Birlesik Dünya Arastırma BD CENTER Innovasyon ve Yayıncılık Merkezi

World Journal on Educational Technology: Current Issues

Volume 14, Issue 5, (2022) 1398-1414

www.wj-et.eu

Can sound waves in computer simulation lower students' misconceptions? Analysis of reduction and change

Achmad Samsudin [a] [*], Department of Physics Education, Universitas Pendidikan Indonesia, Bandung 40154, Indonesia. https://orcid.org/0000-0003-3564-6031

Dendy Mohammad Fauzi [b], Department of Physics Education, Universitas Pendidikan Indonesia, Bandung 40154, Indonesia. https://orcid.org/0000-0003-2702-3512

Andi Suhandi [c], Department of Physics Education, Universitas Pendidikan Indonesia, Bandung 40154, Indonesia. https://orcid.org/0000-0003-3746-7352

Suharto Linuwih [e], Department of Physics, Universitas Negeri Semarang, Semarang 50229, Indonesia. https://orcid.org/0000-0003-0715-1699

Masrifah Masrifah [f], Physics Education, Universitas Khairun, Ternate 97728, Indonesia. https://orcid.org/0000-0002-9826-667X

Bayram Coştu [g], Department of Science Education, Yildiz Technical University, Yıldız, 34349 İstanbul, Turkey. https://orcid.org/0000-0003-1429-8031

Suggested Citation:

Samsudin, A., Fauzi, D. M., Suhandi, A., Linuwih, M., Masrifah, M & Coştu, B. (2022). Can sound waves in computer simulation lower students' misconceptions? Analysis of reduction and change. *World Journal on Educational Technology: Current Issues*. *14*(5), 1398-1414. https://doi.org/10.18844/wjet.v14i5.7864

Received from May 12, 2022; revised from July 23, 2022; accepted from September 19, 2022;.

Selection and peer review under responsibility of Prof. Dr. Servet Bayram, Medipol University, Turkey

Abstract

This study aims to identify reduction and change in students' misconceptions about sound waves after using sound wave in computer simulation (SWiCS). This research is an explanatory sequential mixed methods design. The participants are 25 students from 11 grade [11 *lanang* (males) and 14 *wadon* (females)] with purposive sampling from one school in Karangkobar, Banjarnegara, Central Java. A multi-tiered instrument was used consisting of 20 questions. The reduction of students' misconceptions was analysed using percentages with three categories, namely sloping, currently, and steep. While the changes by codification, which are categorised as good change (GC), bad change (BC), and no change (NC), and other distributions were analysed using Rasch analysis. The average students' misconceptions are reduced by 88% (steep). Meanwhile, the changes in misconceptions moved towards GC (56%), BC (32%), and NC (12%). The SWiCS can decrease students' misconceptions on the sound waves and change conceptions for the better.

Keywords: Sound waves in computer simulation (SWiCS); misconception; reduction and changes

[*] ADDRESS FOR CORRESPONDENCE: Achmad Samsudin, Department of Physics Education, Universitas Pendidikan Indonesia, Bandung 40154, Indonesia
E-mail address: achmadsamsudin@upi.edu

1. Introduction

Sound wave in physics education is an important theme fixed in education curricula. In Indonesia, the sound wave possessions are an accentuated theme for all stages. At the high school level, the concept of sound waves is one of the most difficult concepts to learn. In fact, 77.7% of the students had difficulty with the concept of sound waves (Tuada & Suparno, 2021). This condition hinders the improvement of the quality of students. Meanwhile, Indonesian students generally understand questions, do simple arithmetic and measure factual knowledge in everyday contexts, but do not yet have the skills to integrate information and draw conclusions. This is because the learning system is only directed at the ability to think at a lower level. This conclusion is supported by the fact that the secondary school grading system only tests lower order thinking skills, such as memorising only. An example is a learning system that only teaches the application of formulas without analysis and without learning how to solve complex problems. Another issue, which affects students' skills to absorb sound wave concepts, is having too many complex equations without explanation, thus the potential for misconception. This is reinforced by several researchers who state that there is a misconception in sound waves (Barniol & Zavala, 2016; Eshach et al., 2018; Umar et al., 2021; Volfson et al., 2020).

In sound waves, students' misconceptions happen because they are included in microscopic material, which cannot be observed by the five senses directly (abstract). One of the misconceptions about sound waves is that students think that sound is a material, not a transmission of energy (Linder & Erickson, 1989; Mazens & Lautrey, 2003; Pössel, 2020; Wittmann et al., 1999). This misconception appears because the sound is not seen directly, giving rise to a wrong perception of sound. Finding students' barriers to understanding concepts is a necessary step, significantly assisting teachers in their efforts to design effective learning environments (Eshach, 2014; Galili & Hazan, 2000; Hrepic et al., 2010). In addition to that, students already have initial concepts that are obtained based on their daily experiences (Houle & Michael Barnett, 2008; Ozkan & Selcuk, 2016; Volfson et al., 2020). But the initial concepts are not following scientific concepts. Misconceptions can be corrected through the arrangement of mental models known as the conceptual change process (Kaniawati et al., 2021; Laurenty et al., 2021; Podschuweit & Bernholt, 2018; Samsudin et al., 2015; Surtiana et al., 2020). Posner et al. (1982) suggested that changing students' conceptions require certain situations, namely students must be dissatisfied with the existing concepts and new concepts must be understandable, reasonable and helpful. These situations can be created through a learning process.

The learning process can be carried out in various ways depending on the objectives. In this case, the use of methods and media can be taken into account to reduce and change students' misconceptions into better conceptions. One method that can be used is the predict-observe-explain (POE) method. Previous studies reveal that the use of POE strategies can help students to change conceptions (Coştu et al., 2012; Furqani et al., 2018; Purwanto et al., 2019; Samsudin et al., 2017). Learning media can utilise media that integrate with technology in the form of interactive multimedia (Kaniawati et al., 2021; Siahaan et al., 2020; Suhandi et al., 2017; Susilowati et al., 2021). The first principle of learning with interactive multimedia is to integrate various media components. The use of interactive multimedia components depends on the development needs and the material being developed. Interactive multimedia has five components, including 1) text, which are words or sentences that describe the material or instructions for using the media; 2) graphics, which are pictures, photos and charts/diagrams for illustration; 3) video: which is the simulation of real objects, an overview of an activity; 4) animation, which is moving images or live images to simulate a phenomenon; and 5) audio, which is the back sound, narration, sound effects or conversation (speech)

(Indah Septiani et al., 2020). The second principle of learning with interactive multimedia is navigation and interactivity. Interactive multimedia contain links that allow interaction between users and media, including navigation that facilitates users to operate or direct their learning and can provide feedback to them (Hamidi et al., 2011). One of the interactive media that can be used is the Wolfram Mathematica software (Ceberio et al., 2016; MacCallum, 2018; Musyrifah et al., 2021).

Wolfram Mathematica is a computer simulation developed by Stephen Wolfram. Wolfram Mathematica is an integrated system for performing computational techniques. This software can display information in the form of writing and images of objects that can move. Thus, students can understand the learning delivered through moving objects. All the content contained in this software (interactive multimedia) are coded and can be adapted to the needs of learning physics, not only on sound waves. However, in this study, Wolfram Mathematica was used to develop sound waves in computer simulation (SWiCS). The scheme of the combination of learning media (SWiCS) and learning strategy (POE) is shown in Figure 1.

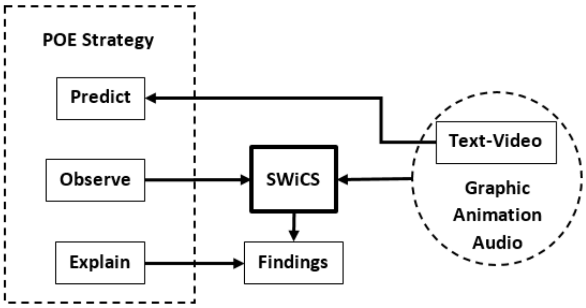

Figure 1. Integration of SWiCS in POE strategy

Figure 1 shows the use of SWiCS in a POE strategy. The use of text and video is determined at the predict stage. However, as a whole, text, video, graphics, animation and audio are all part of SWiCS. Then, at the observe stage on POE, SWiCS is used for experiments. It is finally entered the explain stage, which is simultaneously seen on SWiCS. The description of the computer simulation used can be seen in Figure 2.

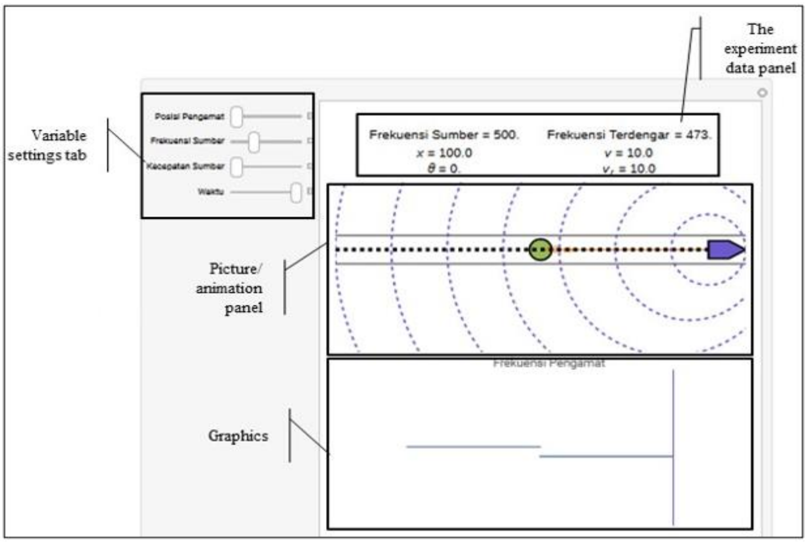

Figure 2. Description of the integration of SWiCS in POE strategy

Based on Figure 2, there are five important parts in the interactive Wolfram Mathematica multimedia: 1) the variable settings tab displays variables that can be varied; 2) the experimental data panel shows the data panel obtained; 3) the picture/animation panel displays the pictures or animations related to the experiment being carried out, making it easier for students to understand physics concepts; 4) the graphics display a graph of the experimental results; and 5) the audio section does not display the sound button on some media, but it is included in the media and will play automatically.

1.1. Framework

Based on the previous explanation, the SWiCS in the POE strategy was used in an effort to reduce and change students' misconceptions for the better. In this research, we created a framework to map how this can happen. The framework in this research can be seen in Figure 3.

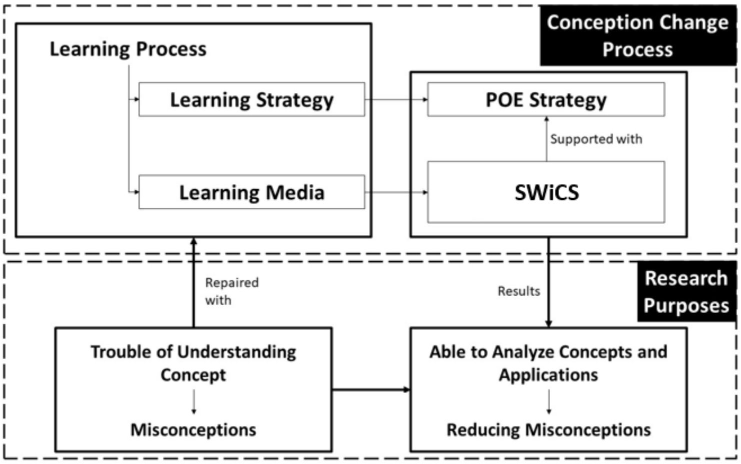

Figure 3. SWiCS framework in learning

Figure 3 shows that the learning process is carried out using the SWiCS and POE. The implementation is expected to improve students' conceptions which were previously divided into several types of conception categories. The results will then be analysed based on the decrease in students' misconceptions, as well as their changes during the learning process.

1.2. Purpose of the study

The aim of this research is to identify reduction and change in students' misconceptions about sound waves after using the SWiCS. This research has implications for the world of education, especially in the part of learning media in the form of computer simulations, especially in the simulation that was developed, which became the novelty in this research. The model is simple and easy to use and is the main point in this simulation, so that users will not be confused in operating it. Thus, the use of SWiCS in learning is expected to help teachers or tutors in the field in conveying a concept, especially in abstract physics studies.

2. Method and material

2.1. Research method

This research is a mixed method, using explanatory sequential mixed methods. Mixed methods research involves collecting quantitative and qualitative data, combining two forms of data, and using different plans (Creswell, 2014). Quantitative data were used to determine the reduction in students' misconceptions after using SWiCS, while qualitative data were used to identify the process of changing misconceptions.

2.2. Participants

The participants are 25 students from 11 grade [11 *lanang* (males) and 14 *wadon* (females)] from one school in Karangkobar sub-district, Banjarnegara district, Central Java. Lanang and Wadon is a term for male and female, respectively, in Javanese. Figure 4 shows the location of the participants in this study.

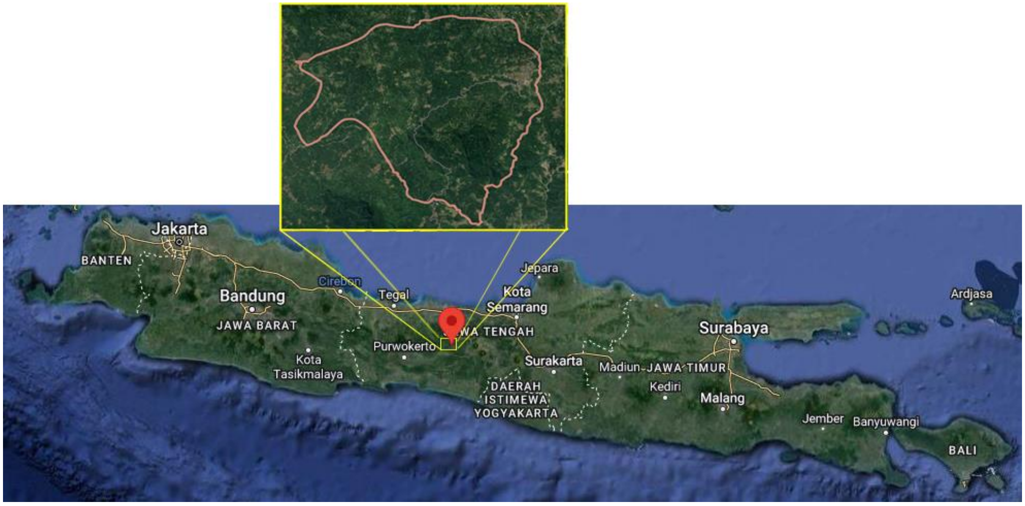

Figure 4. Karangkobar sub-district, Banjarnegara district, Central Java (Google map)

The selection of participants was carried out using a purposive sampling technique, namely the determination of the sample using certain criteria that have been set on the object in accordance with the research objectives. The considerations include students who experience the most misconceptions about sound waves and have laptops or the like to use when opening SWiCS.

2.3. Instrument

A multi-tiered instrument consisting of 20 questions [characteristics of sound waves (7), Doppler effect (4), string (4), and organ pipe (5)] was used in this study. Multi-tier in this study is the multiple choices of four tiers. Tier 1 is a concept question; Tier 2 is the level of confidence in the Tier 1 answer; Tier 3 is the reason for the answer in Tier 1; and Tier 4 is the level of confidence in the Tier 3 answer. The examples of multi-tier questions used are shown in Figure 5.

9.1 Look at the picture below! A sound source (red ball) is moving to the left with velocity v_s. and there are five point observers listening to the sound with arrows as the direction of motion. Among these five points the observer who hears the highest frequency is...

A. Observer A
B. Observer B
C. Observer C
D. Observer D
E. Observer E

9.2 Level of confidence in the answer 9.1
- ⓪ Total guess
- ① Almost guessed
- ② Not sure true
- ③ Sure true
- ④ Almost very sure true
- ⑤ Very confident true

9.3 The reason based on the answer choices in 9.1 is ....
A. The closer to the sound source, the greater the frequency heard by the observer
B. The farther away from the sound source, the greater the frequency heard by the observer
C. The frequency heard by the observer is affected by temperature and air pressure
D. The frequency of the sound source heard by the observer will be greater if the sound source and observer approach each other
E. The frequency of the sound source heard by the observer will be greater if the sound source and observer move away from each other

9.4 Level of confidence in the answer 9.3
- ⓪ Total guess
- ① Almost guessed
- ② Not sure true
- ③ Sure true
- ④ Almost very sure true
- ⑤ Very confident true

Figure 5. The example of a multi-tier test

2.4. Data collection process

In general, quantitative and qualitative data were collected with the same instrument. However, data processing for quantitative was carried out by calculating the values obtained to find the value of decreasing misconceptions. Meanwhile, qualitative data were carried out by means of codification, which will then be discussed in the Data Analysis section. Thus, the results obtained will be in accordance with the aim of the research. The data are taken from students' answers on multi-tiered instruments about sound waves, during the pre-test and post-test. All participants took up the pre-test and post-test. After taking the pre-test, participants took up online learning for 3x2 hours of lessons using SWiCS and POE strategies. After the online learning was completed, participants took up the post-test.

2.5. Data analysis

Quantitative data were analysed using percentages for students' misconception reduction (SMR) as in Equation 2. Meanwhile, qualitative data were analysed based on the codification that had been made to see the movement of changes in misconceptions that occurred in students. The stages regarding this data analysis are mentioned below.

1. Scoring of the results of the pre-test and post-test, as well as tabulating the CRI scores, of each student and categorising them based on students' conceptions is presented in Table 1.

Table 1. Conception category and score

Category	Answer	CRI on answers	Reason	CRI on reason	Score
Understanding (U)	True (1)	≥3	True (1)	≥ 3	3
Partial understanding (PU)	True (1)	≥3	True (1)	≤ 2	2
	True (1)	≤2	True (1)	0-5	
	True (1)	0–5	False (0)	0-5	
	False (0)	0–5	True (1)	0-5	
	False (0)	≥3	False (0)	≤ 2	
No understanding (NU)	False (0)	≤2	False (0)	0-5	1
Misconceptions (M)	False (0)	≥3	False (0)	≥ 3	0
Encodable (E)	If not filling one or more items (level)				(empty)

2. Calculate the percentage of misconceptions in the pre-test and post-test using Equation (1).

$$\%\ \text{Misconception (in pretest or posttest)} = \frac{\text{Sum of students misconception}}{\text{Sum of students}} \times 100 \quad (1)$$

3. After the percentage of misconceptions during the pre-test and post-test is obtained, the reduction of misconceptions will be calculated based on the equation adapted from N-gain (Hake, 1998). However, because of the equation for the misconceptions' reduction, there is a modification to the equation which can be seen in Equation (2) regarding SMR. The results are then categorised as 1) sloping (SMR ≤ 30%); 2) currently (30% < SMR ≤ 70%); and steep (70% < SMR).

$$\text{SMR} = \frac{\%\ \text{Pretest} - \%\ \text{Posttest}}{\%\ \text{Pretest}} \quad (2)$$

4. After the results of Equation (2) are identified, the next step is processing qualitative data. The qualitative data were analysed by mapping changes in students' misconceptions during the pre-test and post-test. The possibilities that can occur can be seen in Figure 6.

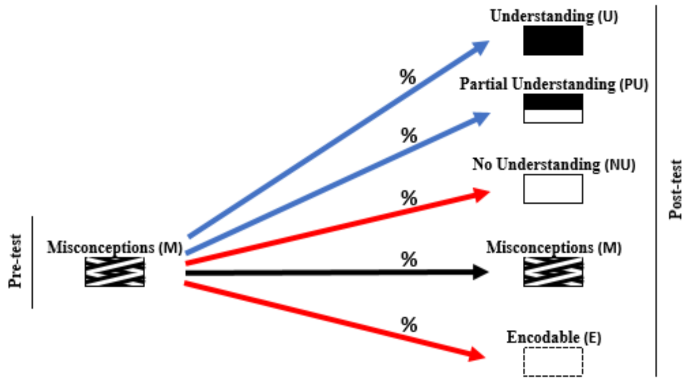

Figure 6. The possibility of changes in students' misconceptions

There are three categories of changing misconceptions, namely good change (GC) (blue arrow with changes coded as M/U and M/PU), bad change (BC) (red arrows with changes coded as M/NU and M/E) and no change (NC) (black arrow with changes coded as M/M) (Samsudin et al., 2016). The percentage change for each category is calculated based on Equation (3).

$$\% = \frac{\% \text{ Students misconception on pretest}}{\% \text{ Students conception on posttest}} \quad (3)$$

Furthermore, the change will be calculated based on frequency. Meanwhile, the overall distribution for pre-test and post-test scores will be analysed using Rasch analysis with Winsteps software version 4.4.5 with variable (Wright) maps output.

3. Results

The results of the SMR calculation show that the reduction in students' misconceptions occurs for all questions. There are 20 misconceptions that occur. The reduction can be seen in Figure 7.

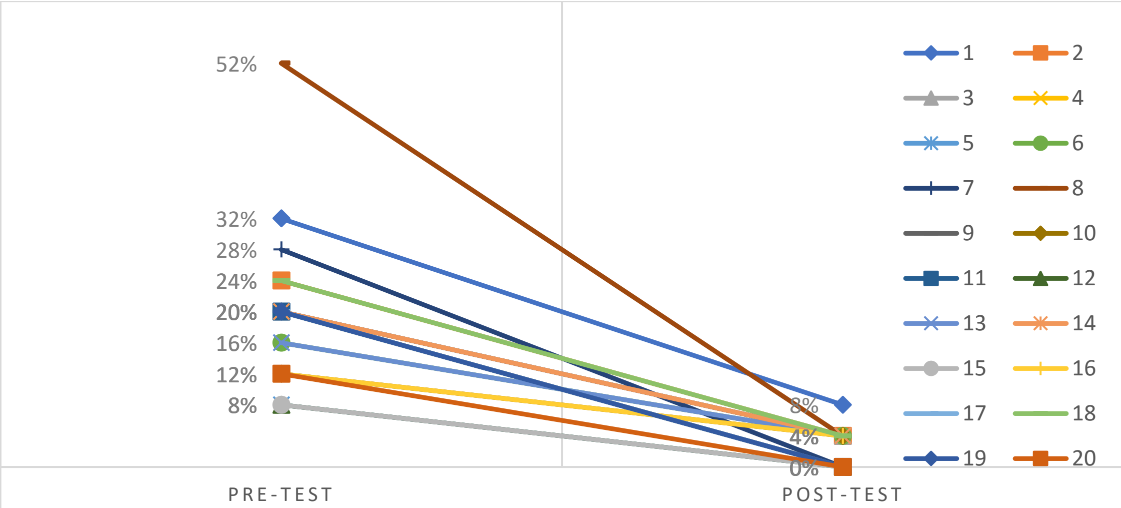

Figure 7. Reduction of students' misconceptions

Figure 7 shows that most students' misconceptions during the pre-test occurred in question 8 (52%) and the least occurred in questions 5, 12 and 15 (8%). Meanwhile, during the post-test, students' misconceptions mostly occurred in question 1 (8%) and the least occurred in questions 4, 5, 7, 11, 12, 15, 17, 19 and 20 (0%). The overall result of SMR can be seen in Table 2.

Table 2. SMR calculation results

No	Pre-test	Post-test	SMR	Categories
1.	32%	8%	75%	Steep
2.	24%	4%	83%	Steep
3.	20%	4%	80%	Steep
4.	20%	0%	100%	Steep
5.	8%	0%	100%	Steep
6.	16%	4%	75%	Steep
7.	28%	0%	100%	Steep
8.	52%	4%	92%	Steep

No	Pre-test	Post-test	SMR	Categories
9.	20%	4%	80%	Steep
10.	12%	4%	67%	Currently
11.	20%	0%	100%	Steep
12.	8%	0%	100%	Steep
13.	16%	4%	75%	Steep
14.	20%	4%	80%	Steep
15.	8%	0%	100%	Steep
16.	12%	4%	67%	Currently
17.	20%	0%	100%	Steep
18.	24%	4%	83%	Steep
19.	20%	0%	100%	Steep
20.	12%	0%	100%	Steep
Average			88%	Steep

Table 2 shows that there are 18 questions that fall into the steep category. The least decrease occurred in questions 10 and 16, which was 67%. This happened because in the post-test there were still 4% of the students who had misconceptions. Meanwhile, the rest are in the currently category. The highest decrease in student misconceptions occurred in questions 4, 5, 7, 11, 12, 15, 17, 19 and 20. The decrease that occurred was 100%. That is, the students in question no longer have misconceptions and because there is no post-test, students who have misconceptions become 0%. Thus, the overall average reduction in misconceptions is 88% in the steep category. For every misconception on the problem, the fruit is identified as a whole. Changes in misconceptions for each question can be seen in Table 3.

Table 3. Students' misconceptions change during pre-test and post-test

No	Pre-test	Post-test				
		Good Change (GC)		Bad Change (BC)		No Change (NC)
	M	U	PU	NU	EC	M
1	S01, S03, S07, S09, S12, S19, S21, S23 8 Students	S23 1 Student (13%)	S12, S19 2 Students (25%)	S01, S07, S21 3 Students (38%)	-	S03, S09 2 Students (25%)
2	S08, S11, S12, S19, S21, S23 6 Students	S23 1 Student (17%)	S19, S21 2 Students (33%)	S08, S12 2 Students (33%)	-	S11 1 Student (17%)
3	S07, S12, S17, S19, S21 5 Students	-	S07, S12, S21 3 Students (60%)	S17 1 Student (20%)	-	S19 1 Student (20%)
4	S01, S07, S08, S11, S19 5 Students	S08 1 Student (20%)	S07, S11, S19 3 Students (60%)	S01 1 Student (20%)	-	-
5	S01, S07	S07	-	S01	-	-

No	Pre-test	Post-test				
		Good Change (GC)		Bad Change (BC)		No Change (NC)
	M	U	PU	NU	EC	M
	2 Students	1 Student (50%)		1 Student (50%)		
6	S08, S12, S18, S20 4 Students	S08 1 Student (25%)	-	S12, S18 2 Students (50%)	-	S20 1 Student (25%)
7	S01, S07, S09, S11, S14, S18, S20 7 Students	S01, S09, S11, S18 4 Students (57%)	S14 1 Student (14%)	S07 1 Student (14%)	S20 1 Student (14%)	-
8	S02, S03, S05, S07, S08, S09, S11, S13, S14, S16, S20, S23, S25 13 Students	S09, S13, S20, S23 4 Students (31%)	S03, S05, S08, S16 4 Students (31%)	S02, S07, S11, S14 4 Students (31%)	-	S25 1 Student (8%)
9	S08, S09, S10, S18, S19 5 Students	S09 1 Student (20%)	S18, S19 2 Students (40%)	S08 1 Student (20%)	-	S10 1 Student (20%)
10	S07, S12, S17 3 Students	-	S07 1 Student (33%)	S17 1 Student (33%)	-	S12 1 Student (33%)
11	S07, S08, S16, S18, S19 5 Students	-	S07, S16, S18 3 Students (60%)	S08, S19 2 Students (40%)	-	-
12	S12, S14 2 Students	-	S12 1 Student (50%)	S14 1 Student (50%)	-	-
13	S12, S16, S18, S21 4 Students	-	S12, S21 2 Students (50%)	S16 1 Student (25%)	-	S18 1 Student (25%)
14	S07, S08, S09, S12, S18 5 Students	-	S09, S12 2 Students (40%)	S07, S08 2 Students (40%)	-	S18 1 Student (20%)
15	S07, S18 2 Students	-	S07, S18 2 Students (100%)	-	-	-
16	S08, S12, S23 3 Students	-	S12 1 Student (33%)	S23 1 Student (33%)	-	S08 1 Student (33%)
17	S01, S08, S11, S17, S18 5 Students	S11 1 Student (20%)	S01, S17, S18 3 Students (60%)	S08 1 Student (20%)	-	-
18	S01, S07, S11, S14,	S11 1 Student	S01, S07, S14, S17	-	-	S21 1 Student

No	Pre-test	Post-test				
		Good Change (GC)		Bad Change (BC)		No Change (NC)
	M	U	PU	NU	EC	M
	S17, S21 6 Students	(17%)	4 Students (67%)			(17%)
19	S07, S12, S14, S17, S18 5 Students	-	S07, S12, S14 3 Students (60%)	S17, S18 2 Students (40%)	-	-
20	S12, S18, S21 3 Students	-	S21 1 Student (33%)	S12, S18 2 Students (67%)	-	-

Table 3 shows the changes in students who had misconceptions during the pre-test and the direction of changes in their conceptions at the post-test, whether they moved towards understanding (U), partial understanding (PU), no understanding (NU), misconceptions (M) or encodable (E). Changes in misconceptions for the good change (GC) category occurred in the U and PU conception categories. For U category, the highest change occurred in question 7 (57%) and the lowest occurred in questions 3, 10, 11, 12, 13, 14, 15, 16, 19 and 20 (0%). Meanwhile, the highest PU category occurred in question 15 (100%) and the lowest occurred in questions 5 and 6 (0%). Both these changes were expected because students who had misconceptions during the pre-test, their understanding changed for the better. The misconceptions for the bad change (BC) category occurred in the NU and EC categories. The highest change for the NU category was in question 20 (67%), while the lowest occurred in questions 15 and 18 (0%). For the EC category, the highest change occurred in question 7 (14%), and the rest was the lowest, which was 0%. This change was not expected because instead of making students' conceptions better, they turned into bad ones. The last is the category of no change (NC), which is the M category, meaning that students' conceptions did not change, either during the pre-test or post-test. Meanwhile, the highest change for the M category occurred in questions 10 and 16 (33%) and the lowest occurred in questions 4, 5, 7, 11, 12, 15, 17, 19 and 20 (0%). This change was actually not expected because no change occurred after the learning process. Furthermore, these changes are reviewed based on the category of changes in the misconceptions shown in Figure 8.

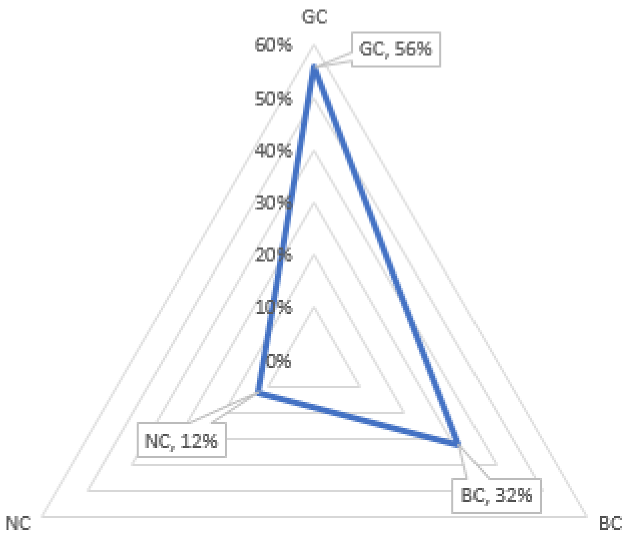

Figure 8. Changes based on the category of misconceptions' change

Figure 8 shows the changes that occurred during the post-test based on the category of misconceptions' change. It can be seen that the most changes occurred in the good change (GC) category (with 56%), followed by bad change (BC) (with 32%) and finally no change (NC) (with 12%). However, these results indicate that there is a change for the better after the implementation of SWiCS. Another analysis was then carried out with the Rasch analysis.

Rasch analysis was also carried out to identify changes overall for all conceptions, either during pre-test or post-test. The output used is variable (Wright) maps which serve to map thoroughly. This output also identifies the potential distribution of students (person) and questions (item). The distribution can be seen in Figure 9.

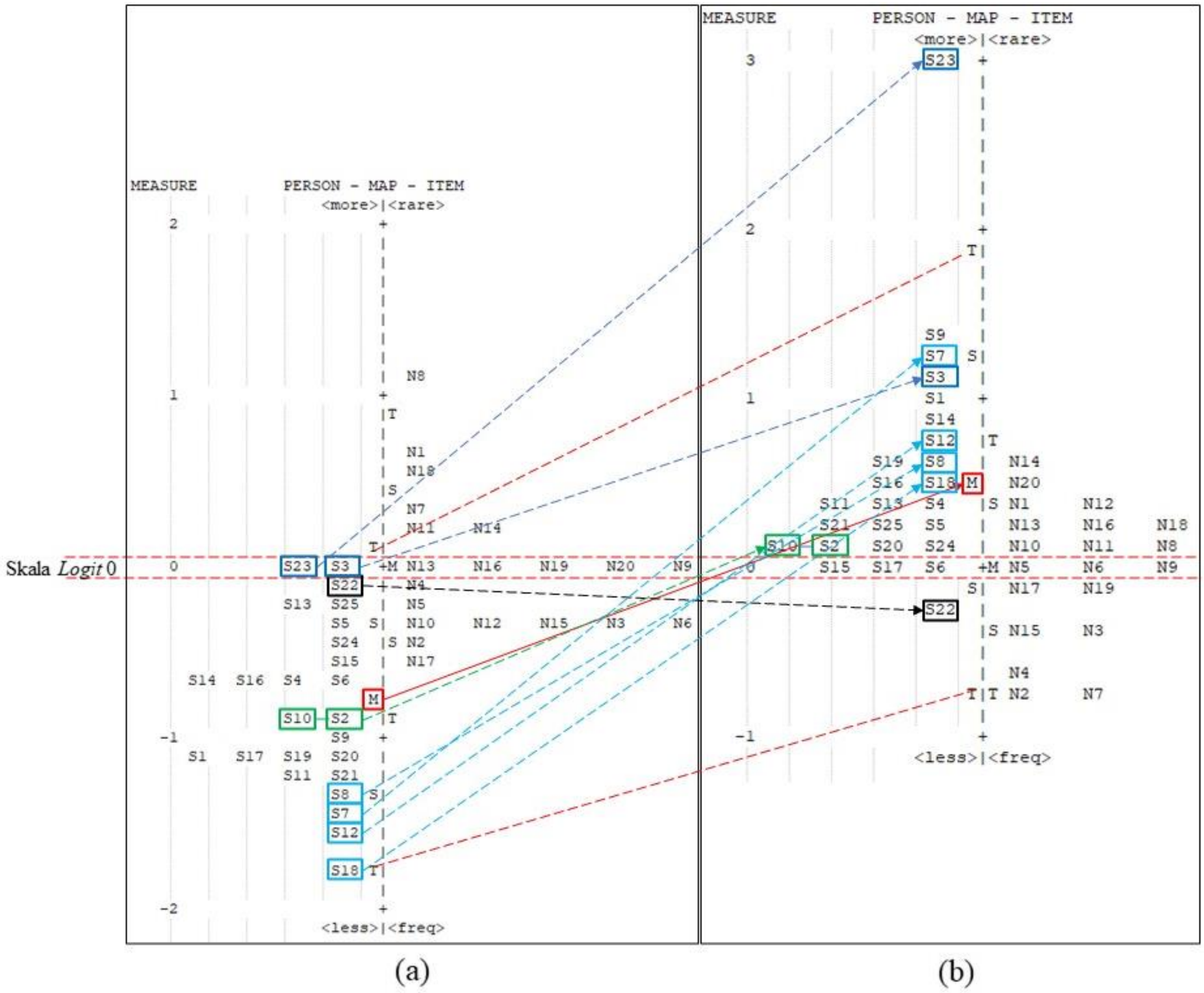

Figure 9. Distribution of conceptions: (a) pre-test and (b) post-test

In Figure 9(a), the left side is the distribution of students marked with the symbol S and followed by the serial number of students 1–25. The right side is the distribution of items or question numbers marked with the symbol N and followed by a serial number of questions 1–20. From this distribution, students have the potential for misconceptions. At the time of the pre-test, all students had the potential to have a misconception on N8, N1 and N18 because the picture shows that the item number is outside the S boundary (standard deviation item). In addition, S8, S7, S12 and S18 students have the potential for misconceptions on all questions because in the picture these students are outside the S boundary (standard deviation person). At the time of post-test, three students S23, S9 and S7 did not have the potential to have misconceptions for all questions. However, S22 had the potential to have misconceptions in all questions. From this comparison, the potential for misconceptions for all questions decreases from pre-test to post-test, as can be seen from the shift in the median (M) indicated by the red box. In the pre-test, the position of M is close to logit −1, while in the post-test the position of M is close to logit +1. If viewed from the students who have the most alternative conceptions during the pre-test (S8, S7, S12 and S18), then at the post-test the position of all students is higher than the pre-test. There is one student (S22) who can be seen in the picture having a decreased position. The researcher concludes that there is a change in the conception of the bad change (BC). This happened because of the limitations of researchers to supervise the implementation of learning, thus many variables were difficult to control (i.e., students' thinking, involvement in collaborative group work, and student motivation). As a result, some changes in students' misconceptions are not included in the category of good change (GC).

4. Discussion

Based on the results of the study, the smallest misconceptions during the pre-test occurred in questions 5, 12 and 15. In sequence, the misconceptions contained frequencies and amplitudes, including 1) students considered that the closer they were to the sound source, the frequency that the observer heard the greater; 2) students assume that if the mass of strings is enlarged, the frequency produced by the strings will be greater; and 3) students assume that the frequency produced by the air column will be smaller if the length of the air column is shortened. This misconception in the basic concept of frequency occurs because of confusion among students about frequency and amplitude. This phenomenon also occurs in a previous research (Pejuan et al., 2012), which suggests that there is confusion between pitch or frequency and volume or intensity. Other studies have also revealed that there are misconceptions about the frequency and amplitude of sound waves. Wiyantara et al. (2021) showed that students have misconceptions when explaining the frequency of guitar strings. This misconception occurs as much as 70%. In fact, it is a basic concept in studying waves. In this study, the least misconceptions occur in the basic concept of frequency (Darman et al., 2019), but this cannot be ignored because it can affect the conception of other concepts. This is in accordance with the statement (Aminudin et al., 2019) which states that understanding the basic concepts is very important in physics. Thus, when the misconception has been detected, the teacher or tutor must immediately deal with it, before the misconception becomes the student's understanding (Ekawati et al., 2021; Samsudin et al., 2021; Suhandi et al., 2017). This action is to anticipate students' conceptions because basically, students come to class with conceptions that come from several sources, such as from experience, TV, the Internet, books or legends in the students' homes, and these conceptions are not necessarily true or in accordance with scientific conceptions.

Meanwhile, the most misconceptions during the pre-test occurred in question 8 regarding the Doppler effect. Students assume that the closer they are to the sound source, the greater the frequency heard by the observer. In fact, the frequency of the sound source heard by the observer will be greater if the sound source and observer are closer to each other. Indeed, the concept of the Doppler effect is an advanced concept of frequency. This is in accordance with the statement (Pössel, 2020) that in the relativistic explanation of the explosion, the Doppler effect is used as a more advanced preconception. Saparini et al. (2021) state that a misconception that often arises when studying sound waves is the concept of the Doppler effect. Thus, it is not surprising that students have the highest misconceptions about the concept of the Doppler effect. In this study, the handling of misconceptions on the concept of frequency and the Doppler effect was carried out using a SWiCS simulation. The simulation for the Doppler effect is presented in terms of the frequency as it passes through the sound source. The use of simulation has indeed been proven in several cases in dealing with misconceptions (Fratiwi et al., 2018; Kaniawati et al., 2021; Wibowo et al., 2017). Moreover, simulations of abstract concepts in physics are very helpful in understanding them. Thus, with the help of simulations, students' misconceptions can be lowered or even changed into a better understanding.

Changes in conception for the better are expected after the treatment is carried out. Based on the results of this study, the use of SWiCS made a change in the conception which was dominated by good changes. This is in accordance with previous research (Samsudin et al., 2020) that uses simulation as a medium for changing students' conceptions. In addition, the use of SWiCS can also suppress changes in the no change category. This means that the misconceptions that occur after treatment are reduced, and their distribution is changed towards a better conception. Thus, the use of SWiCS has a positive impact on changes in students' conceptions. Moreover, the learning conditions after the pandemic have taught practitioners in the field about distance learning, where all preparations in terms of rules, facilities and schemes must be prepared properly because it will become a new habit in learning. The use of SWiCS can help the implementation because its use can be used anywhere, anytime and under any condition, whether conventional or distance learning.

5. Conclusion

The results show that the average decrease in students' misconceptions that occurred for all questions was 88% (steep category). Meanwhile, changes in misconceptions during the post-test mostly occurred in the good change (GC) category (56%) and the lowest category in no change (NC) (12%). This is also reinforced by Rasch's analysis which explains that there is a decrease in the potential for misconceptions from pre-test to post-test after treatment is given. Thus, the use of SWiCS in the POE strategy can reduce misconceptions about the concept of sound waves well and change the conception for the better.

6. Recommendations

Computer simulation media has been widely used in several cases in physics learning. However, only a few studies have developed media based on misconceptions, like SWiCS, which was developed and implemented to reduce and change students' misconceptions for the better. Thus, we recommend the use of SWiCS to reduce misconceptions about the sound wave concept.

References

Aminudin, A. H., Kaniawati, I., Suhendi, E., Samsudin, A., Coştu, B., & Adimayuda, R. (2019). Rasch Analysis of Multitier Open-ended Light-Wave Instrument (MOLWI): Developing and Assessing Second-Years Sundanese-Scholars Alternative Conceptions. *Journal for the Education of Gifted Young Scientists*, *7*(3), 607–629. https://doi.org/10.17478/jegys.574524

Barniol, P., & Zavala, G. (2016). Mechanical waves conceptual survey: Its modification and conversion to a standard multiple-choice test. *Physical Review Physics Education Research*, *12*(1). https://doi.org/10.1103/PhysRevPhysEducRes.12.010107

Ceberio, M., Almudí, J. M., & Franco, Á. (2016). Design and Application of Interactive Simulations in Problem-Solving in University-Level Physics Education. *Journal of Science Education and Technology*, *25*(4), 590–609.

https://doi.org/10.1007/s10956-016-9615-7

Coştu, B., Ayas, A., & Niaz, M. (2012). Investigating the effectiveness of a POE-based teaching activity on students' understanding of condensation. *Instructional Science*, *40*(1), 47–67. https://doi.org/10.1007/s11251-011-9169-2

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications.

Darman, D. R., Wibowo, F. C., Suhandi, A., Setiawan, W., Abizar, H., Nurhaji, S., Nulhakim, L., & Istiandaru, A. (2019). Virtual media simulation technology on mathematical representation of sound waves. *Journal of Physics: Conference Series*, *1188*(1). https://doi.org/10.1088/1742-6596/1188/1/012092

Ekawati, H., Islam, U., Ulum, D., & Education, M. (2021). Teams' games tournaments with cognitive conflict instruction (CCI) model to unveil students' misconceptions. *Cypriot Journal of Educational Sciences*, *16*(4), 1343–1355. https://doi.org/https://doi.org/10.18844/cjes.v16i4.5983

Eshach, H. (2014). Development of a student-centered instrument to assess middle school students conceptual understanding of sound. *Physical Review Special Topics - Physics Education Research*. https://doi.org/10.1103/PhysRevSTPER.10.010102

Eshach, H., Lin, T. C., & Tsai, C. C. (2018). Misconception of sound and conceptual change: A cross-sectional study on students' materialistic thinking of sound. *Journal of Research in Science Teaching*. https://doi.org/10.1002/tea.21435

Fratiwi, N. J., Samsudin, A., & Costu, B. (2018). Enhancing K-10 students' conceptions through computer simulations-aided PDEODE*E (CS-PDEODE*E) on Newton's Laws. *Jurnal Pendidikan IPA Indonesia*, *7*(2), 214–223. https://doi.org/10.15294/jpii.v7i2.14229

Furqani, D., Feranie, S., & Winarno, N. (2018). The Effect of Predict-Observe-Explain (POE) Strategy on Students' Conceptual Mastery and Critical Thinking in Learning Vibration and Wave. *Journal of Science Learning*, *2*(1), 1. https://doi.org/10.17509/jsl.v2i1.12879

Galili, I., & Hazan, A. (2000). Learners' knowledge in optics: Interpretation, structure and analysis. *International Journal of Science Education*. https://doi.org/10.1080/095006900290000

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Hamidi, F., Kharamideh, Z. M., & Ghorbandordinejad, F. (2011). Comparison of the training effects of interactive multimedia (CDs) and non-interactive media (films) on increasing learning speed, accuracy and memorization in biological science course. *Procedia Computer Science*, 144–148. https://doi.org/10.1016/j.procs.2010.12.025

Houle, M. E., & Michael Barnett, G. (2008). Students' conceptions of sound waves resulting from the enactment of a new technology-enhanced inquiry-based curriculum on Urban bird communication. *Journal of Science Education and Technology*. https://doi.org/10.1007/s10956-008-9094-6

Hrepic, Z., Zollman, D. A., & Rebello, N. S. (2010). Identifying students' mental models of sound propagation: The role of conceptual blending in understanding conceptual change. *Physical Review Special Topics - Physics Education Research*. https://doi.org/10.1103/PhysRevSTPER.6.020114

Indah Septiani, A. nisa N. S., Septiani, I., Rejekiningsih, T., Triyanto, & Rusnaini. (2020). Development of interactive multimedia learning courseware to strengthen students' character. *European Journal of Educational Research*. https://doi.org/10.12973/eu-jer.9.3.1267

Kaniawati, I., Maulidina, W. N., Novia, H., Samsudin, I. S. A., Aminudin, A. H., & Suhendi, E. (2021).

Implementation of Interactive Conceptual Instruction (ICI) Learning Model Assisted by Computer Simulation: Impact of Students' Conceptual Changes on Force and Vibration. *International Journal of Emerging Technologies in Learning*, *16*(22), 167–188. https://doi.org/10.3991/ijet.v16i22.25465

Laurenty, F., Sulsilah, H., Amin, A. M., Samsudin, A., & Rusdiana, D. (2021). Enhancing conceptual understanding via Diffraction Grating Innovative Media (DIAGRAM). *Journal of Physics: Conference Series*, *2098*(1). https://doi.org/10.1088/1742-6596/2098/1/012013

Linder, C. J., & Erickson, G. L. (1989). A study of tertiary physics students' conceptualizations of sound. *International Journal of Science Education*. https://doi.org/10.1080/0950069890110502

MacCallum, M. A. H. (2018). Computer algebra in gravity research. *Living Reviews in Relativity*, *21*(1), 1–93. https://doi.org/10.1007/s41114-018-0015-6

Mazens, K., & Lautrey, J. (2003). Conceptual chnge in physics: Children's naive representations of sound. *Cognitive Development*. https://doi.org/10.1016/S0885-2014(03)00018-2

Musyrifah, E., Rabbani, H., Sobiruddin, D., & Khairunnisa. (2021). Development of wolfram mathematica application-assisted learning module on derivative in high school. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1836/1/012076

Ozkan, G., & Selcuk, G. S. (2016). Facilitating conceptual change in students' understanding of concepts related to pressure. *European Journal of Physics*. https://doi.org/10.1088/0143-0807/37/5/055702

Pejuan, A., Bohigas, X., Jaén, X., & Periago, C. (2012). Misconceptions About Sound Among Engineering Students. *Journal of Science Education and Technology*. https://doi.org/10.1007/s10956-011-9356-6

Podschuweit, S., & Bernholt, S. (2018). Composition-Effects of Context-based Learning Opportunities on Students' Understanding of Energy. *Research in Science Education*. https://doi.org/10.1007/s11165-016-9585-z

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, *66*(2), 211–227. https://doi.org/10.1002/sce.3730660207

Pössel, M. (2020). Interpretations of cosmic expansion: Anchoring conceptions and misconceptions. *Physics Education*. https://doi.org/10.1088/1361-6552/aba3b1

Purwanto, M. G., Hidayat, S. R., Fratiwi, N. J., Zulfikar, A., Muhaimin, M. H., Bhakti, S. S., Sholihat, F. N., Setyadin, A. H., Jubaedah, D. S., Amalia, S. A., Afif, N. F., Sutiadi, A., Hermita, N., & Samsudin, A. (2019). Enhancing Junior High School Students Conceptual Understanding Using the POE-based Demonstration Technique on Electrostatics. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1204/1/012045

Samsudin, A., Azizah, N., Sasmita, D., Rasmitadila, Fatkhurrohman, M. A., Supriyatman, & Wibowo, F. C. (2020). Analyzing the students' conceptual change on kinetic theory of gases as a learning effect though computer simulations-assisted conceptual change model. *Universal Journal of Educational Research*, *8*(2), 425–437. https://doi.org/10.13189/ujer.2020.080213

Samsudin, A., Cahyani, P. B., Purwanto, Rusdiana, D., Efendi, R., Aminudin, A. H., & Coştu, B. (2021). Development of a multitier open-ended work and energy instrument (MOWEI) using Rasch analysis to identify students' misconceptions. *Cypriot Journal of Educational Sciences*, *16*(1), 16–31. https://doi.org/10.18844/cjes.v16i1.5504

Samsudin, A., Fratiwi, N. J., Kaniawati, I., Suhendi, E., Hermita, N., Suhandi, A., Wibowo, F. C., Coştu, B., Akbardin, J., & Supriyatman, S. (2017). Alleviating students' misconceptions about newton's first law through comparing pdeode*E tasks and poe tasks: Which is more effective? *Turkish Online Journal of Educational Technology*, *2017*(October Special Issue INTE), 215–221.

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., & Costu, B. (2015). Fields Conceptual Change Inventory: a Diagnostic Test Instrument on the Electric Field and Magnetic Field To Diagnose Students' Conceptions. *International Journal of Industrial Electronics and Electrical Engineering*, *3*(12), 74–77. https://www.researchgate.net/publication/301655170_Fields_Conceptual_Change_Inventory_A_Diagnostic_Test_Instrument_On_The_Electric_Field_And_Magnetic_Field_To_Diagnose_Student's_Conceptions

Saparini, S., Misbah, M., & Rizaldi, W. R. (2021). Understanding the prospective physics teachers conception of the characteristic of sound. *Journal of Physics: Conference Series*, *1760*(1). https://doi.org/10.1088/1742-6596/1760/1/012030

Siahaan, P., Setiawan, Y. C., Fratiwi, N. J., Samsudin, A., & Suhendi, E. (2020). The development of critical thinking skills and collaborative skill profiles aided by multimedia-based integrated instruction on light refraction material. *Universal Journal of Educational Research*, *8*(6), 2599–2613. https://doi.org/10.13189/ujer.2020.080643

Suhandi, A., Hermita, N., Samsudin, A., Maftuh, B., & Coştu, B. (2017). Effectiveness of visual multimedia supported conceptual change texts on overcoming students' misconception about boiling concept. *Turkish Online Journal of Educational Technology*, *2017*(October Special Issue INTE), 1012–1022.

Surtiana, Y., Suhandi, A., Samsudin, A., Siahaan, P., & Setiawan, W. (2020). The preliminary study of the application of the conceptual change laboratory (CC-Lab) for overcoming high school students misconception related to the concept of floating, drifting and sinking. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1521/2/022018

Susilowati, N. E., Samsudin, A., & Muslim. (2021). What do physics teachers need? A need analysis of interactive multimedia to train creative thinking in static fluid. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/2098/1/012029

Tuada, R. N., & Suparno, S. (2021). Increasing Student's Hots Using Mobile Technology and Scaffolding Approach on Sound Wave Material. *Jurnal Pendidikan Fisika Indonesia*, *17*(2), 160–174. https://doi.org/10.15294/jpfi.v17i2.26949

Umar, F. a., Samsudin, a., Ramalis, T. R., Sa'diyah, L. H., Dalila, a. a., & Komalasari, K. (2021). Uyo and nanu misconception investigation (UNAMI) on sound-light waves materials in North Sulawesi. *Journal of Physics: Conference Series*, *2098*(1). https://doi.org/10.1088/1742-6596/2098/1/012027

Volfson, A., Eshach, H., & Ben-Abu, Y. (2020). Identifying physics misconceptions at the circus: The case of circular motion. *Physical Review Physics Education Research*, *16*(1). https://doi.org/10.1103/PHYSREVPHYSEDUCRES.16.010134

Wibowo, F. C., Suhandi, A., Samsudin, A., Darman, D. R., Akbardin, J., Hermita, N., Supriyatman, Rusdiana, D., Nahadi, & Coştu, B. (2017). Contribution of virtual microscopic simulation (Vms) to unveil students' conceptual development and misconceptions of physics concepts of heat transfer. *Turkish Online Journal of Educational Technology*, *2017*(Special Issue 2017).

Wittmann, M. C., Steinberg, R. N., & Redish, E. F. (1999). Making sense of how students make sense of mechanical waves. *The Physics Teacher*. https://doi.org/10.1119/1.880142

Wiyantara, A., Widodo, A., & Prima, E. C. (2021). Identify students' conception and level of representations using five-tier test on wave concepts. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1806/1/012137