, youth, and parents because the concepts of these words are real, but some people will become difficult to understand, for example, the theory of economic collapse and so on because the concepts of these words are abstract. Therefore the concept is categorized into two i.e. real and formal [1].

In science, when learning a concept there will be three different conditions [2], [3], including: (a) Students do not have prior knowledge of a concept when they are going to learn the concept, then in this case there will be lost knowledge or learning occurs so that there is an addition of new knowledge. (b) Students have some prior knowledge (incomplete knowledge) about a concept when

going to learn the concept, then in this case the learning that occurs can fill in the gaps of knowledge. (c) The student has obtained ideas about the concepts to be learned either from school or from daily experience, but there is a conflict between the previous knowledge and scientific knowledge, so in this case, the student experiences a misconception.

The framework of a conception is a network of interrelationships between concepts and will provide a comprehensive understanding of a phenomenon. The main features of the framework of a conception [6], are as follows: (a) A conceptual framework is not just a set of concepts but rather a construction of each concept that plays a role as a whole. (b) The framework of a conception provides an approach that relates to social reality. (c) The conception framework provides an understanding of a thing. (d) The conceptual framework can be developed and constructed through a process of qualitative analysis.

The analysis of a conception usually aims to generate concepts and ideas. If the conception that exists in the student corresponds to the scientific conception of the experts, then the conception is considered a scientific conception. On the other hand, if the conception possessed by the student does not correspond to the conception expressed by experts and the student believes in the correctness of the conception, it can be said that the student has experienced a misconception.

Misconceptions are false beliefs in a person's mental model. Misconceptions are also wrong ideas about a concept. Often the misconceptions found are so firmly enduring that they are difficult to change [2], [3]. Misconceptions are also described as a repetitive and sedentary mindset but do not conform to the scientific conceptions of experts [7]. Misconceptions are also described as alternative conceptions, preconceptions, children's scientific thinking, preconceived notions, non-scientific beliefs, naive theory, mixed conceptions or misconceptions [8].

Experts view the importance of the dangers of the condition of misconceptions experienced and believed by students because: (1) its conception is always different from that of scientific concepts; (2) it is sedentary, will continue to be used by students, and tends to be difficult to change; and (3) difficult for teachers to detect. If a student has a misconception, then they will transfer the misconception to the next level of learning and will cause another misconception. If misconceptions occur at a higher level of education it will result in a person with a low level of professional life [7].

Many things can be the cause of misconceptions, including inaccurate information, the truth can be easily obtained from electronic media. Over the past ten years, it has shown very rapid growth in the use of information technology. Increased ownership of computers and gadgets makes access to the internet easier. The internet is also used in the world of education. Students use internet facilities in doing schoolwork, digging for various information using search engines such as Google, Yahoo, and so on. However, the students do not have the ability and knowledge to judge the correctness of the information obtained by them. Anyone can create a website and load information on it without checking its accuracy. While students also receive information from the internet without considering sources that are accurate and believed to be true. Students tend to copy without worrying about the reliability of the source. This causes mistakes in learning and eventually causes misconceptions, so the role of teachers is needed in direct students to use the internet on the right sites [9], [10].

Many concepts of physics in the field of electricity are abstract, as well as difficult to study and learn for real. Electrical matter is one of the basic materials in Physics. Its application covers many aspects of everyday life such as the use of modern technological equipment that uses the concept of electric current matter. Thus, many students have difficulty understanding electrical concepts, especially in electrical circuits, and eventually experience misconceptions [11], [12]. Misconceptions in students found by experts on series and parallel circuit materials for example in the characteristics of currents and voltages contained in the circuits [13]–[15].

The daily life that students experience will shape sedentary experiences and beliefs. Immature thinking skills will give rise to misconceptions that hinder the assimilation of science. Ways to eliminate misconceptions and achieve meaningful learning, the accuracy of knowledge, and misinformation must be changed to pave the way for new knowledge. This process is called conception alteration [16].

According to cognitive theory, the student will build an understanding that for him is reasonable and coherent derived from phenomena that exist in nature and from their point of view. For better

understanding and meaningful learning, then misconceptions must be rehabilitated. While learning is best seen as a process of changing conception [17]. Conception alteration is the alteration or modification or rejection of one's conception beliefs when in the anomalous situation [18], [19].

If the misconception is to be changed it must go through a process of changing conceptions involving cognitive conflicts and finally changing the cognitive structure of students [2], [3]. Several conditions must be met for the conception change to be passed by students properly [18], [19], among them: Dissatisfaction, the student is in a state of realizing that the concept he has is inadequate. In clarity, students get new concepts that are understood. It makes sense, the student discovers a new concept that is reasonable and imaginable in his mind. Fruitful, new knowledge is formed and students can solve the same problems using new concepts they have.

In the level of understanding, students learn something from reading activities, discussions, and practical activities, and can answer questions about previously stated concepts so that students can reason and finally reach an understanding of the concepts they learn. There are five levels of understanding that students gain from the learning process [20], that is, a good understanding of the concept (S), at this level the student has complete knowledge of a concept and can appropriately apply the concept to the new situation he faces. Concepts are partially understood (P), at this level, students understand concepts correctly but incompletely. Students often understand concepts partially, giving rise to partial misconceptions (*Specific Misconception*/SM). Students do not understand the material being taught and misconceptions are partially developed when the new material is combined with knowledge already possessed by previous students. Students do not understand the material at all (*No Understanding* / NU). Students have absolutely no pre-knowledge that relates to the concepts taught. The results are commonly classified with no response (*No Response*/NR).

Meaningful learning according to David Ausubel is a process in which new information is connected with relevant concepts and is formed in a person's cognitive structure so that changes will be produced in the cognitive structure of students, and students' concepts of knowledge are modified and new knowledge networks will be formed [21]. There are fundamental problems to be able to realize the occurrence of conception changes in students so that meaningful learning occurs as an effort to determine the profile of student conception. Through investigation and identifying the conditions of conception, by re-establishing and internalizing the knowledge of students so that finally a scientific conception is formed [7], [22]. A teacher can help change conceptions in students, one of which is through diagnostic tests.

Diagnostic tests are currently most commonly used in detecting students' level of conception and several studies regarding misconceptions have so far been carried out [23]–[25]. Diagnostic tests are similar to multiple-choice tests in terms of structure, but there is a reasonable explanation section that requires students to explain the reasons for the answers given earlier. By investigating these reasons, researchers and teachers can detect the condition of the conception of students [26]–[28].

Diagnostic tests used in learning as one of the methods of assessment have several functions [29] among them: Used to find out the strengths and weaknesses of students on a concept so that they can provide input to teachers and students to make decisions related to improving the teaching and learning process. As a meaningful source of information to know the quality of teaching a teacher and assist the teacher in determining strategies in teaching. A record of learner learning progress can also be obtained from the assessment results. Become a theoretical and practical guide, so that the feedback provided from the results of diagnostic tests can be used to improve the quality of teaching and learning.

Among the advantages of multiple-choice diagnostic tests, there are several disadvantages [7], [30]–[33], among them: It is open to the possibility of guessing the answer. The answer choices are given often do not provide broad insight into the students' ideas and understanding of their conceptions. Students are required to choose answers among limited answer choices, preventing students from building, organizing, and presenting their answers. The correct answer to the correct reason and the correct answer to the wrong reason are indistinguishable.

To avoid the possibility of the occurrence of correct answers from false reasons (false positives) and wrong answers while students have the right reasons (false negatives), and to emphasize the importance of accuracy in the act of selecting multiple-choice tests, other diagnostic tests such as tier

tests, two-tier tests, and three-tier tests were developed. Diagnostic tests in the multiple-choice form are often used because they can reach a large enough number of respondents [7].

Various multi-tiered multiple choice diagnostic test instruments such as tier tests, two-tier tests, and three-tier tests on physics concepts are made by experts to find out the level of conception of students [32], [34], [35]; [36]. To be able to overcome the shortcomings of the multilevel diagnostic test in the form of a multiple choice one-tier test, a two-tier test, and a three-tier test diagnostic test was developed. In the end, to overcome the shortcomings of the three-tier test, the researchers developed a four-tier test [32], [34]. The four-tier test structure consists of tier-1 in the form of ordinary multiple-choice test questions, tier-2 in the form of the level of confidence of the answers given in tier-1, tier-3 in the form of answer reasons from tier-1 that ask for reasoning, and tier-4 is the level of confidence in the reason for the answers in tier-3 [37].

The identification of student misconceptions is considered more accurate by using the Four-tier test, luck in guessing or lack of confidence, and the student's lack of knowledge can be measured by answers at the confidence level. It is considered important to avoid the percentage of students who misconceptions of false positives, false negatives, and lack of knowledge, since each of these conditions requires different remediation and treatment even though each is related to the student's conception [7], [38]. Another advantage is that the relationship between one tier and its two tiers provides evidence of the validity of the construction of the instrument, the percentage of false negatives and false positives can be estimated without conducting an interview providing evidence of the validity of the content, and misconceptions can be estimated more accurately with the acquisition of student scores [38].

The four-tier test format is used to diagnose a student's conception profile on a physics concept. There are several four-tier test instruments made by experts and used to identify student conception profiles including the concept of Dynamic Fluids [39], [40], Energy and Momentum [41], Temperature and Heat [42], [43], Optical Tools [44], Vibration [45], Migratory Ocean Polluters [46], Hydrostatic [47] etc.

The conception profile of students is needed by the teacher to make improvements in the teaching process and determine teaching strategies in the classroom. Four-tier diagnostic tests are believed to be used to investigate and identify conception profiles. With proper handling of each conception profile, it is hoped that it can realize the occurrence of conception changes and form scientific conceptions to replace student misconceptions. Parallel Electrical Circuit material contains a lot of abstract content so it is difficult to understand and understand which ultimately leads to misconceptions.

To be able to obtain a student conception profile on the Parallel Electrical Circuit material, a four-tier diagnostic test instrument IS needed SKORLP (Online Conceptual Survey of Parallel Electrical Circuits). Diagnostic tests are generally presented paper-based, but with the distance learning carried out by students during this pandemic, SKORLP is presented online using Microsoft Form. Then, as a limitation in this study, which is only focused on instrumenting the four-tier diagnostic test, SKORLP does not arrive at the intervention of handling the conditions contained in the resulting student conception profile.

RESEARCH METHODS

This research is development research on the instrument of a two-tier diagnostic test into a four-tier diagnostic test which is used to identify student concession profiles on Parallel Electrical Circuit material. The development model used is 4D [48]. *Defining, Designing, Developing,* and *Disseminating* are stages in 4D development. The data analysis carried out consists of validity and reliability analysis.

Analysis using CVR (Content Validity Ratio) was performed before the instrument was tested [49]. Scoring on item answers using this method is an approach to content validity to determine the suitability of items to domains measured based on expert decisions, to find out the degree of conformity as in Table 1 and categorized levels as in Table 2

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}}$$

Description:

n_e : number of respondents who answered Accordingly or Yes
N : number of experts who perform validation

Table 1. Index Terms

Index Terms	When less than 1/2 of the total number of experts validating the answer is Appropriate or Yes then the value CVR = -
	When 1/2 of the total number of validating experts answered Appropriate or Yes then the CVR value = 0
	When the entire number of experts who validated answered Accordingly or Yes then the CVR value = 1 (this is set to 0.99 adjusted to the number of respondents)
	When the number of validating experts who answered Accordingly or Yes is more than 1/2 of the total number of validated experts then the CVR value = 0 - 0.99

Table 2. CVR index categorization

CVR Index	Information
0 – 0,33	Non-conforming
0,34 – 0,67	Appropriate
0,68 - 1	Very Appropriate

Table 3. Categorization of conception test validation score percentages

Category	Percentage Score
Good	>75%
Enough	56% - 75%
poor	40% - 55%
Not good	<40%

The validity of the instrument in the form of the validity of the content is carried out by asking for the consideration of experts and the trials carried out in one of the first secondary madrasahs in Jakarta that is a student who has studied the material of the Electrical Network material in a different class with the class to be taken the profile of the conception based on the validation data of the material conception test.

In determining the reliability of the test in this study, it is to use the single test double trial technique, which is to test the same instrument twice. Then the results of the first and second tests are linked to find out the reliability index. To determine the correlation coefficient, the product-moment correlation formula proposed by Pearson is used.

$$r_{XY} = \frac{N\sum XY - (\sum X)\ (\sum Y)}{\sqrt{(N\ \sum X^2 - (\sum X)^2)(N\ \sum Y^2 - (\sum Y)^2)}}$$

Description:

r_{XY} = a correlation coefficient of the first test and the second test
X = The student's score answered correctly on the first test

Y = Student scores answering correctly on the second test
N = Number of test takers
Meanwhile, benchmarks for interpreting the level of reliability of instruments are used criteria, as listed in Table 4 as follows.

Table 4. Interpretation of the reliability correlation coefficient

Correlation Coefficient	Renditions
0,00 – 0,199	Very low (very less)
0,20 – 0,399	Low (less)
0,40 – 0,599	Medium (enough)
0,60 – 0,799	Strong (good)
0,80 – 1,000	Very Strong (very good)

Source: Sugiyono (2015)

A valid Parallel Electrical Circuit conception test instrument totals 6 questions. Henceforth, the question was given to ninth-grade students in one of the junior high schools in Jakarta, a total of 23 people who had studied the Electrical Circuit material to take a conception profile.

Meanwhile, analyzing the conception profile is carried out by interpreting based on a combination of student answers to the four-tier diagnostic test questions. The conception profile of students is divided into five categories adapted from Samsudin, et al [51], namely: Sound Understanding (SU) which is the state of students who have a correct and complete understanding of concepts, and Partial Understanding (PU) which is the state of students who only have part of the understanding of concepts and cannot explain a phenomenon as a whole, No Understanding (NU) which is the state of students who do not understand concepts. *Misconception* (MC) that is, the state of students who have conceptions that are not in line with existing scientific concepts and *Un-coded* (UC) that is, incomprehensible students. Combination or combination of answers *four tier diagnostic test* shown in Table 5.

Table 5. Combination of answers *four-tier diagnostic test*

Tier-1	*Tier*-2	*Tier*-3	*Tier*-4	Conception Profile
1	Y	1	Y	SU
1	Y	1	TY	
1	TY	1	Y	
1	TY	1	TY	
1	Y	0	Y	
1	Y	0	TY	
1	TY	0	Y	PU
1	TY	0	TY	
0	Y	1	Y	
0	Y	1	TY	
0	TY	1	Y	
0	TY	1	TY	
0	Y	0	TY	NU
0	TY	0	Y	

0	TY	0	TY	
0	Y	0	Y	MC
If one, two, three, or all of them are not filled				UC

Table captions:
SU=*Sound Understading;* PU=*Partial Understanding*; MC=*Misconceptions;* NU=*No Understanding;* UC=*Un-coded*; 1= correct answer; 0= wrong answer; Y= Believe; TY= Not Sure

RESULTS AND DISCUSSION

a. Results

A diagnostic test is a test that is carried out to diagnose or identify difficulties in learning. Detect the factors that cause it and establish ways to overcome them [29]. The diagnostic test developed in this study is in the form of four tiers and is used to identify the conception profile of students on parallel electrical circuit material.

1) Defining

The development of the SKORLP instrument in the form of a four-tier test begins with the step of defining a test instrument that can be used to diagnose the level of conception of students on the concept of Parallel Electrical Circuits. SKORLP is a development of diagnostic tests *two tier*. The development is in the addition of the level of student confidence in choosing answers and the reason is that the first tier or also called the answer tier is a level that provides answer choices from the questions/problems asked.

The second tier is a level that provides various confidence scales to measure how confident learners are in determining and choosing answers at the first level. The third level (third tier) or also known as the reason tier is a level that provides reasons that students must choose regarding the determination of answers at the first level. The fourth tier provides a variety of confidence scales to measure how confident students are in determining and choosing answers at the third level.

2) Designing

After going through the definition, the researchers designed the SKORLP diagnostic test instrument in four tier test format. The design of the SKORLP instrument was originally in the form of a two-tier test as shown in Figure 1 into a four-tier test format as shown in Figure 2.

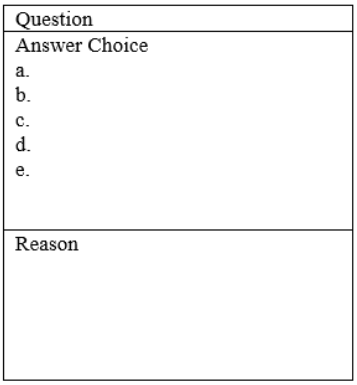


Figure 1. Format *two tier test*

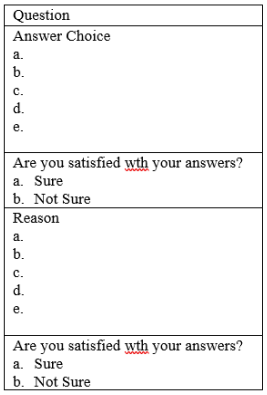


Figure 2. Format *four tier test*

3) Developing

Validity tests were carried out by experts, namely five Physics lecturers by assessing material aspects, construction aspects, language aspects, and the suitability between tier-1 and tier-2 on the instrument. Based on the data from the validation results of the conception test of the electrical circuit material of the experts, from the 9 questions compiled, it was obtained including the Parallel Electrical Circuit conception test as many as 6 questions and 3 other questions were not used. The validity test obtained from experts is with a validation score percentage category of 66.7% (enough) which means that the instrument can be used as a diagnostic test. Table 6 shows the data from the validation of parallel

electrical circuit instruments of 5 experts, while Table 7 is the result of a recapitulation of suggestions and improvements in the conception test from 5 experts.

Table 6. Validation results of parallel electrical circuit conception tests

No. Question Item	Conclusion			Score CVR	Classification
	Unusable	Used			
		Revision	No revisions		
1.	√	-	-	0,2	Not Appropriate
2.	-	-	√	1	Very Appropriate
3.	-	-	√	1	Very Appropriate
4.	-	√	-	0,6	Appropriate
5.	-	√	-	0,6	Appropriate
6.	√	-	-	0,2	Not Appropriate
7.	-	√	-	0,6	Appropriate
8.	√		-	0,2	Not Appropriate
9.	-	√	-	0,6	Appropriate
Validation score percentage categories					66,7% (enough)

Table 7. Recap list of improvement suggestions from experts

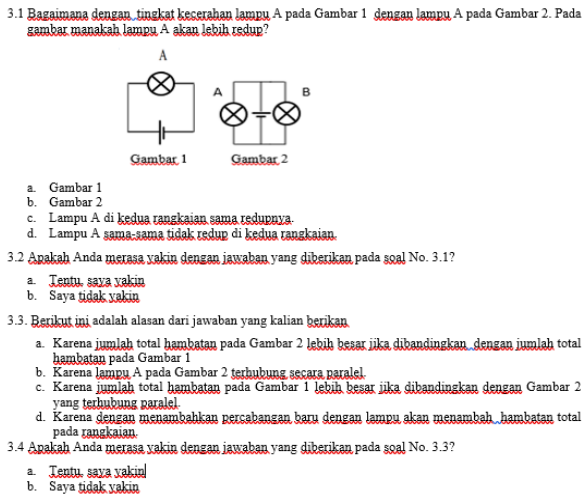
No.	Classification of Validation Results	Suggested improvements
1.	Very Appropriate	The problem is good enough but needs a little improvement in the word redaction and clarifying the image
2.	Appropriate	The questions are good enough, the name of the object needs to be listed, the question is made sharper, clearer, and more critical, correct the question editor, use clear and not convoluted sentences, and correct the answer choices
3.	Not Appropriate	The question cannot be used because the question does not correspond to a misconception

The following are the reliability results of the trial test instruments of series and parallel electrical circuit conception test. The process of analyzing the trial of two conception test packages to see the reliability of the instrument was carried out manually. From the results of the analysis of test answers and student retests, it was obtained that the reliability value of the instrument for changing the conception of parallel electrical circuits was 0.62, which is in the strong (good) category as in Table 8 so that it can be stated that the instrument is reliable and can provide data following reality.

Table 8. Reliability results of electrical circuit conception tests

Reliability Parallel Electrical Circuit Conception Test	
Skor	**Interpretation**
0,62	Strong (good)

The following is given an example of a part of the instrument used in the study totaling 6 questions. For example, the form of question number 3 in a four-level format is as follows as in Figure 3.


3.1 Bagaimana dengan tingkat kecerahan lampu A pada Gambar 1 dengan lampu A pada Gambar 2. Pada gambar manakah lampu A akan lebih redup?

A

A B

Gambar 1 Gambar 2

a. Gambar 1
b. Gambar 2
c. Lampu A di kedua rangkaian sama redupnya.
d. Lampu A sama-sama tidak redup di kedua rangkaian.

3.2 Apakah Anda merasa yakin dengan jawaban yang diberikan pada soal No. 3.1?

a. Tentu, saya yakin
b. Saya tidak yakin

3.3. Berikut ini adalah alasan dari jawaban yang kalian berikan

a. Karena jumlah total hambatan pada Gambar 2 lebih besar jika dibandingkan dengan jumlah total hambatan pada Gambar 1
b. Karena lampu A pada Gambar 2 terhubung secara paralel.
c. Karena jumlah total hambatan pada Gambar 1 lebih besar jika dibandingkan dengan Gambar 2 yang terhubung paralel.
d. Karena dengan menambahkan percabangan baru dengan lampu akan menambah hambatan total pada rangkaian.

3.4 Apakah Anda merasa yakin dengan jawaban yang diberikan pada soal No. 3.3?

a. Tentu, saya yakin
b. Saya tidak yakin

Figure 3. SKORLP question item no.3

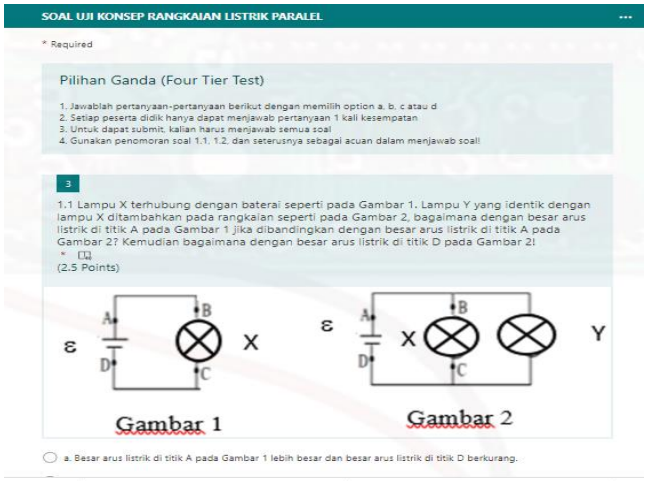


Figure 4. SKORLP presented online

4) Disseminating

At this stage, the instrument is disseminated in the evaluation of the learning process of parallel electrical circuit material online. There are 23 students in one class whose level of conception will be identified. The dissemination stage takes one session consisting of 60 minutes starting with the delivery of the repetition of the Parallel Electrical Circuit material and then students are given a SKORLP diagnostic test to know their conception profile.

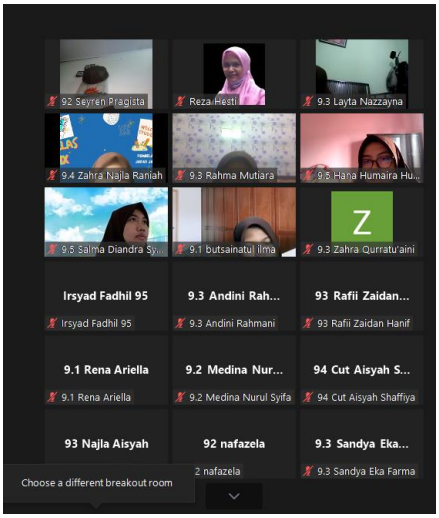


Figure 5. When disseminating online

b. Discussion

In analyzing the conditions of changing the conception of students, the results of the SKORLP diagnostic test are used, which then make a percentage aimed at determining the type of category of changing the conception. To find out the percentage category of student conception change as in Table 9 and to find out the percentage of students who have experienced conception change (Hirca, dkk. 2011) is:

$$\text{Percentage of Changing Student Conception} = \frac{Number\ of\ students\ in\ each\ tier\ changes}{The\ number\ of\ all\ students}\ x\ 100\%$$

Table 9. Percentage of changing student conception

Percentage (%)	Category
0 < PKS ≤ 30	Low
30 < PKS ≤ 70	Moderate
70 < PKS ≤ 100	High

The results of the research data are categorized into five categories, namely *Sound Understanding* (SU), *Partial Understanding* (PU), *No Understanding* (NU), *Misconception* (MC) and *Un-coded* (UC). The Conception Profile can be seen in the table below.

Table 10. Conception Profile

Miscon-sepsi label	Question Item	Student Conception Profile (%)				
		SU	PU	NU	MC	UC
MP_1	1	13	4,3	82,6	0	0
	2	21,7	21,7	56,5	0	0
MP_2	3	21,7	0	78,3	0	0
	4	43,5	21,7	34,8	0	0
	5	30,4	21,7	47,8	0	0
MP_3	6	30,4	30,4	39,1	0	0
Average		26,8	16,6	56,5	0	0

Derived from the data in the table above, it can be concluded that students' conception of the concept of Parallel Electrical Circuit is still low, which is characterized by a value of 26.8% in SU and 16.6% on PU. Reinforced again with the moderate category at a percentage of 56.5% in students who do not understand the concept of Parallel Electrical Circuits. However, what is a relief is that none of the students are in a state of misconception so it can be concluded that SKORLP can detect the conceptual condition of the student and from the results of the profile it is obtained that the learning of Physics in parallel electrical circuit material has not achieved meaningful learning.

Based on the results of the student's conception profile, teachers are expected to be able to improve physics teaching methods in the classroom so that meaningful learning is obtained. There is no need for cognitive conflict teaching interventions in the classroom because no students are found to have experienced misconceptions.

CONCLUSION

From the results of the research conducted, the four-tier diagnostic test instruments developed by researchers are categorized as valid and reliable. The developed instrument can also identify the student's conception profile on the Parallel Electrical Circuit material with the student's conception

profile divided into *Sound Understanding* (SU), *Partial Understanding* (PU), *No Understanding* (NU), *Misconception* (MC), dan *Un-coded* (UC).

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