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Identifying Students' Misconceptions of Sound Propagation

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Abstract

The Objective of this study is to identify misconceptions of sound propagation which students often encounter when asked. Generally, sound is a form of energy: the branch of physics that is concerned with this form of energy is acoustics. In particular, the study focused on the area of sound and misconceptions held by group of science students. In addition, through the use of interview method, the researchers identify students' understanding about sound and sound propagation. There are 4 participants of science students Faculty of Education University Teknologi Mara (UiTM). Two of the participants are bachelor of education science in (Chemistry) and another two participants are bachelor of education science in (Physics) as the sample in this research. All of the participants have the basic knowledge on concept of sound. The approach for this study is phenomenography. In general terms, phenomenography is the study of qualitatively different ways in which people conceptualization various aspect of reality and phenomena. The findings showed that the participants have poor understanding and have many misconceptions on the concept of sound propagation. For the conclusion, it is evidences that the participants possessed misconceptions in sound propagation. So that, misconception issue must be called as serious learning obstructions in learning physics and have to be address if the objective of physics education is to be achieved successfully. Research recommended for teaching and learning for sound propagation, teacher need to aware although, student do not necessarily construct the same conceptual relationship for specific phenomena in different contexts.

Keywords: Misconception, Sound Propagation, Phenomenography, Preliminary.

Introduction

Sound is one of the most commonly used physical phenomena that most of us use without considering its nature. Moreover, sound is a complex phenomenon to understand. Sound also form of energy, the branch of physics that is concerned with this form of energy is acoustics. Like other forms of energy, sound can be generated, it can move from one place to another, it can do work, and it dissipates over time and distance. We hear sounds every day. However that the idea of sound transmission can be a difficult concept to understand (Kanyesigye et al., 2022). It is, therefore, perhaps unsurprising that children commonly hold

the misconceptions that sound requires an unimpeded pathway and that it is an object with dimensions that move from one place to another.

Misconceptions are concepts which make sense to the students, but which deviates from the conceptions proposed scientifically (Driver, 1983; Osborne & Freyberg, 1985). Misconception is also referred to as an alternative conception by (Driver, 1983). The nature of students' ideas of science, students have many meanings and opinions of the world among them, which relate to those being taught in school (Osborne & Freyberg, 1985). So that, this study was conducted to know the students' misconception on the topic of sound.

This study is conducted the issue that arises which is the misconceptions about sound waves. Nowadays, the current scenarios of students who only study to score well in examinations to earn their place in higher learning institutions rather than to understand well what they have learning so it hamper the aim of the science education. Little research has been done on how well sound is understood by students at either the college (Linder 1989). Students often face difficulties in understanding acoustic phenomena, the most frequent one of which is the substance-based view of sound instead of a process of pressure and density differences (Volfson et al., 2022). Sound is used as a foundation that is built on extensive at secondary and tertiary level but it is a concept typically taught at the elementary level. Linder (1989); Wittmann (1998) claimed that studies of undergraduates' comprehension indicate that the foundational understanding of sound is not as nearly as sturdy as may be assumed by instructors. Based on the needs and the problems faced by students, the study aimed the following research questions and objectives:

1. What are the students' misconceptions about concepts of sound waves?
2. What are the students' misconceptions about the propagation of sound waves?

Literature Review

There are many reasons that contribute to the misconception in Physics among students. First of all, the students faced difficulties when to derive from learning characteristic, such as explanation through level which seem so abstract to the students (Nahun et al., 2004). Next, the students find it hard to explain the phenomena accurately since they are dealing with science that they cannot see with naked eyes. According to Sequeira & Leite (1991), they simply applied their previous experiences and make sense of the new concept that they have learnt. As long as they were able to score well in their examination, they still hold firm to their own concept even though they know that their personal understanding deviate away from scientific concepts.

Secondly, the content of the textbook and teaching demonstrate insufficient information and elaborations of concepts (Nahum et al., 2004). This statement was also supported by Osborne & Freyberg (1985), in his study where he asserted that school textbook was one of the sources in contributing misconceptions to students. Then, the research done by Lin et al (2002) supported that students' misconceptions resulted from the generalization of the information in textbooks and classroom instructions. Other than that, students were required to understand multiple definitions and models. Students would also get very confused if they refer to more than one book as defined in the book varies from one to another. For example, during this research, the researcher found that there are different definition of sounds. Not only that, there were also many models used by textbook authors to explain the existing concepts.

The evaluations of students through assessment were also not suitable as it does not assess the student's understanding of the underlying concepts (Nahum et al., 2004). Otherwise, another contribution to the misconceptions is by the way a teacher teaches. Therefore, students were unable to follow the teacher's pace and the students were left out in understanding the concepts. When students and teacher have lack of effective communication, it may lead to a mismatch of concepts between what is learnt and what is taught (Erduran, 2003). According to Osborne & Freyberg, 1985, the main solution proposed to solve misconceptions among students is to let students explains what their conceptions are, rather than telling them the right conception. In an analogy made by Driver (1983) in supporting the same idea, if a visitor who is lost and asking for directions, we have to first ask for the location of the visitor so that we will know where the visitor should go from where he is.

Nahun et al (2004) suggested that the current pattern of assessment which is a fixative questioning form should be abandoned as this kind of assessment does not measure at all the students' understanding of the concepts. Items asked in the exam were taken from the item bank and have been slightly modified. Therefore, students and teachers knew and able to predict very well pattern of questions that will be asked during the exams. This encourages them to do a lot of past years questions, instead of understanding the concepts taught. Therefore, new assessment tools must be formed to gauge student understanding on sound phenomena.

According to Lin et al (2002) in research conducted, it was suggested that the teachers should give more examples and explanations when they teach. They argued that using a single example during teaching will result in students' misconceptions. A researched by Wandersee (1985) found out that the phenomena of alternative conceptions and the conceptual development is very similar to the development of the concept that had once happened in the science history. Back then, the problem was solved by teaching the students the history of the concepts to make the students realized how the concepts were developed. This would promote a better understanding. In the same research paper, the author as well, suggested that students should actively discuss their ideas of the concepts with their peers or teachers.

Sound and Misconceptions

Misconceptions about sound have been quite widely investigated in primary and secondary education, but have received little attention in engineering education. Even if the sound is not perceived as having all the qualities of an object, sufficient misconceptions exist to lead to a common misunderstanding, such as that sound is slowed down by physical obstructions, that pitch and frequency are associated with the material that makes up the medium through which the sound is travelling and that sound can be propagated in a vacuum. So that, when pupils attempt to explain how sound travels, it leads to difficulties because of these misconceptions can develop.

In a study by Merino (1998a), he presented a set of observations that related students' misconceptions about sound at the university level. From personal teaching experience, the author derived these observations. In Merino (1998a) first article, the problems he observed are related to sound loudness and its intensity. Students often wrongly assumed that intensity and loudness are the same thing. Next, the students think that doubling the intensity of the acoustic wave doubles the acoustic level. Then, they assume that if a frequency is halved, the

corresponding pitch is also halved. Regardless of the frequency, a similar acoustic energy always produces the same loudness.

Merino (1998b) second misconceptions article that he observed are concepts of sound pitch and timbre. Since this sensation is commonly linked in a naive manner to the fundamental frequency, the problems of an understanding of the concept of pitch presents. He also concludes that the study of the intrinsic properties of loudness, pitch, and timbre involves in understanding of the nature of sound. Another common misconception is association of loudness with wave amplitude only, pitch with a frequency only and timbre with the mere overlapping of two higher partials. So that, Merino (1998b) suggests if the teachers improve their knowledge on the three acoustic sensations, these problems might be solved.

Methodology

This study used the qualitative approach specifically phenomenology research design. First of all, the phenomenology research is often referred as qualitative research because both provide the researcher some insight and ideas of the topic selected. One of the reasons to conduct phenomenology research is it can provide a better understanding of a situation, particularly the understanding and the misconceptions in sound waves among Science students. Despite the richness and meaningful information gained through phenomenology research, it is not designed to provide final decisions or answers to solve a problem for the overall population. This is because exploratory research, usually involves only a small group of people.

Thus, this research design was suitable for this study because researcher wants to know what the respondents' opinions towards this study and the reason behind their answers. This research had focused on the students' misconception and understanding, so it is more suitable to use qualitative research design rather than other research design. In contrast, the data are collected in the form of words rather than number. So, the preference for this design is narrative. Other than that, this design enabled the collection of data and the analysis of the student's misconception in sound waves. Therefore, by using this design, the objectives of this study were achieved.

As this study intended to probe the misconceptions in the sound wave among students, it utilized semi-structured interview method which focuses on in depth exploratory of students' misconception. Hence, students will be exposed with a set of developing semi-structured interviews to test their conception on sound wave. However, different from other interview methodology in the diverse qualitative approach, the participants in this study were asked to see a simple experiment about propagation of sound waves and explain about this experiment.

Phenomenography is the study of the qualitatively different ways in which people experience and conceptualize the world around them (Lybeck et al., 1988). The experiential perspective is one of the basic features, various aspects of reality and various phenomena are described in terms of the differing ways in which they appear to people. Phenomenology is one of the five major research traditions of qualitative methodologies (Creswell, 1998). Phenomenology is also an experientially based research perspective which facilitates an interpretative experiential analytic approach to characterize how and what students see from their perspective (Linder, 1989). According Creswell (1998), "phenomenological data analysis

proceeds through the methodology of reduction, the analysis of specific statements and themes, and a search for all possible meanings. Table 1 shows the summary of question in a form of semi-structure interview.

Table 1
Summary of question

Research objectives	Questions
To investigate the student's misconceptions about concepts of sound waves	1. What is sound? 2. What is the type wave of sound? 3. Can sounds be produced without using any material object? 4. Sounds can travel through empty space (vacuum) 5. Does a sound can travel through liquids and solids? Which one will travel faster?
To determine the student's misconceptions about the propagation of sound waves.	<u>Situation 1. Voice- Ear</u> 1. How the sounds propagate? 2. Would be anything be different for sound in the space without air and in the space with air? 3. Does the air play any role in the process of sound propagation? What is the role of air in a process of sound propagation? 4. As the sound propagates, does it affect the air in any way? How?
	<u>Situation 2 Voice – Dust Particle</u> 1. If this dust particle was previously still, will sound of the speaker's voice have any influence on the dust particle? 2. How do you expect this particle to behave due to the sound and why? 3. What actually pushes the dust particle and it moves?
	<u>Situation 3. Loudspeaker- Dust Particle</u> 1. Suppose at first moment the particle was motionless and then we turned the loudspeaker on. Do you expect that this sound would affect the dust particle?
	<u>Situation 4. Voice- Obstacle – Ear</u> 1. What would you say about the possibility for those two people to hear each other's voice if they talk loudly and wall is relatively thin? 2. How does the sound reach the listener on the other side in this situation? 3. How does the thickness of the brick wall influence the loudness of the sound received by the listener in another room?
	<u>Situation 4a. Voice – Obstacle – Ear</u> 1. What happens on this microscopic level as the sound reaches the wall? 2. Why is sound quiter on the listener's side of the wall than on the speaker's side of the wall?
	<u>Situation 5 Voice – Two Cans and String – Ear</u>

	1. Did you hear it better with or without these cans and rope?
	Situation 5a. Voice- Two Cans and String – Ear 1. Did you hear it better with tightened rope or with loosened rope?

(Adapted from: Hrepic, 2002)

Findings

From the data collected, the analysis can divide according to the theme, concepts or research questions. So that, easier for researcher to identify which participants have misconceptions of sound. Not only that, the analysis also can arrange according participant so that the researcher can see the comparison among the participants. From the analysis of data the researcher found that participant four has many misconceptions on this topic and she also not confident to answer the questions. Table 2 shows the comparison of misconceptions based on research question.

Table 2
The students' misconception about concepts of sound waves?

Concepts	**Questions**		**Scripts**
Definition of sound	What is sound?	Misconceptions	1. Sound is anything that needs medium to propagate.
		Correct concepts	1. Sound comes from something that vibrate and it has a frequency 2. Sound is the energy produced by the vocal cord and sound also is the energy that released and reached the ears and accepted by the listener. 3. Sound is a form of longitudinal waves which is moving forward and backward.
Sound characteristic	Sound can travel through empty space (a vacuum)	Misconceptions	1. Yes, sound can travel through empty space. 2. Yes
		Correct concepts	1. No, sound cannot travel through empty space. 2. No, if there are any material objects, sound cannot be produced so sound cannot be travel through empty space. Sound is vibration and needs medium to propagate.
Sound characteristic	Does sound can travel through liquid and solid? Which one will travel faster?	Misconceptions	1.Yes, sound can travel through solid and liquid. Sound travels faster through air compared to the solid.
		Correct concept	1. Yes, sound can travel through solid and liquid. Sound travels faster through solid compared to air. 2. Yes. Sound can travel fastest through solid, faster through liquid and slowest through the air 3. Yes. Sound can travel through the solid and liquid because they acts as a medium. So that, sound travels faster through the solid, than liquid and lastly through the air.

Students' Misconception about Sound Waves Propagation

This research question aimed to discover the students' misconceptions about the propagation of sound. There are several questions and situation that need to be asked to the students. Some of the students were pretty clear on sound propagation as defined by (Hewitt, 2002) that anything that switches back and forth, to and fro, side to side, in and out, off and on, loud and soft, or up and down is vibrating. A vibration is a wiggle in time. A wiggle in both space and time is a wave. A wave extends from one place to another. Light and sound are

both vibrations that propagate throughout space as waves. Table 3 shows the students' misconception about the propagation of sound waves

Table 3
The students' misconception about the propagation of sound waves.

Concepts	**Questions**		**Scripts**
Sound propagation	How the sounds propagate?	Misconceptions	1. Sounds propagate through the air particle and then convert to the sound. 2. I do not know how to explain, but who speaks is like of sound waves reaches the receiver and the receiver accept the wave.
		Correct concepts	1. The wave began rarefaction then compression. So the waves propagate parallel with the direction of the mouth of the speaker towards the listener's ear.
Sound propagation characteristic	Would anything be different for sound in the space without air in the space with air?	Misconceptions	1. Yes. Air will make the sound become loud and slow. 2. No, the sound remains same.
		Correct concepts	1. Yes. There is different.it is because when there is no air so it is vacuum then sound cannot propagate. 2. Yes.it has a different. It is because if there is objects that vibrate so there is no sound produced. And without air, there is no medium for sound to propagate.
The importance of air.	Does the air play any role in the process of sound propagation? (What is the role of the air in a process of sound propagation?)	Misconceptions	1. There are no misconceptions
		Correct concepts	1. Yes. Air acts as a medium that move sound to the listener. 2. Yes. Air plays a role, but I don't know how to explain it. What I know is with the presence of air, sound wave can produce. 3. Air is one of a medium for sound to propagate. 4. Air plays as a medium for sound to propagate.
The effect of dust particle	If this dust particle was previously still,	Misconceptions	1. Yes. Because when we talk, there is air produces from our mouth, then sound that

	will sound of the speaker's voice have any influence on the dust particle?		produced from mouth contains air and the air will push the dust particle. 2. Yes, when sound waves propagate, the dust particle will follow the propagation of the sound. 3. Yes. Because we assume that the dust particle is air so actually the air particle is like rarefaction and there is compression of the particle itself. 4. Yes. Because of wave so the dust particle will move.
		Correct concepts	1. All of them have misconceptions
The effect of dust particle	Suppose at first moment the particle was motionless and then we turned the loudspeaker on. Do you expect that this sound would affect the dust particle	Misconceptions	1. Yes, because sound have a frequency. Sound still has frequency so will give effect to dust particle. 2. Yes. 3. The particle will move forward and backward so the dust cannot reach the listener. 4. Same like the previous situation because it will produce a wave.
		Correct concepts	1. All of them have misconceptions.

Concepts	**Questions**		**Scripts**
The effect of dust particle	Can the sound of loudspeaker cause that dust particle gets closer to loudspeaker than it was originally due to sound propagation?	Misconceptions	1. No, because the dust particle cannot close but it goes further from the loudspeaker. 2. No, if the dust comes closer to loudspeaker then it will go further because of the propagation of the wave is like moving forwards and backwards. 3. No, because when the waves compress, it will move forward and backward again. So during wave propagate is like moving forward and backward, the dust will stay in original

			position and cannot closer to the loudspeaker. 4. The dust particle cannot get closer to the loudspeaker.
		Correct concepts	1. All of them have misconceptions
Dust particle	What actually pushes the dust particle and it moves?	Misconceptions	1. Air from mouth contains oxygen, so it will push the particle. 2. Vibration that moves the dust. 3. Air particle will push the dust. 4. Because of propagation of wave.
		Correct concept	1. All of them have misconceptions
The propagation of sound	There are two people in two different rooms separated by walls. How does the sound reach the listener on the other side?	Misconceptions	1. This wall is solid so if we talk between the solid wall we still can hear the voice. Sound needs a medium to transfer so that the wall (solid) act as a medium to transfer the sound 2. Still have a sound wave that comes back to speaker so maybe the listener can hears but still have absorbed by the wall. 3. We can hear but not too clear because have movement of sound from the air that vibrate the wall particle and then vibrate at the listener. But in the air, the particle more easier to vibrate compared to vibration in the wall(solid) so that the vibration will slow down the voice to reach the listener. 4. Sound travels through the wall.
		Correct concepts	1. All of them have misconceptions
The propagation	What happens on this microscopic	Misconceptions	1. From speaker to listener and straight line.

of particles of sound	level as the sound reaches the wall?		2. Particles in the sound like energy so this particle is solid so it vibrate itself.
		Correct concepts	1. It's like the air, the particles sometimes closed (compression) sometimes far each other (rarefaction).
Sound travels	Did you hear it better with or without these cans and rope? How do you explain that?	Misconceptions	1. All of them have no misconceptions
		Correct concepts	1. Use cans and rope much better because have a vibration reaches directly to our ears. 2. Use cans and rope much better because we transfer sound wave through he can and the rope is used to transfer the vibration to another cans. Can acts as an amplifier. 3. Cans and rope is much better to hear because having a medium that's easy to vibrate compared to air. Air has higher intensity so it cannot focus to vibrate. 4. Cans and rope are better to hear.
Sound travels	Did you hear it better with tightened rope or with loosened rope? How do you explain that?	Misconceptions	1. The loosened rope is better because it will vibrate more compares the tightened rope.
		Correct concepts	1. Tightened rope because easier to transfer the sound. If use the loosened rope, it is difficult to transfer the sound. 2. The tightened rope is better because more tension in the rope easier to vibrate. For example, we are playing a guitar, we must make sure the string is tightened enough to vibrate. If the string is loose it is difficult to vibrate. 3. Tightened rope is better because when the rope is tension, it has a frequency and produce loud sound.

From the second research question, the researcher found that all the participants hold several misconceptions in the concepts of propagation of sounds. Most participants have basic knowledge about sound wave so that there is not too much misconceptions. But for the propagation of sound, there are several questions that they were not understand and cannot be able to explain in details. Next, all the participants held misconceptions on the propagation of sound affect the dust particle. According to Wittmann (1998), he said that, the dust particle would move away from the speaker, pushed by the sound wave. I mean, sound waves spread through the air, the air is actually moving, so the dust particle should be moving with that air which is spreading away from the speaker. (Wittmann, 1998). But this statement has misconceptions. Then, he done another study and realized that there is misconceptions and he against the statement that the propagation of sound will affect the movement of dust particles. According to Wittmann, Steinberg, and Redish (1999) said that a dust particle would slightly bounce at the spot. Sound is a dilatational wave, and thus, air molecules do not move in the direction of a sound's travel.

On the other hand, all the participants were not be able to explain more about what happens to microscopic level as the sound reaches the wall. They can explain, but have several misconceptions in their explanations. According to the study done by Periago et al (2009), the right concepts is the wall is a solid, the particle is varying closed together so that sound energy move as one particle hits the other particle. Then, with the particles being so close together, sound travels quicker through a solid. The wall's particles vibrate in the direction (left to right) from which sound is propagated. Thus, at certain times there are areas in which they will appear closer together and areas in which they will be momentarily further apart.

Conclusions

Although the studies examined within the scope of this study belong to a certain region, the previous literature shows us that the learning difficulties or misconceptions are generally independent of culture. It is beneficial to consider this situation in education. In this case, it is seen that the underlying reasons for the difficulties experienced by students, teachers, or teacher candidates are not clear. Therefore, studies should be done to investigate and clarify this issue (Aygun, & Hacioglu, 2022). The purpose of this study is to study the misconceptions of sound propagations among Science students in the Faculty of Education. Throughout the chapters reported in this study, the issues of misconceptions in sound propagations were developed by the reasons for misconceptions and the problems that caused by it. Through the study and interviews with the participants, there were evidences that the participants possessed misconceptions in sound propagation. So that, misconception issue must be called as serious learning impediments in learning physics and have to be eliminated if the objective of physics education is to be achieved successfully. It will be counted as serious issues because if there is a misconception since the secondary school, the students will bring the misconceptions up to the tertiary level and throughout their lives and at the same time, it will affect them. As a conclusion, it is hoped that this study may provide insights on the issue focused throughout this study and contribute to the improvements of physics education in Malaysia as a whole.

Recommendation

It has been concluded in the theses about the sound that students/teacher candidates and even teachers have various misconceptions/concept errors or confusions and some of them cannot be eliminated even with the contemporary approaches that have been tried (Aygun, & Hacioglu, 2022). The conceptual outcomes that are described in this study have reflected differences between both individuals and differences within individuals. So that, from the analysis indicates that:

1. Although the students' conceptualizations tended to be contextually different they were not contextually dependent. People do not necessarily construct the same conceptual relationship for specific phenomena in different contexts. Then, these relationships are often multifaceted reflecting multifaceted conceptualization evocation.
2. The students tended to think about sound in fragmented parts. Each part represented a conceptualization from any of possible conceptualizations. This is characterized as "conceptual dispersion".

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References

Aygun, M., & Hacioglu, Y. (2022). Teaching the Sound Concept: A Review of Science and Physics Education Postgraduate Theses in Turkey. *Athens Journal of Education*, 9(2), 257-275.

Creswell, J. W. (1998). *Qualitative research and research design: Choosing among five traditions*. London: Thousand Oaks.

Driver, R. (1983). *Pupil as scientist*. McGraw-Hill Education (UK).

Erduran, S. (2003). Examining The Mismatch between Pupil and Teacher Knowledge in Acid-Base Chemistry. *School Science Review*, 84(308), 81-87.

Hewitt, P. G. (2002). *Conceptual physics*. Pearson Educación.

Hrepic, Z. (2002). *Identifying Students' Mental Models of Sound Propagation* (Doctoral dissertation, Kansas State University).

Kanyesigye, S. T., Uwamahoro, J., & Kemeza, I. (2022). Difficulties in Understanding Mechanical Waves: Remediated by Problem-Based Instruction. *Physical Review Physics Education Research*, 18(1), 010140.

Lin, H. S., Yang, T. C., Chiu, H. L., & Chou, C. Y. (2002). Students' Difficulties in Learning Electrochemistry. *Proceedings-National Science Council Republic of China Part D Mathematics Science and Technology Education*, 12(3), 100-105.

Linder, C. J. (1989). *A Case Study of University Physics Students' Conceptualization of Sound* (Doctoral dissertation, University of British Columbia).

Merino, J. M. (1998a). Complexity of Pitch and Timbre Concepts. *Physics Education*, 33(2), 105.

Merino, J. M. (1998b). Some Difficulties in Teaching The Properties of Sounds. *Physics Education*, 33(2), 101.

Nahum, T. L., Hofstein, A., Mamlok-Naaman, R., & Ziva, B. D. (2004). Can Final Examinations Amplify Students'misconceptions In Chemistry?. *Chemistry Education Research and Practice*, 5(3), 301-325.

Osborne, R., & Freyberg, P. (1985). *Learning in Science. The Implications of Children's Science*. Heinemann Educational Books, Inc., 70 Court Street, Portsmouth.

Periago, C., Pejuan, A., Jaen, X., & Bohigas, X. (2009). Misconceptions about The Propagation of Sound Waves. In 2009 *EAEEIE Annual Conference* (pp. 1-6). IEEE.

Sequeira, M., & Leite, L. (1991). Alternative Conceptions and History of Science in Physics Teacher Education. *Science Education*.

Volfson, A., Eshach, H., & Ben-Abu, Y. (2022). History of Science Based Dialogues on Sound Waves: From Sound Atoms to Phonons. *Physical Review Physics Education Research*, 18(1), 010123.

Wandersee, J. H. (1986). Can the History of Science Help Science Educators Anticipate Students' Misconceptions?. *Journal of research in science teaching*, 23(17), 581-97.

Wittman, M. C. (1998). *Making Sense of How Students Come to an Understanding of Physics: An Example From Mechanical Waves*. University of Maryland, College Park.

Wittmann, M. C., Steinberg, R. N., & Redish, E. F. (1999). Making Sense of How Students Make Sense of Mechanical Waves. *The Physics Teacher*, 37(1), 15-21.